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SCIENTIFIC CONFERENCE ABSTRACTS

VOLUME 2

XVI INTERNATIONAL FORUM-CONTEST OF STUDENTS AND YOUNG RESEARCHERS

TOPICAL ISSUES OF RATIONAL USE OF NATURAL RESOURCES

UNDER THE AUSPICES OF UNESCO

Saint-Petersburg
Mining University

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The Volume contains works of young researchers - participants of the XVI International Forum-Contest of Students and Young Researchers “Topical Issues of Rational Use of Natural Resources”, which was held at St. Petersburg Mining University on June 17-19, 2020. The Volume can be of great interest for a wide range of researchers, scientists, university lecturers, specialists and managers of industrial enterprises and organisations as well as for businesspeople involved in exploration, prospecting, development and processing of minerals.

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Session 5. ECONOMICS OF SUSTAINABILITY AND GLOBAL INVESTMENT TRENDS

Session 7. EQUIPMENT, VEHICLE MAINTENANCE AND ENERGY EFFICIENCY AT THE ENTERPRISES OF THE MINERAL RESOURCES SECTOR

Innovations and prospects for the developments of mining mechanical engineering

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CONTRACT MODELING OF INVESTMENT PROJECTS IN THE FIELD OF OIL AND GAS CONSTRUCTION

According to analysts, the potential for increasing the efficiency and profitability of investment projects in oil and gas construction by reducing errors at the stage of contract management is at least 25-30%, and the maximum value is close to the cost of the contract itself. In this regard, Russian oil companies are paying more and more attention to the issues of contract modeling. Since the optimal contract model as a reasonable set of stages of the investment and construction process allows you to implement the project with greater efficiency: in a short time, with the lowest costs and high quality of design solutions [2]. The theoretical basis of the research is the work of V.I. Malakhov and A.S. Mishin on EPC(M)-strategies and development of the Russian and Western engineering markets, V.B. Lipavsky in the field of structuring, conclusion and execution of contracts, A.A. Laznik, who reveals the international experience of using progressive contract models, E.A. Kalinenko, V.Yu. Linnik and other experts in the field under consideration.

For effective modeling of contractual relations within the framework of the implementation of investment construction projects (ICP), it is necessary to have a clear understanding of the classification of contracts as such. The existing classification takes into account several aspects at once: the procedure for selecting performers (competitive negotiations / tender procedures), the scope of competencies of the contractor (monocompetent / complex contracts) and the pricing method (price announcement / cost compensation / mixed pricing / application of the «Open Book» concept) [1]. An analysis of more than 70 oil and gas construction projects in Russian and foreign practice showed that not all of the contractual models of ICP are adapted to the specifics of the oil and gas business. Therefore, the study developed a new classification based on two key parameters: the amount of responsibility for performing work and the type of contract pricing. It provides a clear understanding of how the scope and content of work affect the determination of their cost and how the contractual model differentiates risks between the customer and the contractor of work. Based on the obtained classification, a conclusion was made about the set of conditions under which such progressive contractual models are concluded as EPC Lump Sum Turn Key, EPCM-contracts using the Cost + Fee pricing method (general contract with cost recovery, providing a fixed remuneration of 15-20% of the contract value) and EPC(M) – Open Book (when costs depend on market pricing and subcontractor accounts) [3]. A risk matrix of contract pricing methods has also been developed, highlighting the scope of their practical application and the possibility of adaptation by two types of EPC contractors-independent and as part of subsidiaries of oil companies.

At the moment, there is no unified approach to the process of planning and forming a contract model for oil and gas construction projects. Therefore, the author has made an attempt to develop such a process within the framework of the research. Combining the bases of the previously developed classification and the key elements of the project, the author obtained four process steps for planning the contract model.

Summarizing all the results achieved, at the final stage of the work, the contract model of the largest investment project of PJSC Gazprom for the construction of a medium-capacity liquefied natural gas (LNG) plant was justified. For its implementation, the project customer signed an EPC-contract with one of the Russian technological engineering holdings for the design, construction and commissioning of the complex. The author of the article made an assessment of the economic efficiency of this project for several alternative versions of contract models, as a result of which the proposed mechanism for planning the contract model was tested

and concluded that it is advisable to use the EPC-scheme in this project from the point of view of the optimal solution for the customer / investor of the project. The results of the economic assessment showed that the EPC-model is optimal for this project. The use of a standard EPC-contract allows you to reduce the construction lines of the LNG plant several times, compared to the traditional construction scheme, the project pays off significantly earlier, and the return on investment is higher. Speaking about the quality of design solutions, the high level of professional competence of the EPC-contractor and its easy access to the technology of a foreign licensor leads to an increase in the quality of work throughout the EPC-chain. The project risk management system becomes more effective by transferring all risks from the customer to the contractor (the «one window» principle), which bears end-to-end technological, financial and legal responsibility.

Thus, the conducted research has shown that, indeed, the contract model has a direct impact on the implementation of an investment and construction project: its economy, timing, quality of design decisions and the effectiveness of the risk management system. The developed classification of contracts, adapted to the specifics of the oil and gas business, allows the customer and contractor of the project to build an effective contractual strategy that takes into account the volume, nature of work and corresponding pricing models. The proposed mechanism for planning the contract model of oil and gas construction projects can be used as a fundamental basis, which will be adjusted from time to time depending on the intentions of the parties to the contract, the specifics of the project and the impact of any external factors.

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THE MODELING OF INVESTMENT APPEAL OF DONBASS MINING ENTERPRISES

Investment plays an important role in the economy of any enterprise and country in general, as it is the basis for the systematic updating and expansion of production capital, acceleration of scientific and technological progress and balanced development of all sectors of the economy in the context of global transformations. In the context of global transformations the competition for investment resources acquires a qualitatively new essence. It is accompanied by harmonization of interests of transnational corporations and national countries [1].

In the context of increasing global industry competition in the fuel and energy sector of the world economy, attracting investment is becoming increasingly important for capital-intensive enterprises, which undoubtedly include coal mining companies. Although, many authors attach great importance to this subject, scientists still did not find common determination of investment appeal. The investment appeal includes productive capacity, financial status, and management of enterprise, industry sector and concerns of investment players. Also, the investment appeal is considered as integrated assessments of enterprise as investment object [2; 3]. Therefore, research on the investment attractiveness of coal mining enterprises is particularly relevant.

Investment in the coal mining industry has played and will continue to play a significant role in its development. The presence of a well-planned investment policy is the key to maintaining the industry's capacity at the proper level. However, investment resources are limited, so in order to receive financial support, coal mining companies need to be competitive in comparison with the enterprises of related industries, that means, to be investment attractive for domestic and foreign companies.

The authors have developed a line-factor model for evaluating investment attractiveness, in which the significance of individual indicators is regulated by weighting factors determined by the experts [4]. The advantage of this approach is a comprehensive analysis of the business entity, which take into account a variety of quantitative and qualitative indicators that provide a more accurate and objective assessment of the activities of an industrial enterprise. Five state coal enterprises of the Donetsk people republic were analyzed according to this method. According to this method, four out of five enterprises have a low integral indicator, which is characterized by low production efficiency, exhaustion of technical resources of equipment and space, staff reduction, and other negative reasons. To develop measures to increase the investment attractiveness of coal mines, the sensitivity of the integral indicator to changes in the most significant factors was analyzed. At the beginning of 2019, results of the study have shown that the change in the integral indicator significantly affected by the factor "The ash content of coal, shipped to customers", in the range of changes in this factor by 20% (from -10% to +10%), the Kint changes by 3.86% (from -0.94% to +2.92%). In second place is the factor "Per face output" (Kint changes by 2.92%). The "Price of 1T" is in the third place (the Kint changes by 2.01%).

Finally, it can be observed, that it is time for coal mining companies to address the issues that are causing their market value to go down. Among the main challenges that businesses face today are climate change, technology development, and changes in consumer opinion. In order to regain confidence in the industry, coal companies need to prove that they are move with the times and changes. They will be able to win the trust of stakeholders, by focusing on environmentally friendly and customer-oriented strategies based on advanced technologies.

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LEAN MANUFACTURING AS THE BASIS FOR INCREASING OPERATIONAL EFFICIENCY AT THE CHEMICAL ENTERPRISE

The chemical manufacturing has the one of the most important roles in the economy and society. Medicines, agricultural fertilizers, kinds of plastic products, household chemicals, food additives and cosmetics are things that would not appear if the chemical manufacturing did not exist. New demands appear, technologies are getting more improved but neither economic growth nor improvement of the well-being of society can be achieved if the chemical industry stay still. A key to the development of the chemical enterprise may be an introduction of leaning

manufacturing principals that are currently one of the main modern management concepts. Within the framework of operational management, lean manufacturing is one of the most advanced ways to manage and develop an industrial enterprise. [1]

Chemical industry takes the special place in the economics of Russian Federation. By the number of main funds only the fuel and energy complex, engineering and metallurgy are ahead of the chemical industry. At the same time, the growth of production is so low that it is comparable with previous years. The situation with growth of the production of the chemical sector is aggravated by the fact that sanctions, mainly imposed by European countries and USA, reduce the import of raw materials that are necessary for many pharmaceutical companies of Russian Federation. Other main reasons for this situation include the lack of basic capacity, technological backwardness, high depreciation of fixed assets, etc. In addition, an important reason for the dependence of Russian industry on foreign suppliers is the low level of competitiveness of domestic products. [3]

The uncertainty of external factors threatens not only the growth of the industry and an increasing of chemical industry's production but also the preservation the already small production's share of the Russian chemical industry on the world market. The principles of the lean production can include, for example, corporate culture, employees' uniting and creating the trust between them, responsibility instilling for what employees create by their own hands and the minimizing labor cost, improving production quality and staff training as well. Thus, implementation of the principles of the lean production concept leads to an increase in production efficiency not only by minimizing labor costs, reducing waste, improving the quality of manufactured goods, but also by changing the attitude of employees to the work process. [2]

Reasonableness of the concept effectiveness has been tested and proven by Japanese automaker Toyota. The automaker had previously produced low quality cars and then Toyota outperformed American automakers both in quality and price, using lean production. It must be taken into account that even the introduction of such a favorable concept encounters such problems as the reluctance to accept the principles of the concept by employees of the organization due to low awareness of positive results or the usual distrust, a low level of understanding and mutual respect between managers and subordinates, the difficulties of interaction between departments of the organization and any sorts of obstacles during changes implementation by employees for a various reasons.

Nevertheless, given the above difficulties, the Russian chemical industry has all chances to increase productivity, competitiveness and global productivity share mainly thanks to the government support and concepts adoption such as lean production. Having solved all the difficulties and received a strong desire to improve the chemical industry, the economy of Russian Federation will have success and a great future.

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METHANE UTILIZATION AS A RESOURCE SAVING METHOD IN COAL INDUSTRY

Resource conservation is embedded in the context of the Sustainable Development Goals identified by the UN Commission on Sustainable Development in 2015.

This document contains a goal that secures responsible consumption and production, which is relevant for the Russian Federation as a country with resource-based economy.

Official statistics show that, for example, to reduce energy intensity, domestic production lags behind many industrial leaders in the global market. It also actualizes the need for the introduction of resource saving technologies.

Russia is the fourth world emitter of greenhouse gases that have a detrimental effect on ecosystems. The main emitter of greenhouse gases in Russia is the fuel and energy complex, and the leaders in methane emissions are large coal companies.

At the same time, foreign experience shows that modern technologies allow not only to extract but also use methane as an alternative to traditional fuel, which meets the principles of responsible consumption of mineral resources.

Russian large coal companies have sufficient resources to implement technologies that can efficiently extract and use coal bed methane [1].

Therefore, the task of reducing methane emissions is one of the urgent tasks of resource conservation and achieving sustainable development goals.

World experience shows that the organization of coal seam methane production as a separate mineral can provide gas to both the industry itself and external consumers.

According to experts, the global volume of methane is from 225 to 268 trillion. m3. The countries with the richest reserves are Russia, the USA, Australia and China. Among these countries, only in Russia industrial production and the use of methane as a separate mineral are not developed.

According to studies by the World Energy Agency, coalbed methane production in these countries from 2000-2016 doubled, reaching 70 billion m3 per year. [3]. With all this, the further prospect of developing the field of methane use in these countries is ambiguous, since shale gas production is more profitable for companies.

In the Russian Federation, the estimated methane resources in the main coal basins of Russia are estimated at 83.7 trillion m3, which corresponds to about a third of the country's predicted natural gas resources. A special place among the coal basins of Russia belongs to the Kuzbass, which can rightfully be considered the largest of the most studied methane coal basins in the world. Predicted methane resources in the Kuzbass coal basin are estimated at more than 13 trillion m3, the methane occurrence depth varies between 1200-1800 meters [2].

Thus, the need and the possibility of organizing methane coal industries is due to the following factors:

- tasks of resource conservation, in accordance with the goals of sustainable development;
- the presence of large forecasted methane reserves located in the coal basins of the Russian Federation,
- the presence of methane production technology, and the experience of foreign countries, proving the possibility of effective extraction of coalbed methane;
- the presence of investment and scientific potential among leading companies in the industry for implementing measures to introduce resource-saving technologies in the fields.

In this study, the case study method was used, and a single case was the project for using compressed methane extracted from SUEK's coal mines.

In the Russian Federation, companies often do not use any of the possible ways of using coalbed methane (electricity, pipeline gas, LNG, etc.). This is due to special mining and

geological conditions in which methane production is not profitable due to the low concentration of methane in most fields. Nevertheless, projects on the use of methane as electricity have recently been implemented by SUEK JSC at two mines.

It is not advisable for Russian companies to supply methane to foreign markets as pipeline gas, since not all regions have a developed gas pipeline infrastructure, and regulatory risk is high in this market.

Compared to LNG, CNG has the advantage of easier storage.

The choice of the method of use (CNG or electricity) depends directly on the volume of methane. In this study, the CNG method was considered, due to significant volumes of methane.

The essence of the method lies in the simultaneous extraction of coal and gas by conducting mine workings over the developed seam. Next, the gas is compressed at the plant and used for the needs of the enterprise.

The calculation of economic efficiency showed the profitability of the project.

The existing methane production technology used at coal mines in the Russian Federation is focused on the release of methane into the atmosphere. This approach causes great harm to the ecosystem and does not meet the objectives of resource conservation, which determine, in particular, the achievement of sustainable development goals,

Predicted volumes of methane in coal seams allow us to consider it as an independent mineral, especially since methane production has several advantages: 1) large forecasted volumes of methane (about a third of the natural gas reserves); 2) relative small depth; 3) the well-known technology for the further processing of methane.

The world experience in the extraction of coalbed methane allows us to consider methane production as a separate field, which allows us to provide gas both to the industry itself and to external consumers.

The presented project involves: the extraction of coalbed methane, its compression and its further use as a gas engine instead of diesel fuel on mining equipment of the enterprise itself. The main economic effect is achieved due to the difference in the cost of purchased diesel and the cost of fuel.

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ASH AND SLAG WASTE AS A VALUABLE RESOURCE OF RUSSIA (CONSTRUCTION OF A PIPELINE IN THE MOSCOW REGION EXAMPLE)

The use of technogenic mineral raw materials in our country has become an urgent topic in the industrial and economic spheres in Russia during last decade. These raw materials have been accumulated in sufficient amounts in all regions across the country. The number of useful components in the accumulated waste is sometimes higher than in the ores, which are currently being developed. Industrial waste is also a pressing environmental problem requiring an urgent solution. Practice shows this problem can be solved with economic efficiency.

One of the main environmental problem while burning coal at the enterprises of the energy complex (thermal power plants, thermal power stations, state district power plants) is the formation of a significant amount of ash and slag waste (ASW). For example, in the ash and slag dump of the Kashirskaya state district power station (on the bank of the Oka River in the Moscow Region), accumulated 7.1 million tons of ash and slag.

Global and local practice proves that ash and slag refining materials are a valuable, universal mineral raw material, which can replace natural mineral raw materials in the construction, cement industry, and road construction. They contain noble metals and rare-earth elements in industrially significant concentrations. There are patented technologies that help to extract them with a maximum profit.

Table 1 shows the analysis of ash and slag waste from the CHPP of the Central Federal District (CFD). Based on these data, it can be concluded that these wastes can successfully replace sand, clay, gravel, etc.

Table 1 - The chemical composition of thermal power plants with ash and slag dumps, Central Federal District

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	K_2O	Na_2O	Humidity
Aleksinskaya state district power station (Tula region)	47,27	23,6	4,47	2,59	0,53	0,03	0,71	0,07	19,91
Kashirskaya state district power station (Moscow region)	59,2	24,3	8,1	2,6	0,5	1,3	2,3	---	---
Stupinskaya state district power station (Moscow region)	44,17	32,26	9,46	3,23	0,57	0,16	0,50	0,06	---
Ryazan state district power station (Ryazan region)	48,0	34,2	12	3,5	0,7	0,7	0,8	0,15	--

In Russia the most effective way of processing ash and slag ash is a usage of large-capacity technologies: road construction, construction materials, backfilling of mine workings, mines, quarries, dumping of dumps [2]. Currently, in Russia, the large-capacity usage is going locally, pointwise.

In 2016, during the construction of a bridge in Moscow Region, 700 thousand tons of ash and slag from the Kashirskaya TPP were used. This bridge has become a unique object! FOR THE FIRST TIME in Russia, ash and slag waste (accumulated for 7 years) from the Kashira State District Power Plant were used as materials in the construction of embankments of bridge structures! The technology was developed back in the 1970s, it has only been improved [3].

Table 2 shows the economic efficiency of application of ash and slag from Kashirskaya state district power station in the construction of a bridge.

Table 2 - Cost-effectiveness of using ash and slag mash while building a bridge

Volume of used ash and slag ash, tons	**700 000**
The cost of ash and slag, rubles / t	15
Total cost	**10 500 000**
The cost of mountain sand, rubles / t.	180
The total cost of mountain sand, rubles.	**126 000 000**
Economic benefit, rubles	**115 500 000**

The replacement of mountain sand with ash and slag waste during the construction of a bridge structure in 2016 resulted in 115.5 million rubles savings. The total cost of the project, including the federal and regional budgets was 1.46 billion rubles. Another advantage was that local landscape wasn't destroyed during the development of sand pits.

The use of ASW in the national economy will save on average from 30% to 60% of the cost of finished products. The ASW market in Russia could gain 30-35 million tons a year. [1]

Unfortunately, now the use of ASW in Russia is no more than 10-15% of their annual output. At the same time, scientists and experts substantiated the useful properties of ash and slag. It may well serve as a secondary mineral resource in various industries and sectors of the economy.

In order to increase the volume of use of ASW in industry with an economic effect, it is necessary:

1. To develop state standards and regulatory and technical documentation on the use of ash and slag materials. In this case, the ash and slag materials available in the region for the construction work will be already at the design stage of the facilities. Implementation control of these standards can be carried out through state environmental expertise.

2. To upgrade the production technology, storage and processing of ash and slag waste processes. This will contribute to economic and environmental improvement.

3. It is necessary to amend the legislation of the Russian Federation with economic incentives and motivation for companies that processes use ash and slag waste.

4. To develop and implement innovative technologies with economic efficiency and large-scale processing.

5. To conduct marketing research in sphere of building materials, road construction, agricultural fertilizers. It will lead to new types of products and attraction of new investments.

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STRATEGIC CHALLENGES OF TRANSNATIONAL OIL AND GAS COMPANIES ON THE VERGE OF A NEW GLOBAL ECONOMIC CRISIS

In recent years, global energy markets have been undergoing a significant transformation due to a change in market conditions, whereas oil companies have been facing the highest uncertainty. At the same time the connection between the oil market and the global financial market is particularly sensitive [1]. Today the global economy is approaching a great recession mainly delivered by the coronavirus pandemic, and if it triggers a wave of defaults among oil and gas companies, that can hit financial markets in much the same way as it did with mortgage-backed securities in 2008. This emphasizes the significance and the urgency of the analysis of how corporate strategies of leading players of the global oil and gas market can adapt to these challenges. Recent studies of major consulting companies also demonstrate the concernment of executives on this market.

The global oil and gas (O&G) industry has been facing various jolts during past decades, including recent supply-side shock related to the collapse of the OPEC+ alliance and a demand-side shock against the backdrop of the COVID-19 outbreak. The confluence of these two shocks has led to a dramatic drop in oil prices. It is beyond doubt that O&G industry players are being forced to adjust their strategies and business models in order to respond these uncertainties.

Primarily, it is necessary to determine whether a strategy planning seems to be possible in conditions of such turbulence. However high volatility prevents long-term planning, it is

anticipated that companies should integrate risks into strategic management rather than treating them as a separate effort in the framework of immediate crisis management.

Current threats of an economic recession and a crude oil market collapse force companies to take immediate actions to survive. In regard of this, a number of O&G leaders have announced spending cuts. But the measures that have to be taken in a strategic view are to have a greater impact on the economic development in general.

The global environmental agenda along with the energy markets transformation jeopardizes the future of oil companies which highlights diversification as key and necessary part of their strategies. At the same time environmental risks must be finally quantified in strategic plans, not only described. Flexible strategic planning methods must be based on scenario approach, where the uncertainty factor is taken as a constant. Another way of strategy transformation is the digitalization process. It should be admitted that companies which have gone digital are adapting to the crisis better than their peers [2].

Not only spending cuts are required in the framework of transforming global oil and gas leaders' strategic plans, but also rethinking the future of their international projects and foreign expansion strategies. Capital flows are to be re-evaluated and transformed as a result of the collapse in production activity after international value and supply chains were disrupted by the pandemic.

Today, the firmness and irreversibility of globalization processes are being questioned. The position of 'alter-globalization' and 'slowbalization' proponents is being discussed increasingly [3]. One of the likely scenarios of further economic development could be the 'digital globalization' based on the network approach to the internationalization process and promoting social values such as protection of labour, health, environment and other human rights.

Finally, leading companies are to redefine their missions and goals in terms of sustainable development [4]. It will require rethinking the strategic priorities of companies' performance. The key lesson that must be learnt from the current situation is that maintaining sustainability and resilience in a long-run perspective rather than maximizing short-term profits is of great importance in the post-crisis business environment. The pandemic recession is also connected with the humanitarian crisis demonstrating that companies and governments have to review the postulates of sustainable development and their practical implementation into the global business.

Thus, meeting the challenges of the New Normal of the global oil and gas industry, these following points have to be considered:

- integration of risk assessment in the strategy planning process;
- the future role and shape of transnational companies in the age of 'slowbalization';
- sustainability values implementation in business processes.

In accordance with these strategic questions O&G companies' business models should be reviewed to cope with the consequences of the further recession.

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PROBLEMS OF EFFECTIVE USE OF COAL DEPOSITS IN MONGOLIA

Coal remains one of the most widely used types of raw materials for human life and economic development of many countries in the world. In the last decade, scientific papers on the economic problems of the use of coal have been published in Russia and abroad. There are not so much such publications in the framework of the environmental economics of Mongolia. In the coming years, it is very important to conduct research aimed at clarifying the qualitative characteristics of coal resources, including for enrichment and processing industries, the creation of which is necessary in Mongolia [1]. The role of exported coal is great in the socio-economic development of the country. Increase of the efficiency of the coal industry functioning remains one of the system-forming conditions for the sustainable development of Mongolia. Its significance will not only continue, but also increase in the long run.

In Mongolia, the efficiency of using coal reserves cannot be achieved without determining their value - a value that creates a real opportunity to take it into account not only in business, but also for national economic purposes aimed at increasing public welfare. In this regard, the coordination of the interests of the state, business and society within the framework of increasing the efficiency of the use of coal reserves in the country seems to be one of the key ones and is systemically important in solving problems of rational subsoil use. In the absence of a developed model of a market economy and dominance in the solution of economic problems of the so-called “manual control”, the need to seek the “state and business” consensus is becoming more and more in demand in the country's environmental system. Obviously, the value of coal mined and brought to the consumer is higher than the value of coal in earth depths, especially if its use complies with social and environmental requirements.

The determining factors in changing the value of coal deposits are the qualitative characteristics of coal reserves, the level of development of the transport and logistics infrastructure in the country and its regions, current trends in the development of Asia-Pacific resource markets and the prospects for introducing technological innovations in the coal industry [2].

The production capacities of Mongolia’s coal mining companies can significantly increase coal production in the medium term and change the structure of domestic coal consumption and its export. To increase the value of coal deposit reserves, it is necessary to regulate the structure of domestic coal consumption and its export volumes. However, the following take on particular importance: the degree to which the qualitative characteristics of coal deposits are in line with international standards, the government stimulation of the implementation of new road construction projects, regulation of coal and energy prices and tariffs, and regulation of foreign economic activity.

Due to the fact that coal reserves can ensure sustainable exports, the state needs to stimulate the development of transport and logistics infrastructure, which will allow the Mongolian economy to develop steadily and direct export revenues to the most important environmental, social and economic goals.

The methodology for determining the value of coal deposits involves ranking them according to the prospect of exporting mined coal, taking into account the influence of the following factors: field characteristics (reserves, types of coal, coal supply, number of licensed areas for field development), qualitative characteristics of coal (calorific efficiency, humidity,

ash content sulfur), the level of development of the transport and logistics infrastructure (type of road, distance to the consumer).

The methodology for evaluating coal deposits that we tested includes the following steps: a spatial analysis of the location of coal deposits and the formation of an information base for the study, classification of deposits according to the calorific value of coal in accordance with the standards of the importing country in order to identify deposits with export potential, analysis of licensed areas of coal deposits by values of qualitative characteristics, determining the estimated price for licensed areas, based on the qualitative characteristics of coal, determining transportation costs taking into account the distance of transportation and the current transport tariff, determining the increase in the value of licensed sites [3].

In the framework of the proposed methodology, it was proved that it is possible and advisable to use for coal export not only those deposits that are located near the borders of the country, but also deposits located remotely from the border, but corresponding to international standards in volume and quality characteristics.

The production and implementation of innovations in the coal industry of Mongolia is necessary for its sustainable development. However, the country's resource capabilities do not allow solving this problem in the short and medium term. In this regard, the role of the commercial component of the activities of coal mining companies in increasing the value of existing coal reserves increases.

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THE BUSINESS MODEL FOR SUSTAINABILITY (BMFS) AS POTENTIAL SUCCESS FACTOR IN THE MINING AND MINERALS INDUSTRIES

In the 21st century it is no longer enough to preserve life-supporting socio-ecological systems. In this regard, classical management thinking - mainly based on generic strategies - and traditional manufacturing processes will reach their limits soon. In terms of technological aspects, substitution, exploration, modern processing technologies and product lifecycle thinking, will be major contributors to sustainable product/process development and at same time reduce procurement risks. Furthermore, the current consumption patterns of (natural) resources will not enable firms to continue their business in the long term - this is proven by the laws of thermodynamics (entropy). A company in the field of extraction and marketing of critical raw materials will not be able to maintain its position continuously, even if all other factors remain the same in the model. The operating environment changes due to the industrial activities itself. These general conditions imply the need for an innovative sustainability-orientated business model based on an individual strategy set taking into account the Triple Bottom Line (TBL) approach. Ensuring "sustainability" today requires much more than socio- and eco-efficiency to

limit damage. Companies today are expected to use their strategies not only to create economic prosperity, but also to make an effective contribution to sustainable development. Profitability enables companies to contribute to the prosperity of the economy and society. A "sustainable" core business is seen as an entrepreneurial opportunity with aid of which a company can improve its long-term competitiveness and generate profits, i. a. by opening up previously neglected target groups, e.g. bottom-of-the-pyramid approach [1]. State-of-the-art CSR strategies create innovation opportunities and new competitive advantages for companies by increasing the social added value of entrepreneurial activity.

Enterprises gain a competitive advantage when integrated economic, environmental and social benefits (TBL) are greater than those of their competitors [2]. According to a study conducted by the Boston Consulting Group, 67% of the companies surveyed see an innovation advantage in achieving profits through sustainability orientation. Around 50% of each company recognize cost advantages and intangible benefits [3]. Compliance with the principles of responsibility requires structural changes that can lead to competitive advantages, e. g. technological innovation. For example, environmental protection programs can promote innovations that partially offset or even outweigh the costs of implementing them. Still, the measurement of corporate sustainability performance (CSP) is complex and requires individualization. A different perspective on the concept of success is required and has to be developed [2]. Mineral raw materials and sustainable development are very closely related, since they form the basis of the social development in the current economic system [4]. Driven by scientific and technological advances, the extraction of construction materials grew by a factor of 34, ores and minerals by a factor of 27, fossil fuels by a factor of 12, and biomass by a factor of 3.6. This expansion of consumption causes intense environmental impacts. Over-exploitation, climate change, pollution, health, land-use change, and loss of biodiversity rose toward major international concerns. One result is that “sustainable development” is over-arching global social, environmental and economic imperative among governments, international organizations, and the private sector [5].

There is an ongoing debate about whether the mining sector, which the case study’s industry of rare earths can also be assigned to, is or could be sustainable and if so, to what extent. Tost et al. conducted a research in which they found that concepts supporting “strong sustainability” in general dominate in academia, but have not yet become mainstream. [4]. Mining is no exception in this context. Like in many other branches, the neoclassical influence is still clearly noticeable. The way in which ores and minerals should be extracted, processed, used, and recycled - in the context of sustainable development - is less than obvious and often bitterly controversial. Even though Ecological Economics both provide managers with a more realistic perspective of their corporate context and their stakeholders’ demands and also realize a much greater contribution to sustainable development, it has to be pointed out that achieving the desired “strong sustainability” is not feasible in some branches so far. According to the findings of Allan - obviously referring to Daly’s management rules for contributing to sustainable development - sustainable mining could exist if the rate of use of minerals does not exceed the capacity to find new sources, acceptable substitutes or recycle. Furthermore, sustainable mining also includes an environmental component, and miners should use the land with care [6]; [7].

The Global Mining Initiative (GMI) was launched to define what sustainable development should mean to the industry and how it would contribute. They concluded: “In the context of the minerals sector, the goal should be to maximize the contribution to the wellbeing of the current generation in a way that ensures an equitable distribution of its costs and benefits, without reducing the potential for future generations to meet their own needs. The approach taken to achieve this has to be both comprehensive - including the whole minerals chain - and forward-looking, setting out long-term as well as short-term objectives.” [8]. Hilson and Murck developed sustainability guidelines for mining companies that translate “sustainability in mining” into six practical recommendations: (1) improved planning; (2) improved environmental management; (3) cleaner technology implementation; (4) increased stakeholder involvement; (5)

formation of partnerships and (6) improved training [9]. But do these guidelines also represent the stakeholder's perceptions of maximum sustainability in mining?

The current economic paradigm has placed enormous pressure on the planet while catering the needs of only about a quarter of the people on it. It is anticipated, that during the next decade twice that number will become consumers and producers. Traditional approaches to business will collapse, and companies will have to develop innovative solutions [10]. While companies around the globe are trying to position themselves as economically competitive and at the same time as ecologically and socially sound, for example, through more efficient production processes or increasing product responsibility, some pioneers are looking at new ways to meet this challenge on a more systemic level: the development and innovation of sustainable business models [11]; [12]. The authors identify the creation of a sustainability-oriented business model innovation as the best way to successfully enter the market and establish a sustainable market positioning, as the effect of new business models is often described as the "breakup of dominant and purely financially oriented paradigms of value creation" [13]. This can be achieved, for example, through considering closed-loop supply chains, embodying reverse logistics, to enable businesses to meet the growing demands of corporate social responsibility, and to meet wider social goals to reduce the resource-intensity of contemporary economic life [14].

Considering the three basic sustainability strategies sufficiency, efficiency and consistency and especially the regenerative processes. With regard to the possibility of strategy's complementarity, the question arises how co-evolutionary transformation processes can be realized, how they can be supported and accelerated, and how the inertia that counter paradigm changes and path changes can be overcome [15]. Sustainability-orientated business models shall be considered both as an enabler and as lever for the alignment of the three strategies to lead effectively to sustainable development. Common to all strategies is the key role of innovations, which relates to different areas or sustainability dimensions. Adopt the principle of the circular economy, considering that the extraction of primary resources will retain a key role in future due to rising demand. Still, mining companies will experience considerable pressure while the recycling rates will rise. Although several critical raw materials have a high recycling potential, especially in terms of reuse and remanufacturing, and despite the encouragement from governments to move towards a circular economy, the end-of-life recycling input rate of critical raw materials like rare earth elements is actually low. This can be explained by several factors: for many elements sorting and recycling technologies are not available yet at competitive costs. Furthermore, it is impossible to recover materials, which are in-use dissipated; the supply of many critical raw materials is currently locked up in long-life assets, hence implying delays between manufacturing and scrapping and therefore directly influencing the recycling input rate [16]. This idea is in line with UNEP's International Resource Panel (IRP) concept of "decoupling" which means using less resources per unit of economic output and reducing the environmental impact of any resources that are used or economic activities that are undertaken. Beneath changes in government policies, the key to decoupling in practice will be innovations that enable increasing resource efficiency, thereby reducing metabolic rates. Increasing resource efficiency may also justify increasing resource prices, benefitting resource producers (often in developing countries). Innovation with regard to resource efficiency, thus, may remain the core challenge for sustainable resource management for the coming decades [5]. Beneath the classic approaches of exploration of new deposits and the increase of resource efficiency the enlargement of current linear business models to closed-loop ("circular") business models, contains the potential of desired corporate longevity [17].

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INCREASING THE EFFICIENCY OF RUSSIAN URANIUM MINING ENTERPRISES IN CONDITIONS OF EXCESSIVE SUPPLY

Uranium production is the initial stage of the nuclear fuel cycle (NFC). The final product of production - uranium oxide (U_3O_8), is used to produce nuclear fuel to ensure the operation of nuclear power plants. The demand for uranium is set based on the reactor requirements for nuclear fuel. Uranium supply is divided into primary - mining of uranium ore (90%) and secondary - processing of depleted uranium hexafluoride, spent nuclear fuel (10%) [9]. The most effective is considered to be the extraction of uranium ore using in situ leaching (ISL), which differs from traditional methods of production in lower operational costs, less impact on the environment. 50% of uranium is mined using SPV technology [11].

The uranium market has been divided into short-term (spot) and long-term (supply of uranium to fuel companies). After the Fukushima accident in 2011, Germany, France, Great Britain, the USA and Japan began to reduce the volume of nuclear production, 137 reactors were decommissioned [16]. Demand for uranium fell, the average annual price from $57 per pound (in 2011) reached a minimum in 2016 ($19 per pound). In 2018, due to excess supply on the market, world production amounted to 53 thousand tons, which is 9% lower compared to 2017, but the price remains low - $24 per pound (03.23.20) [14]. The market leader is the Kazakh company Kazatomprom - 22% [23]. According to the IAEA, 53 reactors (China, India, the United Arab Emirates, Korea) are currently being built in the world [16]. In view of a decrease in the supply of uranium from secondary sources and an increase in global reactor requirements, the World Nuclear Association predicts a 77% increase in uranium demand by 2035 (calculated by the author) to 94 thousand tons [21].

In Russia, ARMZ JSC is engaged in uranium mining (it consists of JSC PPGHO, JSC Dalur, JSC Khiagda), and the company Rosatom State Corporation. The year 2018 ended for the company at a loss of 4.1 billion rubles: Dalur and Khiagda mine uranium using ISL, have a net profit of 316 and 105 million rubles, PPGHO is mining underground, causing a loss of 4.4 billion rubles [1]. The proposed way to take PPGHO out of loss without expecting a price increase in the long term is to introduce uninhabited technologies, which will reduce the costs of radiation protection, ventilation, and tunneling. On the other hand, the highest added value of products manufactured by Rosatom State Corporation is formed at such stages of the NFC as nuclear fuel and electricity production. Even if there is a loss-making mining division, the profitability of sales (in net profit) of the entire state corporation amounted to 20.05% (2018), which indicates the effectiveness of the implementation of the nuclear fuel complex of Rosatom State Corporation [17].

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APPROACH TO ASSESSMENT THE SUSTAINABILITY OF ARCTIC LNG PROJECTS

Today the sustainable development of the Arctic zone of the Russian Federation is a significant vector of state policy [1]. Among the fundamental tasks are the socio-economic development of the Arctic territories, effective reproduction and rational use of natural resources, and innovative and technological development of industrial systems [2].

The main mechanism for solving these tasks is the implementation of major investment projects. Thus, the implementation of large-scale Arctic LNG projects opens up wide opportunities for using the mineral resource potential of the region with a course for comprehensive infrastructure development of remote Northern territories, inter-industry interaction, and the development of science and technology [3,4].

Sustainable development of the system is associated with its ability to create economic, social and environmental results that meet the interests of stakeholders under existing restrictions [5]. For large-scale LNG projects, the list of expectations of stakeholders is quite wide. This determines the number of possible effects that characterize its significance for the region, industry, and national economy as a whole.

In the course of the research, it was found that the unification of approaches to assessing sustainability at the level of companies and projects is impossible, since project activities have their own specifics in relation to the operating one. The potential for creating results in the company's operational and project activities is also different, as stakeholders and their interests in relation to the company and the project may differ. In addition, the project may involve external participants who create the uniqueness of the asset.

The list of project sustainability indicators cannot be unified, since it is determined by the actual needs of the external and internal environment of the project. The algorithm for assessing sustainability should include an analytical phase that forms a list of promising project results.

The result of this research is a system of indicators for the sustainability of Arctic LNG projects, developed on the basis of strategic priorities for the development of the Arctic region, the gas industry and the subsoil user. The system includes economic, social and environmental groups of indicators, each of which is assigned a weight based on expert assessments and the principle of balance of each of these areas.

The proposed method was tested on calculating the integral stability indicator for the Yamal LNG, Arctic LNG-2 and Ob LNG projects. It was concluded that it is applicable at any stage of the project, including the pre-project stage.

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MULTIDIMENSIONAL FORECASTING MODEL OF METAL PRICE WITH UNCERTAINTY

For any mining company the most important is economic factor. Exploitation of metal deposits requires certain investments. Whether the mining project will be realized or not, depends on the expected profit, which is directly related to the metal prices on the market. The constant demand of the metals at the market affects the constant growth of their annual production as well as their price fluctuations. These attributes cause the certain variation of the stock levels. The variation of metal prices and stock levels is a complex process that requires a multidimensional approach. Metal prices and the stock levels represent a major sources of uncertainty when profitability of mining projects is assessed, which further implies the importance of applying an adequate analysis to assess the metal prices on the stock market to apply the optimal forecasting model. In this paper, forecasting model is developed based on variation of the zinc price and its stock levels of the past 10 years.

The uncertainty of prices movement on stock exchanges made room for developing many models for forecasting. Soft computing is becoming a powerful tool for analyzing data of all kinds in the mining industry, in this case metal price. Several researches tried to applicate some of the soft computing methods such as neural networks or adaptive neuro – fuzzy inference system and genetic algorithms, in purpose of forecasting metals price [1]. On the other hand, some researches used ARIMA (Autoregressive Integrated Moving Average) forecasting or lagged forward price model [2].

In this paper, multidimensional forecasting model based on combination between fuzzy C – mean clustering algorithm and autoregressive model (AR) has been created. Developed model forecasts a state that the variable will be in the next point, i.e. model does not predict the exact value of the monitored series but rather generates its future states. Fuzzy C – mean clustering algorithm has been applied for united division of the monitored series of the metal prices and stock levels into seven clusters and seven states, respectively [3]. Each state consists of two cluster centers and is described by the corresponding numerical number. Multidimensional forecast of future states is performed by autoregressive model (AR). Autoregressive model is a forecasting model where future values are based on the previous values in time series [4]. During the application of autoregressive, the window size i.e. the order size is of a great importance for the forecasting accuracy and precision. Detailed calculation process of the parameters of the developed model is given in numerical example. It should be noted that the model uses a monthly real i.e. actual data of zinc prices and stock levels.

Multidimensional forecasting model contains two main parts. First part means the analysis of the monitored series of metal prices and stock levels. Application of fuzzy C – mean clustering algorithm is performed united multidimensional analysis of the monitored series and is created seven classes and seven states, respectively. Each state consists of the two dimensions i.e. two cluster centers. The order of the obtained centers is sorted in an ascending order of zinc price. It should be noted that centers of the zinc stock levels are not sorted in ascending order,

but randomly, that corresponds to zinc price order. A corresponding cluster is assigned to each month of the monitored series of the zinc price and zinc stock level, i.e. a membership function to the corresponding state is defined.

The second part is referred on the prediction of created states for the corresponding monitored month. As it mentioned, autoregressive model is a forecasting model where we forecast the future state based on past state in time series. Since the window size i.e. order size has a great impact on forecasting precision, we adopted a several order size from 1 to 10. Obtained results of the statistical analysis shows a positive and acceptable error values for the developed model.

Our developed model is burdened with some uncertainties of the input parameters that largely affects on the efficiency and realization of each mining project. In this paper, zinc price and zinc warehouse stock level are established as a major source of uncertainty. Their visible fluctuations on the month level has significant impact on the final financial result of the mining project. On this way, risks are incorporated in multidimensional forecasting model and the basis is created for the strategic decision making. Also, developed model provides assistance to mining companies to be alive in a risky environment. The model is not closed and can be extended by including the uncertainty related to the input parameters. This uncertainty is of a great importance for the decision maker to obtain more accurate and precise results. Since the crisp values of the input parameters are used, the model extension is related to intervals or fuzzy numbers application.

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WHY MINERS SHOULD HAVE A DEEPER UNDERSTANDING ABOUT THE DOWNSTREAM VALUE CHAIN

Pulverized Coal Injection (PCI) is a method to injecting coal dust directly into a blast furnace (BF), in order to reduce coke consumption. The iron and steel industry started to use PCI in the 1970 as coke became increasingly expensive due the rising in global demand.[1] Miners of coking coal often produce PCI coal as an ash richer by-product, which is sold at a discount. Thereby PCI becomes a competitor to other higher-value coal products produced by the mine potentially leading to a loss of sales income.

The PCI coal is a bituminous thermal coal with a low or high content of volatile matter and a low ash content. The coke replacement ratio varies between 75% for a high-vol and 92% for a low-vol coal. It is dried and ground under an inert atmosphere with a roller mill or a roller ball mill below 1% of total moisture and below 100µm in particle size. It is then transported with pneumatic pipes into a storage silo, further in separate injection silos from where it is injected into the balloon shaped race way of the blast furnace.

The chemistry of the PCI coal slag and the thermodynamic reaction kinetics in the raceway are the most important factors for the injection. Both may cause a lower permeability,

which results in a lower efficiency and the risk of uncontrolled peripheral gas flow in the blast furnace which can cause a heat allocation to the walls and lower the lifetime of those. These phenomena limits PCI rates to lower coke consumption; currently, the median injection rate for BF is approximately 140kg/t of hot metal.

Looking at some technical aspects of PCI coal injection in more detail - first of all, the silica-rich slag has a low viscosity and is also lowering the permeability. Secondly, coal particles must be completely oxidized before reaching the end of the raceway. If we assume the same conditions for the injection and only compare different coals to each other, the most important factor is the caking index of the coal used. The caking index in general is measured with the Free Swelling Index (FSI; a standardized test with a rating from 1 to 9). The caking process can be understood as complex process involving an agglomeration and an expansion of the coal during the coking process in a reducing atmosphere.

After the coal is injected into the BF it goes through various stages, such as devolatization, combustion of the volatile matters (gases and tar) and oxidation whilst enough oxygen is available. The remaining char of coal with a higher FSI agglomerates, as it does in the coke battery, until it is gasified. [2] The agglomerated particles glue the porous structure of the dead man at the end of the race way thereby also lower the permeability.

Most producers of coking coal, as mentioned, produce PCI coal as by-product. This accounts for approximately 7 % of their total production. As already described, such coals are unsuitable for the use of PCI as they share most of the properties of the main products (ash composition, FSI, fluidity mean reflectance, petrography, etc.). Integrated steel mills take advantage of this lack of knowledge and officially buy them for the use as PCI at the price of a PCI coal (which is significant lower) and then blend it in the common coking coal charged in the coke battery.

This leads to a measurable economical damage of coal mines. If we assume a coking coal production of 389 Mt (outside China) in 2019, additional ~27 Mt were produced and sold as PCI coal at an average price of $129 (FOB Australia). Given an average Hard Coking Coal 64 (FOB Australia) price of $158 in 2019, the total difference in cash flow is 783 million $ (without adjustments for the different ash contents).

The example with coal shows that there is a need for miners to understand the processes downstream the value chain and thereby add value not only to their companies, but also to their (exporting) countries. It is clear that the case above will not apply to ever coking coal producer but-with my past experience-to many of them.

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ROLE OF VERTICAL INTEGRATION AND DIVERSIFICATION IN STRATEGIES OF OIL COMPANIES IN CENTRAL AND EASTERN EUROPE

Global oil companies are facing increased challenges due to fast-changing energy environment. Apart from traditional challenges, such as new sources of growth, volatility of oil prices, pressure on the improvement of oil technology and limited availability of oil and gas reserves, they are facing now some new challenges such as energy transition – a gradual shift from hydrocarbons and nuclear energy to renewable energy (transition from oil companies to diversified energy companies). From the point of view of oil companies from Central and Eastern Europe (CEE) strategic dilemma is how to balance their medium-term portfolio. On the one hand, they are facing limited possibilities for development of local upstream segment

because the region is relatively poor in oil and gas reserves, while, on the other hand, energy transition is spurred by global (the Paris Agreement), regional (legislation of the European Union in the area of green energy) and local regulation (for example, feed-in tariffs and other forms of incentives for production and consumption of energy from renewable sources). In the strategic terms, the formulation of an adequate product portfolio in the future is one of the most important tasks and more and more oil companies stress this in their official documents. Their possibilities lie down between oil upstream and downstream, on the one side, and other products such as: gas, petrochemicals, electricity and renewables (electricity from renewables and biofuels), on the other. In other world, the important question is whether to diversify and/or vertically integrate and, if yes, to which extent.

The goal of the research is to analyse key responses of oil companies in CEE to the above-mentioned challenges, to figure out what are their strategies to diversification and vertical integration (DVI) and what are their financial results and investments trends. In particular, we answer to the following questions: (1) what are the strategic trends related to DVI in the strategies of CEE oil companies? (2) What is the degree of DIV of CEE oil companies? (3) In particular, to what extent do oil companies rely on renewable energy sources (RES)? (4) what the results / profitability of CEE oil companies and how DVI affect them?

The research sample consists of eight companies from Central and Eastern Europe ("CEE"): PKN Orlen (Poland), OMV (Austria), MOL (Hungary), Hellenic Petroleum (Greece), OMV Petrom (Romania), INA (Croatia), Petrol (Slovenia) and NIS (Serbia). Companies are important market players in 12 countries: Poland (PKN Orlen), Czech Re-public (PKN Orlen through the Unipetrol affiliate company), Slovakia (PKN through the Unipetrol affiliated company and MOL through the Slovnaft affiliated company), Lithua-nia (PKN Orlen through its affiliated company Orlen Lietua, formerly Mažeiku Nafta), Austria (OMV), Hungary (MOL), Slovenia (Petrol), Croatia (INA), Romania (OMV Petrom), Greece (Hellenic Petroleum), Serbia (NIS) and Bosnia and Herzegovina (INA) , NIS, OMV), and these countries cover 89% of the CEE region in terms of population. Key methods that we used are: descriptive statistics, comparative analysis (we compare CEE companies between each other, and as a group to six global majors: Royal Dutch Shell, British Petroleum, ExonMobile, Chevron, Total and ENI) and econometrics. To understand the role of diversification and vertical integration, we analyzed seven business segments of all companies separately: oil upstream, oil refining, gas, petrochemicals, retail trade, electricity generation and electricity generation from renewable sources. By using a modified version of Herfindahl-Hirschman Index, we calculated the index of vertical integration and diversification based on sales of a particular business segment as % of total sales, with total sales including both external and internal sales. In order to test the importance of specific business segments and the level of diversification for profitability, an econometric model was formulated, where the dependent variable was ROACE, while the independent variables were gas production, sales of petrochemicals and petrochemicals. The econometric model was made based on the results for 2018, because: 1) that year oil prices were at the average level for the period 2013-2018, and 2) some companies underwent a restructuring process, and we assumed that they were all in 2018 at the best level of efficiency.

We showed that CEE oil companies pursue different strategies in terms of the depth of vertical integration and the degree of diversification (there is no one-size-fits-all approach), but in general they are increasing activities in to gas, petrochemicals and electricity. Strategic directions are from transition from oil to chemical companies, to balancing between oil and gas to, being pure oil upstream and downstream company. Our research indicates that so far activities of CEE oil companies in renewables have been relatively weak, but, under the assumptions that announced projects are realized, (1) level of investment in renewables of CEE companies in the future will be relatively significant, (2) there are strong differences among CEE oil companies in terms of the significance of renewable productions, (3) those oil companies with relatively weak upstream (crude oil reserves and production) are more interested in

renewables and (4) production of electricity from wind and solar dominates the renewable activities of CEE oil companies.

Econometric results revealed statistical significance of gas production and sales of petroleum products on profitability, while the level of diversification and vertical integration did not show strong statistical significance. One of the reasons for this it that policies of diversification and vertical integration are still at an early stage and their results are yet to be seen.

Analysis of profitability and investments trends in the period 2008-2019 showed that: (1) during the period CEE oil companies increased profitability, (2) in the second sub-period (2015-2019), when oil price was lower, ROACE of CEE oil companies exceeded ROACE of global major oil and gas companies, (3) during the second sub-period investment activity continued to be relatively high and (4) oil price affect to a lesser extent profitability and investment activities of CEE oil companies than major oil and gas companies. We also showed that the upstream segment is less important for CEE oil companies than for major oil companies and the contribution of upstream segment to profitability of companies was reduced during the period of lower oil prices.

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THE IMPACT OF THE DEVELOPMENT OF CIRCULAR ECONOMY ON THE REQUIREMENT FOR LABOR RESOURCES AND THEIR INTER-BRANCH MOBILITY

The national strategy for sustainable socio-economic development of the Republic of Belarus for the period until 2030, the strategic goal of improving the distribution of productive forces defines the rise of production efficiency, to the requirement of a green and circular energy-efficient economy.

In the modern stage, many Belarusian scientists, as well as scientists from neighboring countries, are studying the issues of energy efficiency, energy saving and processing of resources: T. G. Pospelova, T. Kh. Gulbrandsen, L. P. Padalko, V. L. Chervinsky, V. L Ganja, I.V. Galuzo, I.N. Potapov, V.A. Baidakov, V.V. Efremov, G.Z. Markman, I.A. Bashmakov, R.F. Araslanov, A.A. Tupikina , A.S. Gorshkov, A.A. Gladkikh,etc.

The economy of closed cycle (circular economy, circular economy) is the main component of the sustainable development of modern Belarus and the green economy. in this regard , once the created value is stored in the economy for the longest possible time. The focus is on all phases of the product life cycle: product design, raw material extraction, production,

marketing, use and waste management. The closed cycle can be at different levels: energy, raw materials, whole products, individual components, which means the emergence of new jobs in the country and the improvement of obsolete professions into new “green” jobs. It is also important is the re-qualification of the country's labor resources and the intersectoral movement in the context of the development of a circular economy. Modernity and high earnings and demand for such personnel in the labor market can lead to a decrease in the external and internal migration of citizens of the Republic of Belarus.

No more than 30% of industrial enterprises use secondary raw materials, and the use of waste in industry does not depend on the form of ownership. Barriers to more use of waste: 1. the lack of processing technologies, 2. economic impracticability, 3. reducing the quality of products when using secondary raw materials. 4. lack of the necessary legal framework regulating relations in the field of waste. 5. lack of specialists in the field of circular and" green " economy, as well as intersectoral specialists in the Republic of Belarus, who solve the previous points of barriers to the rapid development of the closed-loop economy at a high professional level.

At the moment, there are already: the National Strategy for Sustainable Development, the National Strategy for the Management of Solid Municipal Waste and Secondary Material Resources and Directive No. 7, which contributes to the development of a circular economy.

The introduction of a circular economy is also beneficial because the policy of the European Commission is aimed at tightening product requirements: standards should be increased in terms of service life and maintainability. By 2030, only products suitable for recycling should remain in circulation on the domestic market, and the share of secondary polymers in the composition of plastic containers for beverages should reach 25% by 2025 and 30% by 2029. This is an important argument for those wishing to export their products to EU And this requires the presence of personnel who can carry out all stages of processing at the highest professional level.

The concept of a circular economy is enshrined in a number of national legal documents: National Strategy for the Management of Secondary Raw Materials until 2035, NSUR-2035, NSUR-2030, Presidential Decree No. 313, (Directive No. 7). The key elements are a five-step hierarchy of priorities in waste management and the principle of extended producer responsibility. In order to introduce a circular economy, it is necessary to give knowledge and competencies to employees of administrations, enterprise managers and future labor resources of the country, focusing on the prevention of waste generation, optimization of waste management, as well as preventing the migration of personnel abroad and complete urbanization in the country, which is relevant at the present stage of development country.

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CRITERIA FOR EVALUATING AND WAYS TO INCREASE ENERGY EFFICIENCY OF BELARUSIAN ECONOMY

The relevance of the problem of ensuring energy efficiency of the economy is due to both the specific conditions of functioning of any economic system, the features of the functioning and development of the energy sector, and the current trends in the development of the world economy against the backdrop of global fuel and energy and environmental problems. Energy efficiency is becoming an increasingly important policy priority in many countries of the world. It is widely recognized that it is the most economical and affordable way to address many of the problems of energy supply, including energy security, the socio-economic consequences of high energy prices and concerns about climate change. At the same time, energy efficiency enhances competitiveness and contributes to the well-being of consumers. [1]. Due to the high degree of relevance, the problem of improving energy efficiency is studied by different scientists, research teams of Russian scientists: I.A. Bashmakova, V.I. Danilova-Danilyana, K.S. Losev, I.E. Reif, S.N. Bobyleva, V.M. Zakharova, D.Yu. Savon, G.E. Kudinova et al. The Institute of Oil and Gas of the Russian Academy of Sciences, the Institute for Sustainable Development of the Public Chamber of the Russian Federation, the Center for Environmental Policy of Russia, the Russian Center for Energy Efficiency and other organizations are developing the indicator system and evaluating energy efficiency. A number of scientists are developing the theory and methodology for ensuring energy efficiency in the Belarusian economy: I.A. Bokun, A.A. Bykov, V.N. Ermashkevich, A.M. Zaborovsky, T.G. Zorina, A.A. Mikhalevich, M.V. Myasnikovich, V.N. Nagornov, L.P. Padalko, T.V. Romankova, B.I. Rubenchik, N.A. Smolskaya, A.G. Tabolov, V.I. Trutaev, L.V. Shenets, V.N. Shimov, O.S. Shimova, N.A. Khaustovich and others. The results of studies conducted by the World Bank, the United Nations Development Program and other international organizations have great practical and scientific importance.

In accordance with the National Security Concept of the Republic of Belarus, the main potential or real threats at the national level is the impossibility of guaranteed supply of raw materials and energy in the volumes that ensure the intended GDP growth; the lag in the pace of transition of the economy to advanced technological structures from other states, the degradation of the technological structure of the real sector of the economy; lack of competitiveness of the economy of the Republic of Belarus and other factors. In the economic sphere, the main national interests of the Republic of Belarus are economic growth and increased competitiveness based on its structural adjustment, sustainable innovative development, investment in human capital, modernization of economic relations, cost reduction, import and material consumption of manufactured products; achieving a level of energy security sufficient to neutralize the external dependence on the receipt of energy, etc. [2]. The transition to the construction of energy-efficient buildings and structures in the Republic of Belarus is currently difficult. This is due to the fact that the regulatory framework on this issue is not developed sufficiently. Thus, the energy sector both for the Republic of Belarus and for many countries of the world is key from the point of view of economic and national security and allows us to attribute energy efficiency to factors of economic growth.

We have identified the relationship of concepts and conducted a theoretical and methodological analysis in the field of energy conservation and energy efficiency, which allows

us to identify the most significant criteria for assessing the energy efficiency of the country's economy. The existing system of indicators for analysis and evaluation does not ensure the reliability of the results, which significantly distorts the conclusions in the context of country and regional comparisons. The system of indicators that we propose makes it possible to most adequately and accurately obtain and compare the results of the assessment with the maximum possibilities and ways of ensuring energy conservation and energy efficiency in the economy of the Republic of Belarus.

In 2020, a nuclear power plant is going to be launched in the Republic of Belarus, which will allow to overcome the low level of energy independence of the country, as well as solve a number of issues in the field of advanced economic and legal issues of energy development, in particular, ways to develop green investments in various types of electric vehicles. This area of economic development allows us not only to provide ways of increasing energy efficiency, but also to solve the problems of reducing the environmental burden, which corresponds to global trends in the sustainable development of the state.

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OPTIMAL SUBSEA PRODUCTION SYSTEM SELECTION METHOD BASED ON IMPROVED MANAGEMENT APPROACH TO OIL AND GAS FIELDS DEVELOPMENT PROJECTS

In the Russian Federation one of the promising directions in engineering and technology for the development of offshore oil and gas fields is the use of subsea hydrocarbon production systems. A proposal has been developed to improve the management of oil and gas fields development projects by using subsea production systems, which consists in introducing the developed software product at the preliminary stages of planning, which will allow, after geological exploration and the discovery of industrial oil and gas resources, to optimize the planning process and to make the right choice for installing the appropriate type of subsea production system in accordance with considered factors, on the basis of which the algorithm of the program was built. Furthermore, saving time and cost at the preliminary stages of planning will have a kind of cumulative effect at further implementation stages of the project. It will also allow to make managerial decisions more quickly and to increase the efficiency of operations, and this, in turn, will contribute to better adherence to schedules at further stages of the project development. In total, 83 sources of literature on this issue were studied.

Today the subsea production complex is a combination of subsea equipment located on the bottom of the sea, and designed for extraction, preparation and transport of hydrocarbons from wells to the point of connection with the production pipeline [1]. Subsea production systems can vary from a single well to several wells on the bottom plate or grouped near the manifold. The research considers four main types of subsea production systems. The main factors that influence on the choice of one of the 4 types of subsea production systems were selected by using

standardized interview method. On the example of such Norwegian fields as Snohvit and Ormen Lange, where subsea hydrocarbon production systems are successfully used [2], as well as information from a number of international engineering and production companies such as Aker Solutions (Norway), General Electric (USA) and FMC Kongsberg Subsea AS (Norway), which specialize in supply and installation of subsea production systems, an analysis was carried out that allowed us to assign certain values of factors considered in the research to each of the 4 types of systems, and based on the obtained data create an algorithm for the software product.

The main objective of introducing of the software product is to reduce time and cost at the preliminary stages of planning, so it is proposed to slightly change the approach to managing subsea hydrocarbon production system projects, namely to use the developed program before the planning process begin. The most common problem in project management is the lack of clear distribution of responsibilities in making strategic and operational decisions at each stage. This may keep with great uncertainty of the initial data of the field, which will require a lot of time for the development of project documentation, as a result, a longer process of determining further action program at the subsequent stages of project implementation [3]. Thus, the proposed approach will allow not only to avoid possible errors when choosing an inappropriate type of subsea production system for the field, but also to reduce time for further work at the subsequent stages of project development.

In conclusion, in the research the main types of subsea production systems were investigated and based on interviewing method, a number of factors that have the greatest impact on installation and operation of subsea production systems, were identified. The developed software product helps to select the appropriate type of subsea production system depending on the geological structure of the formation, the depth, size of the field and other factors considered in the research. A proposal for improving integrated project management by using subsea production systems has been developed, which may be found in introducing a software product at the preliminary stages of planning, that will allow to increase the efficiency of ongoing operations. In addition, this will allow to avoid possible risks when choosing an inappropriate type of subsea production system and correctly to develop a project plan, including the content, timing, cost and ongoing work. Finally, this software product will help to optimize the planning process, timely predict possible risks and make the right choice for the installing of the optimal type of subsea production system, as well as saving costs and time at the preliminary stages of planning.

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TRAINING OF LABOR RESOURCES IN THE MINING SECTOR: PROBLEMS AND SOLUTIONS

Balanced use and reproduction of mineral resources create objective prerequisites for sustainable economic growth. Mining enterprises are considered as a driver of the socio-economic development of regions which potential depends on the mineral resources available on their territory. One of the most important conditions of the effective functioning of the mineral

sector is to provide it with highly qualified labor force. Nowadays not only single enterprises and industries but the whole states compete for the right to possess a highly skilled staff.

At the current stage of social development, which is called the economics of risks, we can observe a critical increase in the different kinds of uncertainty such as financial, political, economic, technical and technological [1]. This factor, ongoing globalization processes, the rapid pace of technological progress make constantly growing demands for the quality of personnel training, its receptivity to the innovative solutions. In this way, the relevance of the chosen topic is the necessity of mining enterprises to possess competent specialists.

At the present stage, a geological industry is experiencing a number of staffing problems. First of all, they include a decline in the prestige of the engineering specialties. This issue stems from a high technogenic danger of the job. Secondly, there is an increase in the average age of the employed in this sphere. In the Republic of Belarus the share of highly competent specialists under the age of 45 is less than 20 % of the total number. About 80 % of the specialists who are able to perform managerial functions are retirees [2]. Thirdly, the outflow of personnel is constantly increasing. On the one hand, the reason for this process is internal migration. Internal migration implies a transition of the staff from their profession to another area of activity. This process is caused by the dissatisfaction with work conditions, a weak system of young specialists' retention. On the other hand, the outflow of personnel is due to the brain drain that represents highly skilled staff travel abroad for permanent employment. At the same time, the outflow of intellectual capital is indirectly associated with academic mobility, since some students who graduate from universities abroad decide to stay there for permanent residence. Fourthly, some difficulties are related to the lack of educational programs that meet modern requirements, the discrepancy of the range of specialties to the real needs of the mining industry.

One of the possible solutions to current personnel issues is to take comprehensive measures aimed at the improvement of existing vocational training and retraining system, optimization of educational centers placement. Young specialists should not only have fundamental knowledge in the chosen professional field but be able to apply put this knowledge into practice. It means awareness of up-to-date methods and technologies, skills to cope with specific production problems individually. Therefore, it is reasonable to involve specialists of the mineral resources sector in the development of educational standards. One more effective decision is to create in-house training centers on the basis of large mining enterprises. Such steps help to increase the share of practical components in the training process. Belarusian leader in the sphere of potassium salt extraction «Belaruskali» attaches great importance to the competence of its personnel. That's why the department of training, retraining and raising staff skills has been set up. This department is active in the development of relevant educational programs, application of new studying forms such as training sessions, workshops, round-table discussions on actual topics, seminars. In 2019, 6779 employees of «Belaruskali» passed vocational training [3].

Also, it is important to emphasize the role of cooperation and partnership between universities and enterprises. It has lots of benefits for both sides. On the one hand, enterprises have a good opportunity to carry out different university-based applied researches, thus building up own innovation potential. On the other hand, universities can attract research funding and commercialize successful results. So it is necessary to «nurture» specialists for innovative activity in the field of knowledge-intensive technologies. Besides, it would be useful to organize a scientific examination of the mining industry workers' level of competence and comprehensive monitoring of labor resources aimed at obtaining reliable personnel information.

One of the most important conditions for accelerating the implementation of innovative technologies and improving the competitiveness of mineral resources industry products is the development of professional education. Skilled engineering personnel should be considered as a factor which ensures innovative economic functioning of enterprises, stable industry development, as well as the competitiveness of the whole national economy.

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BUILDING A RATING OF COUNTRIES WITH A RESOURCE-ORIENTED ECONOMY BASED ON THE AGGREGATED INDICATORS OF SUSTAINABLE DEVELOPMENT

Nowadays there is an acute problem of ensuring the universal well-being of humankind, based on the principles of sustainability. It, in turn, raises the problem of assessing sustainable development: the use of adequate methods and indicators for assessing sustainable development (SD) in countries with different levels of economic development and various human, natural, financial and material resources that determine the possibilities and directions of development for one or another country. [1]

The purpose of the study is the analysis of existing methods and indicators of assessment.

The research objectives included selection of resource-oriented countries, selection of the most common, significant and generally, accessible methods and indicators for assessing SD, ranking groups of countries based on selected indices, analysis of the data obtained. [2]

The choice of resource-oriented countries as objects, including Russia, is explained by the high dependence of economies on mineral resources and the fact that these countries bear a serious environmental burden compared with countries consuming mineral resources. In addition to Russia, the objects of the study included countries of the Eurasian continent: Azerbaijan, Mongolia, Kazakhstan, the Republic of Kyrgyzstan, Laos, Norway, Uzbekistan, and Turkmenistan.

The research methodology consisted in the selection of indicators characterizing sustainable development in the economic, social and environmental aspects, ranking countries and obtaining a total rating for each country. [3]

The result - the rating of countries showed that the highest score in assessing SD belongs to Norway, a country with a high level of economic development, followed by countries with a level of economic development above the average - Russia and Kazakhstan, then - countries with an average level of economic development - Mongolia. The remaining countries did not have a range of data on the indicators analyzed. [4]

Thus, despite a significant number of indicators for assessing SD, today there is no single method capable of assessing the level of sustainable development of a country; in addition, the problem is the lack and inaccessibility of information and the inability to reflect the industry specifics of countries.

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ANALYSIS OF PSC GROSS SPLIT APPLICATION POSSIBILITIES IN RUSSIAN OFFSHORE

KEYWORDS: Production Sharing Contract (PSC), Cost-recovery (CR), Gross Split (GS), Host-Government (HG), International Oil Company (IOC), oil and gas (o&g), Operation Expenditure (OPEX).

In the last ten years, there've been various problems in the o&g business faced by HGs around the World. A familiar matter is the long though discussion about Plan of Development (POD) between IOC and HG which leads to the delay of production period. In some cases, HG's income is lower than OPEX. These issues are closely related to old contracts that are no longer applicable in the current situation. Therefore, HG should be more careful in selecting the future contracts. For instance, in Indonesia. After considering low level income by applying PSC Cost Recovery since 1970 and the incompatibility of existing contract types, Indonesia recently designed a new concept "PSC Gross split scheme", which is until now considered attractive to Investors and has been signed for 39 working areas since the date it came into force in January 2017. The main differences of this hybrid of PSC and concession from others are as follows: split starts from gross revenue; IOC takes 100% responsibility of E&P cost; and HG can increase/decrease IOC's share by assessing variable (every POD) and progressive components (monthly), design of which is based on existing o&g fields calibration. Overall, this scheme is believed to offer best approaches in ensuring certainty, efficiency and simplicity in the world o&g business.

The goal of this study is to comprehensively show to what extent PSC Gross Split Scheme can fairly meet business interests of HG and IOC. This paper seeks to present a mapping of comparisons, opportunities and challenges in the GSS implementation. This paper, most of all, focuses on adjusting-split components and tax mechanism. This paper is based on both qualitative and quantitative comparative analysis methods of gov. documents, companies' outlooks, statistics and academic literatures.

As a greatest country in the world based on recoverable o&g reserves, Russia should implement Gross Split Scheme as an alternative contract to optimally explore and extract hydrocarbon in its offshore. In another side, having traumatic problems with Cost Recovery Scheme last two decades and continuous changes in Russian tax mechanism lead to the main challenge in accepting new offer of PSC's scheme, though GS may able to increase Russian fiscal attractiveness. In case GS becomes acceptable, the next challenge is the adaptation process in both sides, HG and IOC. Based on technical and economic characters of this country, authors found some adjustments in determining base split, parameters and splits of incentive components as well as in taxation. This paper not only describes gross split scheme, but also discusses comparisons, opportunities, problems and challenges of its application. Regarding that, it's

believed that Indonesian PSC “Gross Split” has precise ingredients to bring about healthy, fair and sustainable business corporations in Russian offshore.

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SOCIO-ECONOMIC ASPECTS OF THE ENERGY SECTOR DEVELOPMENT THE ARCTIC ZONE

Every year, the role of the energy industry in people's lives continues to grow. The economy of the Russian Federation, along with the economy of the entire world, directly depends on the state of the hydrocarbon market, despite the fact that a lot of effort is spent on its diversification. Every year more and more new fields are being developed, but the number of those that are running out is much higher. Explored sources are no longer useful, and people begin to look for new places and sources of fuel located in harsh conditions for development. One of these areas has become the Arctic Zone. The area of the Russian sector of the Arctic shelf within the borders established by international agreements currently amounts to 4.1 million square kilometers. This is a huge space, comparable to the size of the European Union. Potentially oil and gas-bearing territories make up almost half of this area. The resources of the Russian Arctic Zone currently amount to approximately 511 billion tons of the oil equivalent. This is approximately 65% of the world's potential hydrocarbon resources, or about 2/3 (two thirds) of all reserves currently being developed in the world. The basis of our country's current policy in the Arctic region is the “The Strategy for the Development of the Arctic Zone of the Russian Federation and National Security up to 2020” [1].

The following aspects are presented in the Strategy as the priority areas for the development of the Arctic zone and ensuring national security: integrated socio-economic development of the Arctic zone of the Russian Federation; the development of science and technology; the establishment of a modern information and telecommunications infrastructure; environmental security; international cooperation in the Arctic; provision of military security and protection, and protection of the state border of the Russian Federation in the Arctic [2]. Thus, according to the document, among the main national interests of the Russian Federation in the Arctic is the use of the Russian Arctic zone as part of the strategic resource base of the Russian Federation which ensures the resolution of issues of socio-economic development of the state as well as the use of the Northern Sea Route as a national unified transport communication of the Russian Federation in the Arctic. But at the end of 2019, the Ministry for the Development of the Russian Far East and Arctic has already completed the preparation of a draft Strategy for the development of the Russian Arctic zone until 2035. The document was developed with the broad participation of representatives of the scientific community, regional authorities, civil society, and experts [3]. Today, the main mechanism of Russia's policy in the development of the Arctic zone of the Russian Federation is the supporting development zones in the Arctic, which are complex projects of socio-economic development and imply the use of certain mechanisms for implementing investment projects, including on the principles of public-private partnership [4].

In order to implement plans for the development of the Arctic, it is necessary to achieve an acceptable level of returns on the capital invested in a huge amount. We believe that this is only possible in integrated projects with a long lifecycle. Such projects require the creation of certain investment conditions – the incentives. The development of the Arctic Zone is also a major infrastructure project that will affect not only the oil market, but also provide a multiplier effect for the entire Russian economy. According to experts, it may exceed 30 trillion rubles by 2038, which is essential to stimulate the economic growth of Russian society. In the North,

people face problems not only of a technical nature, but also of a social one. Not every employee is ready to face a challenge in the context of the Arctic Circle. The situation of single-industry towns in the Far North raises concerns for the reason of extremely difficult economic and social situation, such as the cities of Vorkuta and Inta shows. These were thriving cities with many city-forming enterprises as well as high earnings and living standards. Now the most important social problems that are inextricably linked to the economic development of the Arctic zone, we emphasize: intensive depopulation, outflow of qualified personnel, low internal and external transport accessibility, poor road conditions, the threat of mass migration of residents to the southern territories due to earnings equalization with the rest of the territory, inefficiency and discomfort of urban space, which also leads to the population exodus.

Thus, as a solution of majority of the acutest socio-economic problems of the development of the Arctic zone, the need to support small and medium enterprises, as well as stimulating cooperation between small and large businesses, was highlighted. Solely large corporations are not able to solve the socio-economic problems of the region alone, because small businesses are more responsive to market changes and more resistant to crises. That kind of small and large business interaction will have a beneficial effect on the socio-economic situation of the region: cooperation in the development and use of local sources of raw materials and waste treatment; innovation-related collaboration (implementation in small businesses and independent inventors); small-scale energy supply; tourism; livestock farms [5].

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HEDGING RISKS OF EXPORT-IMPORT OPERATIONS OF ENTERPRISES IN THE REAL SECTOR OF THE ECONOMY

Corporate sector development largely determines the development of the country's economy. By generating GDP, enterprises provide with domestic and external demand for goods and services. The country's export volume determines the availability of demand and competitiveness of exported products. The ratio of exports and imports indicates the degree of openness of the economy. For the development of the real sector of the economy and strategically important industries, state support measures are being taken in the form of subsidies, guarantees, and preferential tax treatment. Indicators of the state of the country's economy can include indicators of inflation, the key rate of the Bank of Russia, the RTS and Moscow exchange indices, as well as the number of participants in the corporate sector and their bankruptcies. In the circumstances, due to the epidemiological situation and restrictions imposed, there is a decrease in both demand for goods and services and business activity. Business development is also negatively affected by both internal credit risks associated with the actions of counterparties, and external negative influences can be political, environmental, and exogenous factors. To reduce credit risk and prevent an increase in the volume of accounts receivable, it is advisable to use financial instruments. Negative consequences for small and medium-sized businesses may threaten not only to reduce revenue, but also to be unable to be liable for debts in the future. For large business companies, this threat is also relevant, especially in terms of non-receipt of amounts under contracts due to the bankruptcy of contractors.

The purpose of the research is to find solutions that help minimize risks for maintaining and developing the country's foreign trade activity in conditions of uncertainty. In 2019, the volume of trade turnover amounted to 666.6 billion US dollars [1]. There was a decrease in trade turnover by 3.13% or 21.6 billion US dollars compared to 2018. The volume of exports decreased by 6.04% in 2019 compared to 2018 and amounted to 422.8 billion rubles. The volume of imports had a positive trend and in 2019 amounted to 5.6 billion US dollars, which is 2.36% more than in 2018. Russia's trade balance in 2019 was positive and amounted to about 179 billion US dollars. This figure is 15.49% less than in 2018. In April 2020, the volume of nominal GDP (6.3 trillion rubles) decreased by 28% compared to the corresponding period of 2019 according to the report of the Ministry of Finance[2]. The reason for the fall in GDP may be the introduction of measures to combat the coronavirus pandemic, the announcement of a period of non-working days and a sharp decline in oil prices – 18.2 dollars per barrel. Since 2018, we can observe a downward trend in the number of corporate clients bankruptcies.in 2019, the trend also continues, the number of bankruptcies decreased by 5.6%[3]. However, in comparison with the pre-crisis period of 2013, the figure for 2019 is 15% higher.

Companies need to develop their own strategies for working with contractors. To reduce the risks associated with foreign trade contracts, it is necessary to regularly monitor and rank contracts by payment terms and develop methods for determining and reviewing shipment limits. It is also possible to encourage early repayment of debt under the agreement if you show loyalty to the buyer, in terms of providing a discount for early payment. Regular monitoring of counterparty solvency and determining the deferred payment period will reduce credit risk.

To work with the collection of overdue debts, you can create an internal division, and the employees of the Department must be motivated to conduct effective work. The issue of collecting overdue debt can be resolved through insurance or factoring services. A preventive measure to avoid credit risk can be the use of a documentary letter of credit as for payments.

The development of foreign economic relations between countries requires building a reliable system of relationships. Well-built logistics chains, the procedure for concluding and executing contracts contributes to effective trade cooperation between companies. However, negative changes in the economy can contribute to the implementation of corporate sector risks, in particular, reduced solvency and bankruptcy. If a contract is concluded on deferred payment terms, minimizing these risks is particularly relevant.

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INCREASE OF PRODUCT COSTS MANAGING ON CLOSED JOINT STOCK COMPANY «SOLIGORSK INSTITUTE FOR RESOURCE SAVING PROBLEMS WITH PILOT PRODUCTION»

Product costs reflect enterprise costs, connected with production and distribution of goods in monetary terms. That is why costs reduction is one of the main issues the enterprise has to solve in order to ensure the competitiveness of the product. Closed joint stock company (CJSC) «Soligorsk Institute for Resource Saving Problems with Pilot Production» is huge Belarussian research and production enterprise in the field of development and production of mining, mining-chemical, lifting-and-transport, earth-moving, drilling and special equipment, storage and handling facilities, and also resource saving systems of potassium deposits development and geological explorations.

CJSC «Soligorsk Institute for Resource Saving Problems with Pilot Production» uses mixed strategy of resource managing with predominance of intensive approach. In 2018 growth indices of quantity indicators are higher than those indices of qualitative indicators of most of the resources supposedly because of introducing new equipment into an operation. But this also causes unit production cost increase, that shows lack of economy, which could be reached as a result of more effective use of productive resources.

Comparative analysis of product costs and production volume provides an opportunity to find out proportionate growth of those indicators in 2017. Production volume increase naturally led to product costs increase. Also it led to unit production cost decrease, so enterprise activity during this period can be characterized positively. Nevertheless, despite of the fact, that in 2018 production volume reduced significantly which shows decrease of enterprise activity effectiveness, unit product cost increased during that period. Its value even exceeded the value of unit product cost of 2016, before it decreased because of scale. Therefore, huge necessity of costs verification improvement and finding out the opportunities of production costs reducing appears at the enterprise. A positive trend in product costs dynamic is reduction of material consumption of production. In 2018, despite the fact that unit product cost increased in general, material consumption value was lower than in 2016. The value of material consumption was 0,52. In 2018 share of labor costs increased significantly. The changes accounted to 2215, 61 thousand Belarussian roubles or 5,55%. Also increase of 3,65% of depreciation charge share, connected with fixed assets purchasing affected on unit production costs increase. In 2017 and 2018 в 2017 и 2018 enterprise received and introduced into an operation fixed assets amounting to 7923,89 thousand Belarussian roubles and to 5332,70 thousand Belarussian roubles respectively. At the same time the dynamic of capital productivity is negative. In 2018 its value

was only 1,99 while in 2016 it was 3,73. Thus, production and distribution volumes reduce while production capacity and labor costs increase. That means that productivity decreases and production capacities aren't fully used. Those lead to capital productivity and labour costs productivity decrease, unit production cost increase and as a result to profit reduce.

According to the analysis of product costs and general costs on CJSC «Soligorsk Institute for Resource Saving Problems with Pilot Production» and the results which were found out the following conclusions could be made. In order to improve the efficiency of the enterprise activity, namely, reduction of unit product cost and growth of production and distribution volumes it is necessary to improve the efficiency of existing production capacities use. First of all it is necessary to use existing opportunities of profit increase through the growth of product and services distribution volume. Also in order to provide full use of production capacities the opportunity of development of the new activity direction (new product development) should be discussed. Besides, it is necessary to work regularly on the new distribution channels search in order to provide the opportunities of production and distribution volumes.

Analysis of the effectiveness of financial and economic activities of CJSC «Soligorsk Institute for Resource Saving Problems with Pilot Production» let to find out some problems, connected with profitability indicators reduction and high level of internal risks. The solution of those problems could be reached only through the huge cut of production and distribution costs. In order to decrease unit production cost several measures were offered to introduce and their economic efficiency was proved. Predictive profit increase accounts to 14 793,43 thousand Belarussian roubles and net profit increase accounts to 10 200, 05 thousand Belarussian roubles.

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CIRCULAR ECONOMY IN THE CONTEXT OF THE FOURTH INDUSTRIAL REVOLUTION

The world has witnessed three fundamental economic transformations over the past century. Initially was the first industrial revolution then the technological revolution followed by the modern era of globalization. K. Schwab argues that «the fourth industrial revolution will have a profound impact on the structure of the world economy, and if we are to be among its leaders, we must understand the direction in which technological development will take place in the coming»[1, c. 8]. The results that have changed the quality of life of people have negative consequences: depletion of natural capital, widespread poverty, lack of fresh water, food, energy, environmental problems (desertification, climate change, loss of biodiversity). Environmental concerns are now becoming increasingly important, as the traditional global economic model threatens the achievement of the Millennium Development Goals set by UNO. The poor use of wealth can lead to an excess of adequate consumption, which already exceeds the physical boundaries of the planet.

A. V. Volkova emphasizes: "Despite the fact that every year the amount of recycled waste increases, the removal of waste to the landfill remains a common practice for many countries. At the same time, there is a clear correlation between the level of development of the country and waste management. In developed countries, garbage is considered a strategic resource for the production of heat and electricity, metals, plastic, glass and other valuable materials.»[2, c. 22]. The world economy awaits another phase transition. The essence of the circular economy is that almost any resource will be recycled. This will save and generate a large amount of energy. The most important principle of circular economy is to extend the life of things. Such an economy places emphasis on consciousness as well as a thoughtful attitude towards resources and needs. Waste recycling is a tool for building a green economy, that is, the involvement of secondary raw materials in civilian circulation or reuse. A large part of the

consumed resources can replace secondary raw materials, but it will not be possible to fully meet the need for them recycling waste, even with 100% efficiency of processing and collection. Circular economics is characterized by a society in which most waste is treated, an economic system designed to keep products, components and materials in circulation so that maximum possible use is constantly restored, that is resource efficiency and environmental benefits.

The original concept of circular economics was based on the principles of 3Rs: "reduction, reuse, recycling," now the concept is seen more broadly. As K. Schwab put it, the 4th Industrial Revolution "is characterized by a fusion of technologies that erase the line between the physical, digital and biological spheres» [3, c. 63]. That is, in modern times the circular economy is already something known and gaining popularity, characterized by the use of various types of technologies, as well as with the involvement of other spheres. At the beginning of the 20 century it was an innovation and, on the basis that technology was not allowed to be introduced into the usual economy, circular economics was widely and not used. However, there are countries in which it is used little or no, due to insufficient technological equipment.

The circular economy is now becoming not only a fashion destination, but also attracts a large number of representatives of the business environment, and it is also beneficial for the environment. S. N. Sylvestrov in his article gives a good example of the action of the circular economy on the example of the company Puma Corporation "In 2013 the company launched a whole line of certified goods Incyle Trainer (clothing, shoes and accessories), completely decomposable and suitable for recycling, which reduced the environmental burden by 87% compared to conventional goods.»[4, c. 8]. Business processes of circular economy include: use of renewable raw materials, waste processing, secondary use of things, extension of service life of goods, shering services, which prove their economic efficiency. The most important factor that hinders the introduction of business projects of the circular economy is the presence of barriers that restrict access to bank financing and investment, insufficient state support, etc. In this regard, there is a need to develop a common methodological basis for assessing the effectiveness, payback and risks of such projects, taking into account the collateral value of material resources and wastes used in the circular economy, to extend the service life of assets, and to carry out significant awareness-raising activities.

The circular economy is focused not only on the single task of recycling production waste, it is looking for opportunities for innovation at all stages of creating new value, which results not only in good end results, but also in them with lower material, energy and environmental costs.

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CHALLENGES OF HYDROGEN AS A PERSPECTIVE FUEL IN ENERGY TRANSITION

In the world energy industry, the issue of modern energy source that meets the world's requirements for reliability, sustainability and environmental friendliness is acute. As a part of well-established fossil energy sources complex, natural gas is considered such, but it is not without disadvantages inherent in oil and coal, namely carbon dioxide emissions, which oblige to use solutions in the field of CCUS (carbon capture, utilization and storage). The next step, aimed at decarbonizing natural gas use, is to eliminate the carbon component in fuel at all – other words, development of hydrogen as a future energy source.

Hydrogen energy, despite appearing and fading interest to itself over the past seven decades, is currently positioned by international energy organizations (such as IEA and IRENA) as a separate new direction in the renewable energy complex [1]. On an industrial scale, hydrogen is currently produced not for power generation, but for use as a raw material in metallurgy and chemical industry. Most of the hydrogen is produced by coal gasification or natural gas processing, but the share of hydrogen produced by electrolysis is also increasing. Coal gasification, in turn, does not have sufficient environmental friendliness and requires additional costs for CCUS solutions, which makes it unprofitable in relation to even «gray» hydrogen from natural gas without capturing carbon emissions [3].

At the moment, experts identify three key ways to produce clean, «blue» and «green» hydrogen as an energy resource: steam methane reforming (SMR), thermal methane pyrolysis (TMP) and electrolysis of water. SMR is most common way in production of hydrogen, but its key disadvantage concludes in difficulty of capturing carbon dioxide gas. In contrast, when producing with TMP method, carbon is precipitated as a powder or granules, which significantly reduces the cost of CCUS solutions, but this method has not yet been actually introduced into the industry, although key players in the natural gas market (in particular, Gazprom) are actively developing this technology. Electrolysis is promoted by proponents of renewable energy as a solution for storing energy derived from solar and wind power in the context of Power-to-Gas technologies. However, the key issue is the profitability of hydrogen fuel compared to more traditional natural gas in terms of energy generation [5].

To assess this profitability, we can build a model of a plant that uses natural gas both as a source of raw materials (excluding electrolysis) and as a source of energy. Based strictly on the thermodynamic properties of methane (as a key component of natural gas) and hydrogen, we can conclude that the latter has a low efficiency compared to natural gas: 93% for SMR, 48% for TMP and 67% for electrolysis (based on a lower calorific value and in comparison with use of similar natural gas volume spent on production).

Despite the results obtained, the existence of systems for estimating carbon emissions and taxing them hypothetically reduces the relative costs of production and usage hydrogen fuel. The cost effectiveness of hydrogen production and use does not exceed 85% compared to the equivalent volume of natural gas. To increase this value, the following measures are proposed: to expand support for carbon-free projects in relation to hydrogen energy [6], to continue development in the field of production and generation of hydrogen, to develop other methods for obtaining hydrogen.

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IMPACT OF MINING INDUSTRY GROWTH ON MACROECONOMIC INDICATORS OF SUSTAINABLE DEVELOPMENT (ON THE EXAMPLE OF MONGOLIA)

The ideas of sustainable development are becoming more and more widespread recently, which is why many countries and companies have questions about how to assess the correctness and compliance of their actions with this trend. This topic is particularly relevant for countries with resource-based economies. This abstract examines various approaches to this assessment on the example of Mongolia mining industry functioning.

The first step was to consider Mongolia's compliance with the category of countries with a resource-based economy. Basing on the main criteria (more than 10% of GDP from mining revenues; the share of natural resources in exports is more than 40%) [1] and information about the country this fact was confirmed. Also due to the analysis of the resource base and production capacity of the country [2] it was concluded that Mongolia would continue to use the functioning of this sector as a way to develop the economy in the near future.

The second task was to choose a way to assess the impact of the mining industry on the main macroeconomic sustainable development (SD) indicators. Various options for addressing the issue were considered, including the use of multiplicative effect [3] and the use of indicators at the macro level. It was concluded that indicators at the macro level were the optimal method of assessment. The analysis of international methodologies allowed to create a sample of indicators and integrated indices that allows to comprehensively assess the country's achievements in the field of SD.

To identify if there are some dependencies between the development of the mining industry and the country's economy, as well as SD indicators, there was used a correlation analysis based on a previously formed sample. There were obtained interesting results, which

from one point of view, signal the possibility of confirming the hypothesis of work – that functioning of the mining industry can contribute to the development of a country with a resource-based economy in the unity of economic, social and environmental components; but from another point of view once again confirm the existing problematic issue of the absence of a unified generally accepted methodology for assessing SD.

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PROJECT MANAGEMENT MECHANISM DEVELOPMENT AND PROSPECTIVE OF ITS USAGE IN OIL REFINERY INDUSTRY

Project management is an essential part of the activities of managers at various levels. Often, the use of project management tools is associated among managers with the implementation of large-scale projects, however, even in small organizations, the successful implementation of projects is of great importance for development and effective operation. The article tells about the prospective of using project management in the oil refinery industry. Taking into account the all the modern conditions the new mechanism of development and realization of the projects in oil refinery industry has been proposed. Relevance of the research into the peculiarities of project management in the industry of oil refinery is, first of all, conditioned by the necessity of increasing the speed of economic development by applying more effective methods of project management. Problems of project management theory were studied by Russian scientists: V.I. Voropaev, I.I. Mazur, V.D. Shapiro. Project management mechanisms were studied by such scientists as V.N. Burkov, D.A. Novikov, and E.V. Kolosova. However, there are no formal mechanisms to effectively manage projects in the oil refining industry, so this study was conducted. The scientific novelty of this research is that a project management mechanism has been developed in the oil refining industry, which is a matrix with a set of management methods based on the type of project and its stage, as well as the algorithm for using this mechanism.

The oil refinery industry is part of the oil industry that manufactures oil products out of raw materials. These products are used as petroleum, lubricants and electro insulation materials, solvents, road surfaces and petrochemical materials. Oil processing in Russia is carried out by mineral and oil refineries of Russia. The role and purpose of the oil refinery industry is to produce the necessary amount and range high-quality products and raw materials for petrochemical industry. In the oil refinery 37% of the production is the other petroleum products, such as jet fuel, bitumen, petroleum oils, petroleum coke, etc. The petrol rate is only about 24-25%, and fuel oil makes 35-40%. One of the reasons of the outdated capacities is lack of the investment attractiveness to the industry, high taxes and export duties. The fall in export isn't because of the low quality of the Russian oil products, but due to the growing competition in the export markets, increase in the domestic demand in diesel fuel and decrease in export of the black oils. For instance, export in 2010 was at the rate of 130 million tons, while in 2018 the number fell down to 120 million tons. According to the prognosis the number is going to fall even more, and by the 2030 it is expected to be about 82 million tons.

The notion of the project management method is a complex of different techniques and mechanisms applied to the developing project to achieve certain goals. Traditionally any project is divided into four main steps: initiation of a project, planning, implementation and completion of the project. The concept of a project management method includes a combination of various techniques and mechanisms of influence on a developed project to achieve goals. In the classical sense, a project is divided into four main phases: project initiation, planning, execution and completion of a project. Effective project management and project control presupposes systematization of different management tools according to the project realization stage. In this research proposes a matrix of project management, which includes a set of management methods relevant to the project type and its realization stage. The proposed approach to the project management is applied to the creative projects, technical projects, such as research projects, as well as for production processes automation projects and modernization projects.

The correct use of project management tools allows you to optimally use the available resources, take into account project risks, make timely adjustments to the schedule and progress of work, effectively manage conflicts, and expand the experience in implementing projects of various sizes.

There is fairly large number of methods used in practice for selecting projects in project management. The choice of this method depends, first of all, on the type of activity of the organization. Factors contributing to business development can have a strong impact on the form models used to select projects.

Thus, the theoretical significance of the research is to develop a methodology for managing investment projects in the oil refining industry. The practical significance of the research is that the use of the project management mechanism will provide an improvement in the quality of the project, optimize the execution time, and improve the control process.

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THE MATERIAL CRITICALITY OF OIL AND THE PERILS OF THE UNSUSTAINABLE ECONOMICS AT PLAY IN GLOBAL OIL MARKETS: EXPOSITIONS AND BACKSTOP RESOURCES

In December 2019, the Geological Survey of Finland published a report on Oil from the perspective of a Critical Raw Material, warning that the unsustainable economics at play in global oil markets could wreak havoc in the world economy. Just three months apart, the whole world witnessed something similar in the oil markets with the May 20 Futures contract of WTI Crude Oil tanking to a low of negative $37 dollars, a feat that was unimaginable for decades. It was a point in time, when the US had technically run out of storage space, which was a result of excess supply in the oil markets and demand shrinking more than 30% due to the COVID 19 pandemic. Oil is a very important natural resource and perhaps the most important critical material in today’s industrial economy, because the demand for oil is increasing by one million

mbd every year and about 90% of all industrial supply chains depend on oil or its derivatives. There's no other natural resource that quotes so much national importance for all nations alike.

Material criticality of any material can be assessed on the basis of three criteria: supply risk, vulnerability to supply restrictions and environmental implications. Oil perfectly fits in all the three criteria and can be determined as a Critical Raw Material. Oil is susceptible to huge supply risks, because oil production will eventually come to a standstill as it's a highly exploited finite natural resource. Oil is also highly vulnerable to supply restrictions as the OPEC and OPEC+ being the largest producers of oil have a huge sway in deciding supply and output levels in the oil markets to a great extent. Also, oil has huge environmental implications. Classifying Oil as a Critical Material helps us lessen chances of its scarcity or be prepared with backstop resources, minimize any supply risks or restrictions and soften its environmental impact. The above-mentioned critique is the material flow analysis side of the argument that makes oil so important as a natural resource with severe economic ramifications if mismanaged, and the world has seen many instances of it happening since the OPEC Oil Embargo of 1973.

The rate of resource discovery of conventional oil resources has flattened since 2005. For instance, Saudi Arabia increased its rig count by 144% in January 2005, only being able to increase production by 6.5%. Tight oil resources from shale rocks by fracking have managed to fill the annual incremental supply gap since 2005. US shale oil has contributed to about 71.4% of the new global oil supply since 2005. However, increased tight oil supply has come at a massive cost. Between 2010 and 2018, the mean production levels of a fracked well increased by 28%, while water injection increased by over 118%, implying an extraordinary increase in fracking costs. In 2016, the average cash cost per barrel of oil equivalent was about $23.35 for US Shale producers, while it was under $10 for easy-to-extract, surface oil producers in the OPEC. With such a massive cost structure, the US Shale Oil Boom has only been possible because of the prolonged low interest rate environment in the US since the global financial crisis of 2008. Shale companies have taken up massive loads of debt, while production has declined because it's become even harder to extract. And with oil prices at record low levels, most of these producers have negative cashflows and are struggling to raise capital for capex investments, which might eventually take a toll on global oil supply. So, it is highly likely that oil might peak in production over the next two decades, mainly because it might not be economically viable to produce oil anymore. One the one hand, the cost structure might discourage producers from making new investments. On the other hand, the price of oil is in contention. Between $45-$60/bbl, it might not be profitable for producers for long as they might have to borrow more to produce in order to keep up with the costs. At a price around $100/bbl, the global economy might not grow at the current rate or above it as Emerging Market growth engines can come under significant stress.

Therefore, it has become increasingly important to realize the material criticality of oil and the unsustainable economics at play in order to manage such a finite resource well for long-term economic sustenance, as oil is at the center of the global industrial economy today. Alternatively, we need to develop new and existing clean and renewable backstop resources in order to replace oil and its derivatives eventually from all industrial and non-industrial processes. The world's reliance on oil has to be managed and eventually reduced.

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EVALUATING THE POTENTIAL OF ESTONIA AS EUROPEAN REE RECYCLING CAPITAL VIA ESG RISKS ASSESSMENT MODEL

This study evaluated the feasibility of Estonia as viable rare earth elements (REE) recycling hub in Europe via an environmental, social and governance (ESG) risks evaluation model. The REEs are mainly used in magnets, alloys, catalysts, polishing agents, glass, ceramics, batteries and lamp phosphorus. [1] Among the aforementioned applications, the first three has a growing market due to low carbon economy. The consumption of REEs is rising [2] and presently the REEs such as Nd, Eu, Tb, Dy and Y are being identified as more critical. [3] Since REEs to date are not mined in Europe, the REEs recycling, especially from End-of-Life (EoL) products are imperative in Europe. In origin ESG reporting is a tool used by responsible investors to measure company's future performance and identify the places to invest money.[4] In our study we argue that ESG risks assessment model is also suitable for assessing the country's performance for a new business scope, i.e is Estonia suitable country for establishing a potential REEs recycling industry in the EU.

From previous studies, we identified that the top three viable and valuable products for potential recycling of REEs from EoL wastes are permanent magnets, phosphors and NiMH batteries. These products are significantly concentrated with REEs and some of them has high demand in future. [5] The study covered and discussed the history and the state of the art of REEs recycling practices based on the available literatures. Our research found that extraction of individual REEs from EoL wastes is still challenging and novel cost-effective extraction methods are required, what could compete with virgin REEs prices. In addition, other main constraints are the inadequacy EoL waste collection and dismantling infrastructure. [6]

The ESG model highlights the main ESG indicators used in the Estonian context and summarises the main ESG risks associated with the establishment of the European REEs recycling industry in Estonia. For the identification of ESG indicators, the study followed the guideline for the integration of ESG data into corporate performance reporting. [7] Since our investigated subject was country instead of a company, we modified chosen indicators in such a way that they characterize and express the capacity of the Estonian State to establish REEs recycling management. The data collection is mainly carried out from 'Eurostat' database while domestic reports, legislation and statistics, and internationally known indices are also been used. The study has used the most recent published data(s) (since 2016) and compared the Estonian figures to the European average at all applicable places. Some of the past studies and information are also included to better understand the global evolution in this field. We collect the environmental indicators in the field of energy efficiency, GHG emissions, (hazardous) waste produced and recycled, environmental goods and services produced, environmental taxation rate and international indinces expressing environmental performance. From social side we look indicators as health status, education and training, labour costs and earnings, income and social inclusion, social protection, community engagement in large-scale developments and international indinces related with social performance. Looked governance indicators were GDP national statistics, government finance statistics, anti-corruption policy, expenditures to the R&D and usage of ICT, Estonia`s taxation system and international indinces expressing governance performance.

The ESG findings reveal that the country`s environmental burden seems to be reduced due to the decrease of the oil shale industry while switching to renewable energy sources. Thus, have been expected investments increase in environmental goods and services. This all indicates that environmental health in Estonia is good and expected less environmental risks due to the establishment of a REE recycling industry. In view of the social aspects, Estonia has a highly educated and skilled workforce and the education system is of high quality. In addition, people are interested in lifelong learning and upgrading skills, even in older ages. The State's lower average earnings (compared to Western Europe) can turn into an advantage to keep daily costs low. The establishment of a REE handling industry will increase the number of people participating in the labour market and contribute to the economic growth. The State is financially viable and establishing a business in Estonia is relatively easy. Moreover, the State is open to foreign labour and investments. In addition, the risk of corruption is very low and the tax system is among the finest in the world. To conclude, a) the present studied model showed that the use of ESG indicators is also suitable for assessing the country's performance for a new business scope, and b) the ESG risks evaluation model demonstrates that Estonia is suitable for establishing a potential REEs recycling industry in the EU. Based on the ESG risk assessment model, it is assumed that the implementation of a REE recycling industry in Estonia is feasible around 2030 then REE-rich wind generators and hybrid electric vehicles (HEV) approaching to their EoL and better cost- efficient REE recycling technologies exists.

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PLASTIC IN THE OIL AND GAS INDUSTRY: A CIRCULAR ECONOMY APPROACH

Whenever cost-effectiveness (i.e., Economic, Environmental and Social Cost) of resources in a Circular Economy is discussed, the normal human mind automatically wanders to the three Rs (i.e., Reduce, Reuse, Recycle). Dr. Julian M. Allwood has been a pioneer in discussing the implementation of these three Rs for achieving a Circular Economy in detail for various materials (including Iron & Steel, Cement, Plastic, Aluminium, Paper, Textile & Clothing and Glass). Inspired by Dr. Allwood's work, this paper provides an extension of the implementation of the 3 Rs for a Circular Economy in case of the Oil and Gas Industry. Although there has been research on the implementation of Circular Economy as well as its performance measurement in the Oil & Gas industry, the method to achieve it (or whether CE can be achieved realistically in the Oil and Gas Industry), with respect to the raw materials used, is not mentioned explicitly in literature. In addition to this, a detailed discussion of the effect of a Circular Plastic Economy on the Oil Industry is also missing in literature, thus providing room for more innovative research in this paper.

Common sense reveals that the final products of Oil and Gas industry (consisting mainly of Petroleum and Gasoline) are all perishable, thus cannot be reused or recycled. Thus, in contrast to the very ideal of a Circular Economy, the products of this industry are a one-way material. The reuse of decommissioned off shore installations of the industry is a possibility being taken up by many companies now. This actually saves the economic and environmental cost of decommissioning and is rather beneficiary; but finding other uses for these installations is challenging, mainly due to their remote locations. The Recycling of platform materials leads to their downgrading, thus, using it in the same industry is a far off possibility. Even though the recycling and reuse of these products is highly improbable, the reduction in their demand can actually lead to reduction of some material cost (i.e., the economic, the environmental and the social cost), especially since there are alternatives to these products that can be pursued realistically.

In terms of GDP, the economic cost of a Circular Plastic Economy can be very high. But the strong reduction in the environmental cost can easily offset and even tower over the high economic cost. This general conclusion can also be extended in case of the effect that a Circular Plastic Economy can have on Oil and Gas Industry and vice versa, albeit some exceptions, in which case the economic cost can be reduced as well.

The general conclusion that can be drawn from this research is that the implementation of Circular Economy in case of Oil and Gas Industry is highly improbable because of the perishable final goods and services that it produces. It becomes a possibility if the principles and rules of assessing a circular economy is bent slightly, but even then, the continuously increasing demand for these products will make it harder to do so.

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PUBLIC PERCEPTION AND AWARENESS OF PROJECTS OF SECRESTATION OF CARBON DIOXIDE GAS: WORLD EXPERIENCE AND SITUATION IN RUSSIA

At present day world one of the acute global problems is the environmental problem -the greenhouse effect, which is caused by carbon dioxide emissions. For many years, specialists have been developing methods to deal with this problem. One of the most innovative method is sequestration of carbon dioxide, which is the capture, injection and disposal of carbon dioxide in underground storage facilities, as well as their monitoring. The use of this technology allows many foreign countries to improve the environmental situation, and in some cases use carbon dioxide for commercial purposes - to increase oil recovery or use carbon dioxide as an energy source. The application of this technology in Russia is rather perspective, since there are many depleted oil fields and technogenic sources of CO_2).

The work examines the foreign experience in applying carbon sequestration technology, which revealed that many projects were canceled due to negative public reaction. Such reaction can be explained as a result of a low level of public awareness of sequestration technology, doubts about its safety (the possibility of carbon dioxide leakage from underground storage facilities). Therefore, in order to identify the awareness of Russian society for the prospects of implementing sequestration technology in Russia, surveys were conducted among students of St. Petersburg universities (St. Petersburg State University, Mining, Polytechnic Universities), which showed a low level of public awareness. As a result, were developed recommendations to increase public awareness of the implementation of carbon dioxide sequestration projects.

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COMPLEX USE OF MINERAL RAW MATERIALS: FORMATION OF ORGANIZATIONAL AND ECONOMIC MECHANISM

To date, the problem of complex use of mineral raw materials (CUMR) is particularly relevant, owning to increase the threats of national mineral and raw material base development. In Russia the CUMR index is about 40% for the main types of metals and only 20% for rare-earth elements [1-2]. The implementation of the CUMR projects might be the priority direction within the providing of the national industrial complex with necessary «critical materials». Nevertheless, the existing organizational mechanisms of multicomponent ores exploitation and current economic risks do not create the robust incentives to the future development of these projects [2].

The methodology of the study includes case studies, techniques of system-oriented and strategic analysis. The content-analysis method for the academic literature and analytical reports on the topic has been used. The key problems related to the legal and institutional framework have been identified. They include deficiencies in the mechanism of the reserve fund deposits formation and the licensing system. It has been determined, that from an economic point of view,

the projects of complex use of mineral raw materials are usually unprofitable as they are notable for a high level of knowledge and capital intensity. The need for the introduction of unique mining and refining technologies leads to significant costs in the stage of research and development and in implementation phases. Moreover, there is a high level of macroeconomic uncertainty. Therefore, economic mechanisms are the subject of particular interests.

This study has identified the list of prospective Russian deposits in terms of complex use of mineral raw materials. Specific proposals regarding to the application of the governmental measures to support the CUMR projects implementation have been discussed (development institutions, fiscal regimes, et al.). The economic assessment of their using has been provided at the example of the Africanda project. Moreover, a range of proposals to improve the quality of the current system of the subsoil use management for the stages of strategic forecasting, planning, organization and control have been presented. The function of the economic and organizational mechanism offered will allow to increase the efficiency of the CUMR projects implementation. Long-term effects will be connected with the ensurance of the national industrial complex in strategically important types of mineral resources.

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ANALYSIS OF THE MARKET OF LIGHTWEIGHT ARTIFICIA AGGREGATES USING SELECTED ECONOMETRIC METHODS AND FINANCIAL ANALYTICS TOOLS

The subject of the paper is to show the author's own scheme of conducting an analysis of the market of light artificial aggregates using econometric methods and financial analysis tools, as well as an example of conducting this analysis.

The speech focused on showing the multi-stage analytical process, as well as on the presentation of the logical and causal system of the individual analyses used, indicating that, ultimately, it is possible to make a comprehensive assessment of companies active on the described, but also on any other market.

Five analyses were included in the scope of the presented methodology. These were: comparative analysis of net general revenue with net sales revenue, profit analysis, fixed asset coverage analysis, general debt ratio and SWOT analysis.

Net general sales revenue - in accounting, it is revenue understood as the sum of sold products, works, services, goods and materials, as well as their unit selling price. The analysis covered companies offering sales of lightweight artificial aggregates and their derivatives.

The company's profit index shows the position of the analysed company on the market. Profit is the picture of the company's operations. On the basis of a profit analysis, the situation of the company can be determined. It is an indispensable indicator in econometric analyses.

Analysis of fixed assets coverage - the indicator indicates to what extent the equity covers fixed assets. Equity should be sufficient to finance fixed assets. The indicator should be at least 1. If the value of the ratio is less than 1, it means that part of the assets is financed by foreign

capital, which does not indicate an adverse financial situation of the company. Together with other indicators, it is helpful in assessing the risk of financial disadvantage.

The general debt ratio shows the ratio of the company's liabilities (foreign capital) to its assets. High levels of the ratio (above 0. 5) mean a large share of debt in the company's activity and thus the risk of even bankruptcy in case of a downturn. On the other hand, the low levels of the indicator show the financial strength of the company and the fact that it can finance its activities and assets on its own.

SWOT analysis is the most basic tool for creating business and marketing strategies. Its great advantage is its versatility. It allows for the analysis of both small and large companies. SWOT stands for strenghts, weaknesses, opportunities and threats. SWOT is used to analyse the company's internal and external environment and is the first stage of strategic analysis.

With these indicators the survey can be considered reliable and accurate.

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METHODOLOGICAL APPROACH TO THE FORMATION OF A COMPREHENSIVE MECHANISM FOR REGULATING SOCIAL PROCESSES OF COAL INDUSTRY RESTRUCTURING

Main negative socio-economic consequences for coal-mining regions where coal production is completely or partially stopped are increase in unemployment, low wages, etc. In theory and practice the results of scientific research have already been applied in the development of a methodological approach to the formation of a mechanism for regulating negative social processes of restructuring. The development of this issue was handled by A. S. Astakhov, F. I. Evdokimov, I. S. Kozhukhovsky, V. N. Popov, A. A. Rozhkov, A. I. Yarembash and others. The accumulated experience and constant development of the economic and social system make it possible to form new approaches to the elimination of socio-economic problems that arise during the restructuring of the coal mining industry. In this regard, research aimed at improving the validity of management decisions by developing and improving the methodological basis for restructuring is particularly relevant.

The efforts of state structures in the past period of restructuring were aimed at preventing the growth of negative social consequences in working groups and in coal-mining territories. However, the lack of a strategic approach to managing the structural transformations of municipalities has become a significant disadvantage of the existing mechanism of structural changes. Currently the official unemployment rate of the working-age population in the DPR reaches 14.2 % [1]. Consequences that infringe on the rights of people to work and decent standard of living are unacceptable and socially dangerous. Therefore, they require special attention when programming, developing and implementing restructuring in order to eliminate the growth of social tension in industrial regions.

In methodological, organizational and technical terms the mechanism for regulating the social consequences of restructuring should be based on modern methods and socio-economic monitoring using new technologies. Also, the mechanism for regulating social consequences should be constantly developed in accordance with the emergence of new socio-economic goals, resource and legal measures to localize the negative consequences of restructuring [2]. A number of restructuring projects that should have been successful were not completed and "choked" at the initial stage. This happened for a simple reason - the company's management was convinced that the project was unfounded without having time to feel its results. Reform was necessary in almost all areas, and it required significant resources, both financial and human, but it was dispersed and did not have a tangible effect [3]. This can be avoided by using a minimax approach - building a restructuring plan as a sequence of steps that will achieve the maximum

effect with minimal costs and risks. Therefore, this paper proposes to use the following methodological approach based on the construction of a step-by-step algorithm for effective implementation of industry restructuring:

Step 1: conducting a SWOT analysis (identification of the state of the enterprise, analysis and assessment of weaknesses and strengths) or a similar analytical model in order to identify problems and optimal ways to solve them. This requires a lot of input from managers to make the necessary organizational changes. The initial stage of restructuring is aimed at eliminating the main disadvantages of the transition of former Soviet enterprises to a market economy, namely: organization, marketing, finance, etc. As well as the analysis of weak points in all areas of the enterprise and the development of specific proposals for the "treatment" of the enterprise. Step 2: assessment of the impact of external and internal opportunities, threats to the environment: political, economic, technological, market and socio-demographic. Organizational and administrative issues include identifying current and optimal business lines and markets. The implementation of the second stage makes it possible to develop an effective concept of restructuring. Step 3: choosing the restructuring methods that meet its goals and contribute to the best results. Redevelopment and modernization of production is carried out in such way as to form optimal technological and logistics chains that reduce costs and increase labor productivity. Also, at this step it is necessary to review approaches to employee training, implement an effective motivation system and improve the work culture. Step 4: development of a comprehensive restructuring program that includes alternative actions, cost-effectiveness assessment and selection of the best option, depending on existing restrictions. The fourth step is aimed at improving the situation of the enterprise, improving the skills and mental state of workers as well as improving the opinion of others about the enterprise. At this stage the company improves its economic activities and ensures a stable position relative to external sources of financing. This increases the chances of attracting the necessary funds to purchase new technologies, increase production and reduce the cost of coal products. Step 5: monitoring the restructuring process, analyzing its results and, if necessary, making adjustments. At this stage, a service is being created to identify, analyze and solve current problems of enterprise restructuring. Step 6: design of a comprehensive mechanism for managing negative social consequences, including balanced release and employment of employees, social protection and other measures to prevent the occurrence of social conflicts.

Thus, the correct use of modern and optimal methods when choosing a strategy for the socio-economic development of coal-mining regions allows us to create an algorithm for the effective implementation of industry restructuring and overcoming social tensions in coal-mining territories which ensures the maximum use of the existing potential of the territory.

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EFFICIENT USE OF RESOURCES IN THE FIELD OF ENERGY EFFICIENCY THROUGH THE PRINCIPLES OF THE CIRCULAR ECONOMY

The energy transition is one of the most important environmental problems of the 21st century. One solution that will help accelerate this transition is a circular economy. The approaches of the Ellen MacArthur Foundation, the report of the Greenpeace organization, the report of the World Wind Energy Association (WWEA), the report of the International Geothermal Association, Europe 2020 Strategy, and the European Commission study are systematized. The novelty of the article is that: a category of efficient use of resources in a circular economy is defined; types of energy are systematized for sustainable development: a balance of economic, social and environmental components, through a model of circular economy, which will achieve resource conservation in the field of energy efficiency.

The approaches of the Ellen MacArthur Foundation, the report of the Greenpeace organization, the report of the World Wind Energy Association (WWEA), the report of the International Geothermal Association, Europe 2020 Strategy, and the European Commission study are systematized.

Having studied the various approaches of the authors to the definition of these concepts by comparison and analogy, we can conclude that the Concept of the circular economy offers effective business models to ensure more environmentally friendly resource use, contributing to the achievement of the goals of sustainable development of society.

The article used historical and statistical methods, as well as a systematic approach to the study of economic phenomena [systems approach in eeconomics], which helped to identify the relationship of all elements, accounting for these relationships and the study of individual economic objects as structural parts, identifying the role of each of them in The general functioning of the circular economy and its impact on individual elements. The method of comparison and scientific modeling reveals the role of the circular economy in resource conservation, minimizing waste and reducing environmental pressure while achieving significant economic and social results

The first step is to change our systems by switching from carbon-based energy (oil, gas, coal) to clean energy (solar, wind, hydropower, etc.). But it is also important to act on the principle of energy efficiency, which is to measure the difference between the actually used energy and the total energy consumed (often higher due to losses) and, accordingly, in order to reduce consumption. The principle of the circular economy is to achieve the most efficient use of resources. Therefore, it is the main lever for the development of innovative solutions for the transition to clean energy [1].

The circular economy offers increased resource efficiency; more environmentally friendly resource use, separation of welfare from resource consumption; reuse and recycling involve the use of primary resources. At the same time, they reduce our dependence on such resources. It improves our capabilities and the ability of future generations to meet their needs.

Our studies have allowed us to state that the concept of a circular economy acts as a practical basis for resource efficiency and offers effective business models to ensure more environmentally friendly resource use, contributing to the achievement of sustainable development goals of society.

The circular economy is based on a paradigm shift: waste turns into a resource. Efficient use of resources means reducing the amount of resources needed to produce a unit of output, that is, simply put, doing more with less. Reducing the consumption of resources (such as raw materials, energy and water) not only leads to a reduction in by-products (including waste,

wastewater, air pollution and greenhouse gases per unit of production), but also reduces the demand for the supply of these materials upstream, as well as Entrances along with their environmental costs.

Consequently, it is an economy of recovery and reuse. At the same time, it transforms production chains and consumption patterns and does not link GDP growth with the use of natural resources.

It will be important to invent new economic models and think outside the box, as for cities, so that efforts to improve resource efficiency remain available to government agencies and companies, as their quality of supply and competitiveness must be maintained. The European Union can make a significant contribution, in particular through legislative and regulatory policies that will stimulate innovation, encourage the development of alternative resources and stimulate initiatives [2].

World experience in implementing circular projects indicates that business models based on its principles are successfully used by many companies, including transnational corporations, including Apple, Coca-Cola, Philips, Renault, Unilever, etc. At the same time, widespread adoption this concept is constrained by many barriers due to the lack of sufficient experience in the practical implementation of such projects.

Resource efficiency makes economic sense. This is one of the basic principles underlying the entire circular strategy of the economy, and it is fundamental to green growth. Using less resource, more efficiently, you can maintain your competitive advantage, create green growth, create sustainable jobs and better protect the environment [3].

Transformation into a resource-saving, environmentally friendly and competitive low-carbon economy is one of the three goals of the 7th Environmental Action Program. To achieve this goal, we need to apply resource efficiency at every stage of the product life cycle: we must use eco-innovation to develop smarter products, produce and consume in a more reasonable way, and process and reduce waste in general.

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ORGANIZATIONAL AND LEGAL ASPECTS OF USING SYSTEM OF RENEWABLE ENERGY SOURCES FOR INVESTMENT ACTIVITIES IN RUSSIA

At present, Russia is at the initial stage of diversification of electricity exclusively from gas and oil in favor of establishing the priority of renewable energy sources (RES). The relevance of the study lies in the fact that the legal regulation of the use of renewable energy sources (RES) as a fuel and for the production of electricity is a new area of Russian jurisprudence, which is at the initial stage of its development. The novelty of the study is the analysis of existing mechanisms for stimulating the production of renewable energy and the subsequent development of doctrinal proposals for legislative improvement of civil law

regulation of relations in the field of renewable energy sources and measures to stimulate the production of renewable energy. In the Decree of the Government of the Russian Federation No. 449 “On the mechanism for stimulating the use of renewable energy sources in the wholesale market of electric energy and power” [1], the legislator has fixed a mechanism for supporting qualified generating facilities operating on the basis of using renewable energy sources on the basis of a payment for demand charge, which provides investors with a basic yield 12%.

In order to attract and subsequently increase investment assets for the development of alternative energy, the terms of this agreement provide for state guarantees for reimbursement of investors' costs due to the increased cost of capacity sold. The presence of the above guarantees for investors leads to a decrease in the price indices of borrowed funds and, as a consequence, the cost of capacity for renewable energy resources. Along with the provision of state guarantees, investors have a number of obligations and restrictions associated with the construction, reconstruction and commissioning of renewable energy generation facilities. They, in turn, act as constraining factors for the development of renewable energy in Russia. Thus, the state has established requirements for the localization of equipment for generation and engineering services, which require the predominant use of domestic technologies in a percentage ratio, reaching a level of up to 90% [2].

The legislator also provides for a strict system of sanctions against investors who violated the terms of the capacity fee in the form of significant fines for both the untimely commissioning of generating facilities for the purpose of supplying power and for the failure to comply with the terms of such introduction. Obligations under the contract are provided in the form of a monthly forfeit out of court by debiting the corresponding amount from the account of the offending party [3]. Thus, in addition to a significant amount of penalties, the investor also incurs financial losses, which are expressed in non-profit for the sale of capacity and electric energy.

Resolution No. 449 also provides for a restriction regarding a number of renewable energy generating facilities subject to state support under the payment for demand charge mechanism. So, these include only objects operating on the basis of wind, solar and small hydropower. They should be located exclusively in the price zones of the wholesale electricity and capacity market, and the minimum value of capacity should be 5 MW. Accordingly, the circle of generating facilities that are entitled to count on investment activity is legally limited.

Thus, the conditions provided for by payment for demand charge are quite workable, but require some clarification on individual points. This is necessary to increase investor confidence and create transparent, understandable mechanisms to stimulate renewable energy production, since investments are an effective tool for the long-term development of renewable energy in Russia and achieve established strategic goals in the future [4]. The legislator should take into account other types of renewable energy included in the similar concept of renewable energy in the Federal Law [5], as well as reduce procedural and regulatory barriers for investors, taking into account the experience of leading foreign countries in the field of renewable energy.

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Session 6. INFORMATION TELECOMMUNICATION TECHNOLOGIES AND DIGITAL TRANSFORMATION

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INDUSTRIAL LIFTING TECHNOLOGY BY SUBMERSIBLE PUMPS AND CONVERSION OF THE OIL FIELD TO A DIGITAL FIELD USING DOF TECHNIQUE (E.G. RUMAILA OIL FIELD)

KEYWORDS: artificial lift**,** Electric Submersible Pumps, DOF system, Variable Speed Drives.

The aim of this research is to reveal how oil is produced by the artificial lift technique in the method of Electric Submersible Pumps (ESP), taking into account the pump control devices, variable speed devices and submersible pumps used in Rumaila oil field.

The study refers to a proposal of converting conventional monitoring and operation of oil wells into digital wells through a DOF system. This vision began to take shape in Rumaila oil field at a steady pace, and through available programs used in the field, such as PIVISION and PI Process Book.

An example of this is how to monitor remote submersible pump wells by taking important values such as pressures, temperatures and frequencies from VSD equipment to see the operating parameters of the various sensors and meters that transmit signals via the antennas to a control centre.

In contrast, the study pointed out the types of submersible pumps and Variable Speed Drives used in Rumaila oil field which is the third largest field in the world and is produced by submersible electric pumps, on average 364 thousand barrels of oil per day. This important issue however understands reasons for failure of an ESP system, and actions taken to mitigate and minimize ESP system failures as successfully implement in Rumaila oilfield.

The study also points out the possibility of remote control of an ESP well, which includes operation of such wells and takes into account the changing the operational conditions of the wells, such as pressures and temperatures through the introduction of values and the use of several variables.

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INTELLECTUAL EFFICIENCY: INNOVATION, CHANGING ENERGY EFFICIENCY MARKET

The improvement of energy efficiency and energy conservation is one of the main areas of state policy with regard to the country's energy security. At the same time, the use of alternative energy sources will make it possible to solve the problem of the high-energy intensity of the domestic economy and to minimize the impact of human activities on the environment.

Scientific novelty of research consists in improvement of scientific and methodological approach to technology of construction of energy efficient buildings through application of intelligent innovative construction technologies and materials. The rationale for the development of an appropriate approach is based on the study of the legal and regulatory framework governing energy conservation and energy efficiency, as well as on the scientific work of domestic and foreign scientists, to address the problems of alternative energy sources.

According to the World Meteorological Organization, our planet is warming up and 2019 is the second warmest year in human history. Atmospheric carbon dioxide concentrations reached record levels of 407.8 parts per million in 2018 and continued to rise in 2019. It is predicted that the demand for energy will increase markedly in the coming years due to the growth of the population, the growth of the economy and the desire of the person to move from the «comfort zone» to the «absolute comfort zone». According to the International Energy Agency, published in the World Energy Report 2018, world energy consumption increased by 2.3 per cent [1]. Residential and public buildings account for a huge share of the pressure on electrical systems, energy resources, the environment and the viability of savings. Overall, this represents 40 per cent of total energy consumption and 71 per cent of electricity. Therefore, the improvement of energy efficiency in buildings should be addressed in an integrated manner and should include clean energy sources, energy-efficient storage and intelligent consumption management, as well as the use of energy-efficient materials in construction [2].

The potential for improving the intellectual efficiency of energy saving is provided by the implementation of the mechanism for developing energy-efficient buildings or zero-energy buildings. The identification of requirements for energy efficiency indicators, including criteria for assessing the environmental impact of the project, ensures the rational use of all types of energy. The approval by law of the possibility of using them will increase the efficiency of energy saving, speed up the implementation of projects related to the country's energy security, improvement of the quality of the human habitat, preservation of natural riches, and protection of the interests of future generations [3].

Energy conservation measures are presented below:

- energy-positive buildings;
- «Anti-sunlight» panels;
- solar panels for raindrops;
- interactive bricks-brixels;
- V3 Solar Roof Tesla;
- Halio electrochrome glass;
- floor covering of cellulose fibres;
- heat-insulating foam from wood.

Smart energy-efficient technologies are the most effective way to combat climate change. Energy conservation combines the benefits of introducing intelligent solutions for environmental protection with economic benefits. The main role in supporting and financing the construction of energy-efficient buildings should be played by the State, because the implementation of these projects is related to the energy security of the country, improvement of the quality of the human habitat, preservation of natural wealth - protection of the interests of future generations.

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DEVELOPMENT ENVIRONMENT POWERED WITH ARTIFICIAL INTELLIGENCE

Everyone knows that all industries use machine and/or software control to make the process more simple. In our days lots of applications are powered with AI(artificial intelligence). It is used by many industries for automating tasks and doing complex data analysis. There are many AI tools to solve the most difficult problems in computer science. Digitalization and automation can become an easy and fast process using AI and machine learning. George Day and Paul Schoemaker recently published " See Sooner, Act Faster: How Vigilant Leaders Thrive in an Era of Digital Turbulence" book. The book offers insights on how leaders can spot and respond sooner than their competition to non-obvious signals that foreshadow opportunities or threats to their business. It is one of the best books about digitalization processes.

A software development process is the process of dividing software development work into distinct phases to improve design. Building a high-quality product is the end goal for any engineer, but the software development process is evolving while automation is becoming rampant, and new tools and libraries are emerging daily. Problems are many while the goal is one, so engineers must spend time and the owner of product must spend money for getting a powerful software.

Now let's imagine that engineers have a powerful tool powered with AI that can help them to make a good software in a short time. In this case engineers can save time and the owner of product can save money but get the expected result.

As you know each field of industry has its own/special technologies. Each technology is a mathematical model. A mathematical model is a description of a system using mathematical concepts. The integral part of mathematical models are algorithms. Algorithms can be used to select the model terms, determine the model structure, and estimate the unknown parameters in the model.

If developers want to digitalize a technology, they must spend lots of time for knowing deep descriptions of every step and create the tool from scratch using paid or free libraries provided by IT companies(library is a collection of related algorithms). Instead of that developers can use a special development environment which is powered with AI and can advise simple, clear and fast optimizations for specific technologies. It is state-of-the-art and famous way in the world. The offer is a tool which is powered with AI and can help to make the software development precess simple and fast. In short terms the name of offer is development environment powered with AI.

There are many types of artificial neural networks that can help programers/engineers to get good suggestions and optimizations of designing software. One of them is Recurrent Neural Network. It is designed to process sequential data and recognize patterns in it. Recurrent Neural Networks are often used in Natural Language Processing (NLP) tasks because of their effectiveness in handling text.

Designing a software and writing source code is a NLP task too. That means RNN can be helpful for getting good suggestions and advices from neural network. But before that the neural network must train with the data set that is specific for the field of industry. Data set can include implementation of algorithms, mathematical models, specific data containers that are specific for software solutions designed for that field of industry.

Development environment powered with AI can give programmers and engineers an ability to design software in a short time and in an efficient way.

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STEGANOGRAPHY IN FRAMES OF GRAPHICAL ANIMATION

Everything around us is information or a carrier of information. And because of that, there are many ways to store information in a digital world. The simplest examples of these are text files, pictures, videos, and more.

This work explores images, their types, formats, storage features, and offers secret data steganography using small data segments, specific features of GIF data format, and LSB algorithm.

Nowadays nearly every mining company has big databases for storing information like data about some new or rare minerals, or it can be the geographic locations of the mining firms and a lot of other types of data. All this data is very important, and it obviously should be private. So, every mining company may need a strong data security and management system. For this purpose, the company can use the data security method that I am introducing in this paper.

Why steganography..?

Steganography is the art of hiding information and an effort to conceal the existence of the embedded information. It serves as a better way of securing a message than cryptography which only conceals the content of the message not the existence of the message. The original message is being hidden within a carrier such that the changes so occurred in the carrier are not observable.

But nearly all types of data hiding can be broken by just using brute force hacking algorithms, so I offer one method for data hiding that is using random data spreading in frames of graphical animation.

In this method, data is dividing into random pieces, then these pieces are separating to randomly chosen frames of graphical animation. Besides that, every piece of data is hiding only in one color of the entire pixel. But unfortunately, a third party may access some piece of the hided data, if they could find the carrier frame from the entire graphical animation.

The described method has two main working threads. The first one was created for encryption and the second one for decryption. So, the same system can be used by both sides of the secret conversation.

For implementing this method, I had to choose the carrier file format, that can handle all changes during encryption and visually stay the same. Because LSB method changes the last bit or bits of the carrier byte to the secret data bits, it can cause some visual changes.

This method is using GIF files as a carrier of the secret data. GIF was chosen because it is a very common data type for storing graphical animation, very widely has been used in WEB browsers, it stores unique color pallets for each frame of the graphical animation. That ability is very important for this method because when the secret data is hidden in the frame, that frame loses some color depth, and if there was a single pallet for all frames, or combined one, these losses could become visible to the human eye. But in GIF file every single frame has its own color pallet in the file memory.

GIF file format uses 3 bytes of memory for storing each pixel, providing one byte for each color in pixel. It uses RGB (red, green, blue) color order for describing each pixel in the frame. In each pallet GIF file format provides 256 different colors, so each frame can use 256 different colors. But what if we need to store more colors in GIF image? There is a very simple solution for that. We can separate big images, with many colors to small pieces and every piece,

in that case, can use its own 256 colors. So, GIF file format is a very powerful, simple, and well-supported format and can be used in many kinds of applications.

Overall, this method complicates data stealing by using algorithms like brute force. Also by using this method the carrier file doesn't change in size after data hiding, so a third party can't identify the carrier file by comparing it with the similar one.

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PROTOCOL DEVELOPMENT FOR HARDWARE LEVEL

To simplify the structure, most networks are organized into sets of levels or layers, each of which is built on the previous one. The number of levels, their names, content and purpose vary from network to network. However, in all networks, the goal of each level is to provide certain services for higher levels. At the same time, details of the implementation of the provided service are hidden from them.

This concept is not new and has been used for a long time. Its variations are known as hiding information, abstract data types, encapsulation property, and object-oriented programming. The fundamental idea is to provide a certain software or hardware level of services to its users without revealing details of its internal state and details of algorithms.

Level n of one machine communicates with level n of another machine. The rules and conventions used in this communication are called protocol of n level. In essence, the protocol is the agreement of the communicating parties on how communication should take place. Violation of the protocol will create difficulties in communication, or maybe even make communication impossible. Objects that include the corresponding levels on different machines are called peer-to-peer, or equitable, nodes, or network's entities. They communicate using the protocol.

We need to understand the relationship between virtual and real communication and the difference between protocol and interface. Peer-to-peer processes of level 4, for example, consider their communication horizontal, using the protocol of the 4th level. Each of them has a procedure called SendToOtherSide and GetFromOtherSide, even if in fact these procedures do not communicate with each other, but with lower levels using 3/4 interfaces.

Abstraction of peer-to-peer processes is key to network design. With its help, the impossible task of developing an entire network can be divided into several smaller and quite solvable development problems, namely the development of individual levels. It should be noted that the lower levels in the hierarchy of protocols are often implemented in hardware or soft-hardware. Nevertheless, complex protocol algorithms are used in this case, although they are implemented partially or whole in the equipment.

Some of the key aspects of development that arise when creating computer networks are present at several levels. Briefly describe the most important of them. Each level needs a mechanism for identifying senders and recipients. The network usually runs quite a lot of computers, they can run several processes simultaneously, each of which needs a tool to indicate who he wants to talk to. Therefore, an addressing system is needed.

It is also necessary to develop rules for data transfer. In some systems, data can only move in one direction, in others in any direction. The protocol should also determine the number of logical channels related to the connection and their priorities. Many networks provide at least two logical channels per connection: one for regular data and one for urgent data.

An important aspect is error control because the physical communication channels are imperfect. There are many codes that recognize and correct errors, however, both sides of the connection must agree among themselves on which code will be selected. In addition, the recipient should be able to tell the sender which of the messages were received correctly and which were not.

Not all communication channels retain the sequence of messages sent over them. To correct a possible loss of message order, the protocol must explicitly provide the receiver with packet numbers so that the received message fragments can be collected in the correct order. An obvious solution to the problem is packet numbering, but the question remains open: what to do with packets arriving in the wrong order?

In addition, the question arises at each level: how to organize data transfer so that the fast transmitting side does not flood the slow receiving side with packets? There are various solutions to solve this problem. Some of them involve direct or indirect recipient responses to the sending part, informing them of the current status of the recipient. Another solution may be to limit the transmission rate to some contractual level. This is generally referred to as flow control.

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SIMULATION OF POWDER SINTERING PROCESS OF BLUK MATERIAL TO STUDY NEW MATERIAL PROPERTIES

Sintering is a manufacturing process used to produce various parts from metal or ceramic powder mixtures. Sintering is the compaction of loose or loosely bound powders at elevated temperatures close to the melting temperature with or without additional pressure. This is a complex process that is influenced by many factors. Modeling can be used to optimize and better understand the sintering process and improve the quality of sintered components.

It is quite obvious that the sintering process parameters are affected by both the physicomechanical properties of the powder mixture (bulk density, granular composition, etc.) and its rheological characteristics (angle of repose, friction coefficients) necessary for modeling a granular medium. Physical and mechanical properties are easily measurable using various laboratory devices, while the determination of rheological properties has its own features. In this study, the most important rheological properties of the powder mixture are the DEM parameters of the bulk material, among which the static and dynamic friction coefficients, as well as the recovery for particle-particle and particle-surface interaction pairs, are included. In addition, when modeling spherical particles, it is extremely important to be aware of the value of the rolling friction coefficient. The determination of such values of DEM parameters that provide adequate reproduction of the rheology of the bulk material under study in the model (the so-called calibration of DEM parameters) is a non-trivial task and is still relevant in the world scientific community [1-4]. Within the framework of this study, it is advisable to use complex methods for accurately determining the DEM values of the powder mixture.

Currently, studies are underway [5-6], a methodology has been developed to determine the DEM parameters of bulk materials based on machine vision and a neural network algorithm [9-10]. This technique allows you to obtain the exact values of the DEM parameters of the investigated bulk material by comparing the visual images of the material's behavior on the experimental stand in reality and in the model. Thus, the most accurate reproduction of the rheology of real bulk material in the analyzed DEM model is achieved.

The aim of the work is investigation the features of the nanostructured characteristics of NiAl intermetallic compounds by computer simulation methods, in particular, the sintering of the material using the discrete element method.

When analyzing the packing of high-density particles, it is necessary to take into account the effect of each contact force on all contacts around the particles. In the proposed model, the influence of the neighboring contacts is considered indirectly using the concept of a Voronoi diagram, using the existing method [7]. When performing a weighted three-dimensional

separation of the Voronoi packing, the sum of all cell volumes corresponds to the packing volume, and each powder particle (initially spherical) is surrounded by a Voronoi cell (please refer to Figure 1). Thus, it is easy to determine the density of the solid fraction associated with a particle from the Voronoi decomposition.

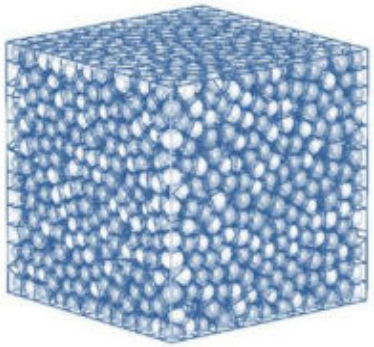

Figure 1 - High density packing using the Voronoi cell diagram

In addition to studying the packing of spherical particles, modeling of sintering and shrinkage was carried out. The initial configuration of the model included about 350 particles (shown in Figure 3 a). The goal of this study was to further verify whether the proposed model matches the results obtained in laboratory tests. Figure 2 b) shows the model after sintering. As can be seen from the comparison, shrinkage of sintered particles is clearly observed.

a) b)

Figure 2 - Numerical simulation of the sintering process of particles of a spherical shape

The discrete element method is a suitable tool for modeling powder sintering. The sintering mechanism of the material is explicitly taken into account in the model of discrete elements. The presented results show the great potential of the developed numerical model in modeling sintering processes, although further development and validation with the results of laboratory tests are necessary. The study of the nanostructural characteristics of the NiAl intermetallic compound in the pre-transition weakly stable region depending on the composition, external factors, such as temperature changes, deformation, the presence of point defects, and the presence of antiphase boundaries is an important task. Modern capabilities of computer modeling allow us to perform theoretical calculations and predict structural states on specific models.

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DEVELOPMENT OF A METHOD FOR MEASURING LOCAL ELASTIC MODULES OF METALS AND ALLOYS AT MECHANICAL STRESSES USING LASER ULTRASONIC DEFECTOSCOPY

The increasing complexity of the structural features of the parts leads to an increase in the requirements for controlling the physical and mechanical properties of the materials used for them. One of the most important parameters is Young's modulus. Its change by at least a few percent from point to point in the workpiece leads to unacceptable deformations in the manufacture of the part [1,2].

In this paper, we will present a method for measuring the local elastic moduli of metals and alloys at mechanical stresses based on laser ultrasonic flaw detection. The precision determination of the velocities of longitudinal and shear ultrasonic waves allows us to calculate the Young's modulus and shear modulus with an error of the order of 1% [3].

As a result of the study, conversion factors for residual stress values on samples of heat-resistant nickel alloys with regulated residual stress values were determined.

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CONCEPT FOR THE AUTOMATION OF EXCAVATORS IN MODEL SCALE

Autonomous driving in road traffic is currently a much-discussed research topic. In order to meet the future requirements of modern construction projects [1], the transfer of autonomous systems to this sector is inevitable. At the Institute of Automation Technology at the TU

Bergakademie Freiberg, the automation of excavators is being pursued on a model scale in order to depict methods, which are relevant in a real case application, in a model experiment. For this purpose, remote-controlled models (further description for program environments: “agents”) on a scale of 1:14 are equipped with programmable controllers (Arduino Mega 2560, Raspberry Pi 4B). The computed specifications are initially determined exclusively on a central computer and sent wirelessly to all agents. The long term goal is to outsource parts of the computation gradually to the agents.

The construction size presents a particular challenge. In real machines, a large number of different types of sensors can be employed to cope with complex situations. If one type of sensor does not provide a useful result, the signal of another type of sensor can be used instead at any time. On the model scale in contrast, only few and small sensors are available for use. These must also provide a useful result because no alternative source is available. Furthermore, initial tests have shown that the pre-installed low-cost brushed DC motors are not sufficiently dimensioned for the planned scenario. This is entirely adequate for use as a remote controlled model, because the operator can adjust his control instructions based on visible deviations from expected behaviour. However, it is particularly difficult to compensate for the unpredictable fluctuations in response behaviour when operating autonomously. The existing motors must therefore be replaced by more powerful brushless DC motors. It is expected that this will lead to the capability of executing precise movements, since information about the covered rotation can be read out simultaneously. This will avoid the necessity of additional sensors at this particular spot.

For the implementation of computer-based planning, the environment has to be mapped first so that the current surface structure with possible obstacles is known. In order to achieve this objective a Kinect camera is mounted above the setup. The existing continuous height profile is determined, which is limited to the top level. Possible underlying levels are not mapped by the currently used methods. This mapping has to be carried out continuously, as the existing profile is to be changed during the course of the process. Outdated information could lead to faulty planning in subsequent process sections, which should be avoided at all costs, as safety-relevant conditions could be violated. The position of excavators and other possible process participants can thus be determined using image processing methods. GPS information, which would be used in a real case, provides inaccurate results on a small scale and is therefore not an appropriate option.

Profile information is considered discreetly, so that blocks of material have to be re-sorted [2]. In current earthworks projects, planning takes place in advance of the execution, so that a general specification for the construction site workers can be created. Human intelligence is used to translate these requirements into individual working steps. In the autonomous approach basic tasks are generated via the difference between the current actual profile of the mapped material and the target profile specified at the beginning, which is to be achieved by excavator intervention. The resulting list of tasks has to be divided among individual agents. The sequence in which tasks are completed is strategically decisive, since in the worst case scenario, material is brought into a future path and blocks this very path. Ideally, the aim should be to minimize the distance covered, the process time or the overall energy costs incurred. Predictable conflicts between agents have to be avoided to minimize downtime.

Algorithms for trajectory planning enable on the one hand the path finding in the terrain, but on the other hand also the targeted movement of the excavator arm towards the material to be moved. The information thus obtained is converted into actuator instructions and transmitted to the motor controls. Currently, an A* algorithm approach is used, which explores a mapped environment without fixed routes and determines an optimal path [3]. This pre-planning has to be extended by a component for collision avoidance for the interconnected operation of several agents in order to be able to consider unforeseeable safety-relevant situations.

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NEW REVOLUTION OF COMPUTER SIMULATIONS IN GEOSCIENCE

Since the first large-scale application during the Manhattan Project in World War II, the computer simulation has been widely used in both natural science and social science. In geoscience, computer simulations have been a basic research method and once were considered as the second Copernican revolution [1]. A number of computer models (Phenomenological models and Mechanistic models) have been developed to simulate atmosphere, hydrosphere, cryosphere, geosphere, pedosphere, biosphere. All the models were built for different purposes with significantly different modeling approaches and computational costs. However, there is a consensus that the computational costs increase exponentially along with spatial and temporal resolution of the models. Some integrated numerical models have been developed to incorporate connected processes [2, 3, 4, 5[. Furthermore, agent-based model 6 and modeling environment (e.g., OMS [7], OpenMI [8]) were developed to integrate different models for simulating the multidisciplinary nature of natural systems and human systems which leads to more complicated and computationally expensive models. The subsequent procedures (e.g., sustainable analysis, optimization, uncertainty analysis) may exacerbate the problem seriously. Although the development of information science and technology is rapid, the problems can hardly be solved within acceptable computational time costs.

On the other hand, the machine learning algorithms have been thoroughly investigated in many researches 9, 10 and applied in numerous domains of science, business and government with good-enough results. In broad sense, the conventional computer simulations can be regarded as regression analysis (e.g., Linear Regression, Polynomial Regression and Stepwise Regression). However, several limitations exist in regression analysis. One of these limitations is the assumption of linearity between predictor and predictand which makes it less capable for long-lead forecasting. The other limitation is the inability when dealing with complex problems and big data. The machine learning, especially deep learning algorithms [11], are gaining momentum in the field of classification, regression and simulation [12]. The approximation bounds and capabilities of neural networks have been stated and proved by various researchers [13, 14, 15]. Furthermore, the astonishingly ability in handling big datasets with unknown noise and uncertainty makes machine learning algorithms particularly impactful in the geosciences where large sensor networks, continuous monitoring and high-resolution simulations generate huge datasets. Therefore, constructing surrogate models for the numerical models or the natural systems becomes an alternatively effective solution. Prof. Christine A. Shoemaker have focused on finding cost-effective, robust solutions for problems in engineering and science by using statistic based surrogate response surfaces for optimization, modeling and statistical analyses [16, 17, 18]. Promising results were obtained in water resources and environmental issues [19, 20].

It is time to embrace a new revolution of computer simulations by combining usage of numerical models and machine learning methods. A comparative study among machine learning and numerical models for simulating groundwater dynamics has been conducted by our research group 21 which presents more accurate results and lower computation costs in both simulation and prediction stages from machine learning methods than those from numerical models. However, the generalization ability of numerical model is superior to the machine learning methods because of the inclusion of physical mechanism. This result implies that machine learning methods are applicable to the scenarios which require numerous executions (e.g., real-time models, sensitivity/uncertainty analysis, and optimizations) and numerical models are applicable to researches related to physical mechanisms, long-term simulations and predictions. Furthermore, machine learning methods are supposed to integrate/couple (by model environments), cohesion with or even surrogate (parts of) the numerical models depending on different purposes.

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RESEARCH ON WIND POWER FAULT PREDICTION BASED ON IMPROVED BP NEURAL NETWORK

KEY WORDS: wind power failure; Neural Networks; Variable learning rate; Reduce training time.

Aiming at the problem that the variable learning rate algorithm still has oscillations and slow convergence speed during the actual training process, this paper optimizes the existing variable learning rate algorithm, by adjusting the local variable learning rate algorithm and the overall variable learning rate algorithm Effectively improve the convergence speed of the training process, thereby reducing training time. The improved BP neural network is used to predict the faults of wind turbines. Experiments show that the algorithm has high prediction accuracy and can reduce training time by more than 30%.

The traditional wind power fault detection is to first calculate the characteristic parameter weights of the wind power system data through the Relief algorithm, and then select the appropriate parameters through the weight coefficient ranking, and use the BP neural network to classify the various data collected by the current sensor, through the traditional neural network Perform nonlinear mapping[3]. Because the traditional BP neural network has many parameters and the calculation and training process is slow, especially in large-scale wind power networks, it is especially important to improve the optimization method or use other network structures. Previous literature [1] and literature [2] The individual variable learning rate alg orithm and the overall variable learning rate algorithm used in the algorithm are relatively simple, and there is a certain optimization space. In this paper, the individual variable learning rate algorithm and the overall variable learning rate algorithm are optimized and adjusted to achieve faster convergence speed and more Short training time. The optimized improved BP neural network is applied to wind turbine fault prediction. Experiments show that the algorithm has good applicability in wind turbine fault diagnosis, and further reduces the training time compared with traditional methods.

The BP neural network is composed of three parts: the input layer, the hidden layer, and the output layer [4]. The operation process of the BP neural network is mainly divided into two parts: forward propagation and reverse propagation. Input the sample x and the parameters $w^{[1]}$ and $b^{[1]}$ to the hidden layer [5], find $z^{[1]}$, and then get $a^{[1]}$; then input the parameters $w^{[2]}$, $b^{[2]}$, and $a^{[1]}$ together into the output layer to find $z^{[2]}$, and get $a^{[2]}$ through the activation function; finally get the loss Function $L\left(a^{[2]}, y\right)$, such a process of progressive propagation from front to back, is called forward propagation. During the training process, there is always a certain error between the final result obtained after forward propagation and the true value of the training sample. This error is the loss function. To reduce this error, one of the most widely used algorithms at present is gradient descent, so we use the loss function to seek the partial derivatives of each parameter from back to front, which is called back propagation.

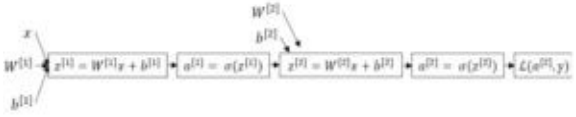

Figure 2 - Forward propagation

Forward propagation process:

$$z^{[1]} = \omega^{[1]} X + b^{[1]}$$

$$a^{[1]} = g(z^{[1]})$$

$$z^{[2]} = \omega^{[2]} a^{[1]} + b^{[2]}$$

$$a^{[2]} = \sigma(z^{[2]}) = sigmoid\,(z^{[2]})$$

$$L(a^{[2]}, y) = (y-1)\log(1-a^{[2]}) - y \log a^{[2]}$$

The derivative of the sigmoid function is:

$$a^{[2]'} = sigmoid\,(z^{[2]})' = \frac{\partial a^{[2]}}{\partial z^{[2]}} = a^{[2]}(1-a^{[2]})$$

The chain rule in the derivation of the compound function, the back propagation process:

$$da^{[2]} = \frac{\partial L(a^{[2]}, y)}{\partial a^{[2]}} = -\frac{y}{a^{[2]}} + \frac{1-y}{1-a^{[2]}}$$

$$dz^{[2]} = \frac{\partial L(a^{[2]}, y)}{\partial a^{[2]}} \cdot \frac{\partial a^{[2]}}{\partial z^{[2]}} = a^{[2]} - y$$

$$d\omega^{[2]} = \frac{\partial L(a^{[2]}, y)}{\partial a^{[2]}} \cdot \frac{\partial a^{[2]}}{\partial z^{[2]}} \cdot \frac{\partial z^{[2]}}{\partial \omega^{[2]}} = dz^{[2]} \cdot a^{[1]T}$$

$$db^{[2]} = \frac{\partial L(a^{[2]}, y)}{\partial a^{[2]}} \cdot \frac{\partial a^{[2]}}{\partial z^{[2]}} \cdot \frac{\partial z^{[2]}}{\partial b^{[2]}} = dz^{[2]}$$

$$da^{[1]} = \frac{\partial L(a^{[2]}, y)}{\partial a^{[2]}} \cdot \frac{\partial a^{[2]}}{\partial z^{[2]}} \cdot \frac{\partial z^{[2]}}{\partial a^{[1]}} = dz^{[2]} \cdot \omega^{[2]}$$

$$dz^{[1]} = \frac{\partial L(a^{[2]}, y)}{\partial a^{[2]}} \cdot \frac{\partial a^{[2]}}{\partial z^{[2]}} \cdot \frac{\partial z^{[2]}}{\partial a^{[1]}} \cdot \frac{\partial a^{[1]}}{\partial z^{[1]}} \quad dw^{[1]} = \frac{\partial L(a^{[2]}, y)}{\partial a^{[2]}} \cdot \frac{\partial a^{[2]}}{\partial z^{[2]}} \cdot \frac{\partial z^{[2]}}{\partial a[1]} \cdot \frac{\partial a[1]}{\partial z[1]} \cdot \frac{\partial z[1]}{\partial \omega[1]}$$

$$= dz^{[2]} \cdot \omega^{[2]} \times g^{'}(z^{[1]}) \qquad = dz^{[1]} \cdot X^{T}$$

$$db^{[1]} = \frac{\partial L(a^{[2]}, y)}{\partial a^{[2]}} \cdot \frac{\partial a^{[2]}}{\partial z^{[2]}} \cdot \frac{\partial z^{[2]}}{\partial a^{[1]}} \cdot \frac{\partial a^{[1]}}{\partial z^{[1]}} \cdot \frac{\partial z^{[1]}}{\partial b^{[1]}} = dz^{[1]}$$

Although the BP algorithm is very powerful, its shortcomings such as slow convergence, long training time, and easy to fall into the local optimal value have been criticized. Documents [1] and [2] have proposed individual variable learning rate algorithms and overall variable learning rate algorithms for this problem, but there is still room for optimization and

improvement. The improvement schemes of variable learning rate algorithms are proposed below.

Variable learning rate algorithm.

1）Individual variable learning rate

If the weight matrix of the input layer and the hidden layer is set to a_{ij} and the learning rate matrix is set to η, then the learning rate corresponding to the weight a_{ij} is η_{ij} [6]. $a_{ij}(n)$ is the value obtained after n iterations of the weight a_{ij}, then the learning rate corresponding to $n_{ij}(n)$ is $a_{ij}(n)$, and $E(n)$ is the global error obtained after the n th iteration. The adjustment method of the existing individual variable learning rate:

$$\eta_{(n+1)} = \begin{cases} 2\eta_{(n)} & E_{(n-1)} > E_{(n)} \\ 0.5\eta_{(n)} & E_{(n)} > E_{(n-1)} \end{cases}$$

2）Overall variable learning rate

Set b_{jk} as the weight matrix of the hidden layer and the output layer, η is the initial learning rate matrix, and its value range is [0,1], $\eta(n)$ represents the n th learning rate, and $E(n)$ represents the n th iteration. Global error. The dynamic adjustment rules for the overall learning rate are:

$$\eta_{(n+1)} = \begin{cases} 2\eta_{(n)} & E_{(n-1)} > E_{(n)} \\ 0.5\eta_{(n)} & E_{(n)} > E_{(n-1)} \end{cases}$$

Improved variable learning rate algorithm.

Since the existing variable learning rate algorithm is not perfect, an improved variable learning rate algorithm is proposed. The difference between the two iterations before and after the error is used to determine whether to increase the learning rate, and the magnitude of the change is determined in conjunction with the magnitude of the difference. Moreover, the variable step size uses the logarithm of the difference as a multiple of the unit step size, to realize the rapid adjustment of the learning rate of the system when the system quickly converges, and the slow adjustment of the learning rate when the system slowly converges to increase the convergence rate and reduce oscillations Possibility.

1）Improve individual variable learning rate

The improved individual variable learning rate algorithm is to set the weight matrix of the input layer and the hidden layer to a_{ij}, and the learning rate matrix to η, then the learning rate corresponding to the weight a_{ij} is η_{ij}. $a_{ij}(n)$ is the value obtained after n iterations of the weight a_{ij}, then the learning rate corresponding to $n_{ij}(n)$ is $a_{ij}(n)$, and $E(n)$ is the global error obtained after the n th iteration. *Sde* is the step size adjustment coefficient, and the improved variable learning rate adjustment method is:

$$\eta_{(n+1)} = \eta_{(n)} + \log(E_{(n)} - E_{(n-1)} + 1) \times Sde$$

When the error $E(n)$ of the n th iteration is less than the $(n-1)$th time, it means that the system has converged, then the learning rate increment is positive, the $(n+1)$ secondary learning rate is equal to $\eta(n)$ plus a positive number, the learning rate increases, otherwise the learning The rate decreases. In this way, the learning rate of the weight matrix a_{ij} is dynamically adjusted repeatedly until the global error is smaller than the target value.

2）Improve overall variable learning rate

Let b_{jk} be the weight matrix of the hidden layer and the output layer, η is the initial learning rate matrix, its value range is $[0,1]$, η is the initial learning rate matrix, and its value

range is $[0,1]$, $\eta(n)$ represents the learning rate of the n th time, and $E(n)$ represents the global error of the n th iteration. The dynamic adjustment rules to improve the overall learning rate are:

$$\eta_{(n+1)} = \eta_{(n)} + \log(E_{(n)} - E_{(n-1)} + 1) \times Sde$$

When the error $E(n)$ of the n th iteration is less than the $(n-1)$th time, it means that the system has converged, then the learning rate increment is positive, the $(n+1)$ secondary learning rate is equal to $\eta(n)$ plus a positive number, the learning rate increases, otherwise the learning The rate decreases. In this way, the learning rate of the weight matrix b_{jk} is dynamically adjusted repeatedly until the global error is less than the target value.

In the same way, the threshold matrix between the hidden layer and the output layer is also dynamically adjusted by changing the learning rate as a whole.

Improved variable learning rate algorithm for wind power fault detection.

The main parameters during the operation of the wind turbine include multiple parameters such as power factor setting value, aircraft position, tower acceleration, transmission system acceleration, and cabin rotation [7]. There are many parameters, so you need to use the RelieF algorithm to rank the original parameter weights for the original data, and select the parameters with higher weighted feature parameter weights.

Table 1 - Feature parameter weight ranking

Serial number	Parameter Description	Weight
1	Pitch cabinet 1 temperature (℃)	0.0236
2	NG5 1 temperature (℃)	0.0236
3	Temperature of air inlet at the bottom of tower (℃)	0.0163
4	Engine room temperature (℃)	0.0154
5	Grid side reactor 2 temperature (℃)	0.0154
6	LVD control cabinet cabinet temperature (℃)	0.0118
7	Control cabinet temperature (℃)	0.0117
8	Data availability	0.0106
9	Topbox temperature (℃)	0.0095
10	Converter DC voltage positive (V)	0.0085

Figure 3 shows the error curve of the standard BP neural network with the number of training cycles. It can be seen that the minimum error is reached when the number of iterations reaches 1000 (the maximum cycle number limit).

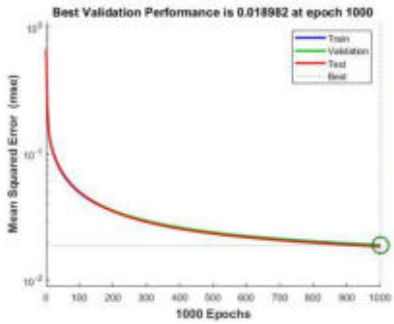

Figure 3 - Standard BP neural network error graph

The error of the BP neural network with variable learning rate changes with the number of training cycles as shown in Figure 4. The minimum error of its training reaches the minimum value at the 149th cycle, which is greatly reduced compared to the standard BP neural network training times.

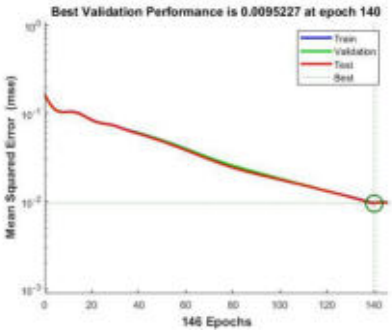

Figure 4 - Error graph of BP network with variable learning rate

The change of the training error of the improved variable learning rate BP neural network with the number of training cycles is shown in Figure 5. The error of the improved variable learning rate BP neural network reaches the minimum at the 93rd cycle, which is reduced compared to the variable learning rate 47 cycles.

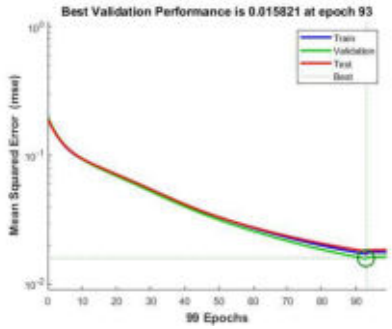

Figure 5 - Error graph of improved BP network with variable learning rate

The training results of standard BP neural network, variable learning rate BP neural network and improved variable learning rate BP neural network are shown in Table 3-2. The improved variable learning rate BP neural network reduces the number of training cycles by 33% compared to the variable learning rate BP neural network. Therefore, improving the variable learning rate BP network can significantly shorten the model training time and improve the efficiency compared to the variable learning rate BP network.

Table 2 - Comparison between standard BP and improved BP

	Standard BP	Variable learning rate BP	Improve variable learning rate BP
Optimal training times	1000+	140	93
End of training error	0.018982	0.0095227	0.015821

This paper proposes an improved variable learning rate BP neural network used for wind turbine fault detection. By calculating the difference between the last two training errors, the training step size of the BP neural network is dynamically adjusted to shorten the training time and improve the training error. The purpose of convergence speed. This paper compares the curves of the error of the improved variable learning rate BP neural network and the variable learning rate BP neural network and the standard BP neural network with the number of training cycles, and uses the actual wind turbine operation data to improve the variable learning rate BP neural network. The convergence performance of the network is verified. On the one hand, it proves that the improved variable learning rate algorithm can shorten the training time compared with the variable learning rate algorithm. On the other hand, it proves the applicability of the improved variable learning rate BP neural network for wind turbine fault detection.

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LOGISTICS OF ORE MASS FLOWS FROM MILLS TO THE RECEIVING BUNKER OF THE BAR IN THE POTASSIUM MINE

Monitoring and predicting the quality of mined rock mass in potash mines is a complex task associated with a large number of simultaneously working faces located at different stages of the technological cycle, various quality indicators in each of them, large distances of rock mass movement, many ore mixing nodes on the main conveyors. The relevance of this problem is determined by the general decrease in the quality of ore at enterprises, the increasing complexity of mining, and the increased requirements on the part of environmental authorities for the volume of rock stored in salt tailings pile.

The panel belts of potash mines are equipped with ultrasonic level gauges that fix the level of ore on a moving belt and give indications of this level in graphical and digital forms (trends) with a increment of 5 sec. The use of these gauges for modeling the logistics of rock mass movement is proposed. It seems possible to determine the position of the shearer in the face at the end of the shift. Knowing the image that the sensor is currently giving, it is possible to determine the position of the shearer in the lava. To solve this kind of problem, it is necessary to consider the time of passing the ore flow from the shearer to the level gauge - we will call this time the term "lag time". It is known that the time of movement of ore depends on the length of the path and the speed of movement. In almost all mines, this path is represented by a conveyor system consisting of the following: face belt, panel and main conveyors. The speed of the main conveyors varies depending on the load on them, which means that the time of movement of the ore flow will constantly change. Therefore, the path length will be the length of the conveyors, which is presented as the parameter “L”, and the speed as the parameter “V”. Then the simplified formula for determining the travel time will have the form: $t = Lz / Vz + Lp / Vp + Lm / Vm.$, where the indices: z, p and m denote the face belt, panel and main conveyors, respectively. The face belts and panel conveyors move at a constant speed, so we can take the values of their speeds as $Vz = const$, $Vp = const$. But for a face conveyor, a variable parameter is the distance, which depends on the position of the shearer in the mine. Taking this factor into account, we mark it with the parameter dL. As for the main conveyor, its variable parameter is the speed of movement and it changes depending on the amount of ore supplied to it (controlled electric drive). This is due to the fact that when operating several lavas at the same time, the main conveyors cope with the load. From the technical characteristics of the conveyors, we determine the minimum 0.315 m/s and the maximum speed 3.15 m/s. Also, from the experience of the mine, we find out the minimum and maximum load on the conveyor. Then the variable parameter of the speed of the belt of the main conveyor can be represented as a linear dependence of the speed on the load $V = k (Q)$. Knowing the level gauge, it is also possible to determine the position of the shearer in the lava. To do this, you need to know the time during which the last ore will reach it (the term "lag time"). The concept of this term has a range of meanings and is different for each technological operation. Therefore, it can be argued that the boundaries of this range will be the extreme values of the lag time of each technological operation. That is, the values of the lag time at which the shearer completes a certain technological operation. Ore lag time directly depends on the length of its movement from the bottom to the level gauge. Since the shearer moves from the lava ventilation drift (LVD) to the

lava conveyor drift (LCD), then, as you approach the LCD, the time for which the last ore of the technological cycle reaches the level gauge will be significantly less than the time for which the ore would go from LVD. Thus, we can assign each point of the ore lag time a point. At each technological process, the number of n points is formed. Knowing what technological operation the gauge and its extreme point are showing at the current moment of time, we can determine the lag time of the last ore that he recorded. In order to determine the final position of the shearer, it is enough to know the speed with which the combine moves in this technological operation. Having learned the distance that the shearer managed to travel while the last ore reached the level gauge, we will determine its true position in the lava.

Knowing the technological parameters of the lava, as well as the speed of the shearer in different technological processes, we can mathematically determine the time during which one chip of the mineral is removed. Since the time of a working shift lasts 6 hours, we can not only determine the number of chips that the shearer removes for a certain time interval, but also the remaining time that falls on a new technological cycle. The advantage of this method is the simplicity of calculation and the accuracy of determining the parameters of the cycle.

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CONDUCTING DATA MINING OF HOT-ROLLING SETTINGS QUALITY BY APPLYING MACHINE LEARNING ALGORITHMS

The main purpose in the field of hot-rolling production is to produce competitive products of high quality. Continuous improvements of the production processes are required to ensure proper quality. Flatness and geometric parameters are among of the most important quality parameters of hot-rolled strip, to which the majority of enterprises have the highest requirements[1]. The formation of flatness and geometry of strips at the hot-rolling process depends on a large number of factors of technological process: cross-section of the semi-finished rolled stock, its temperature varying when passing through the mill train, profiling of roll bodies, wear, thermal profile and cooling intensity of rolls, distribution of drafts per pass, the interstand tension, the stand stiffness, etc.

In view of the foregoing, the author of this work has set himself a complex scientific and technical task related to the development of a mathematical model of the hot-rolling process at a wide-strip continuous mill, which will take into account many factors affecting the quality of produced products by applying Machine Learning Algorithms[2].

The hot rolling process is a dynamically varying process, as during the manufacturing process there is a change in the factors that influence the process itself, a change in the roll profile due to wear, a variation in the temperature parameters of the rolled stock, a change in the steel grades and sizes of the products rolled at the hot rolling mill, a variation in the cross section and longitudinal profile of the semi-finished rolled stock.

There are many options for automation of hot rolling mills. They allow controlling hot rolling process. But current technology is unable to automate all desired tasks. Some tasks cannot be easily automated, because there are factors of production process that is impossible to

consider their influence and to estimate their change. Therefore using machine learning algorithms allow solving these issues. Applying Machine Learning Algorithms will allow using of Predictive Technologies to forecast the quality of the setting parameters of the hot rolling mill and, accordingly, their timely adjustment, which will allow responding more quickly to changes in the system, which in turn will affect the quality of the final product. It should be noted that many databases affecting the hot rolling process and, accordingly, the quality of the rolled stock would be taken into account, namely temperature of semi-finished rolled stock, thickness and width of semi-finished rolled stock, shape of semi-finished rolled stock, and the current rolls profile of rolling stand[4].

Data analysis and building machine learning models will be done using the Python programming language[3]. The use of modules such as pandas, seaborn, keras, scikit learn, etc., will allow to prepare data for analysis, carry out regression analysis of influence of production process factors on quality indicators of rolled products, visualize them, and build a machine learning model from the results of analysis. By using the Python programming language a web-application will be created as well, which will process databases online, output display messages to the interface to the user about the need to configure make settings to the system, as well as to be able to perform control action on the system to get the ability to control the system[5].

The development model of machine learning have permitted obtaining regression dependencies of parameters and factors of the hot rolling process that are not to consider. Mathematical model and machine learning model have allowed using the predictive technology to forecast the quality of the setting parameters of the hot rolling mill. The implementation of these models will allow changing the mill settings before and during the hot rolling process. Using models will improve quality of hot-rolled products. The first stages of testing models show a significant reduction in products of inappropriate quality. It should be noted that these models will be useful when developing new kind of hot-rolled products.

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APPLICATION OF MEASURES TO ENSURE INFORMATION SECURITY OF THE BANKING SECTOR IN THE FIELD OF MINING INDUSTRY

Any market participants' activity is subject to negative influence of external factors. Socio-economic, political factors, illegal actions of competitors, including fraudulent actions can have a negative impact. Fraudsters' operations to steal confidential information and money are becoming more sophisticated. Despite the measures taken to maintain the economic and information security of data and property, the banking sector is not an exception, along with

other financial organizations it is subject to adverse effects. Development of remote methods of customer service and usage of electronic payment instrument, economy digitalization are also expanding and areas potentially exposed to risk and cyber attacks. Banks are responsible for maintaining the confidentiality of customer information, as well as their funds and valuables. As part of ensuring economic security, banks also resist cyber attacks, what is especially relevant at present. Application of measures to reduce the risk of cyber attacks requires an comprehension of the impact to be resisted, for which research is conducted on both vulnerabilities of banking technologies, as well as possible threats and their sources.

Introduction of new products and business processes is increasingly dependent on information technology. Disrupting systems, introducing malware, compromising information, and obtaining unauthorized access has significant consequences for business profitability, reputation, and counterparty trust. In order to protect commercial confidentiality of enterprises, it is advisable to adopt the experience of the banking sector, since it is associated with increased risks due to its specificity. Unauthorized, deliberate attempt and exploitation of computer systems, technological enterprises and networks and constitutes a cyber attack. The main types of cyber attacks include: phishing, trojans, distributed denial-of-service, botnet, JavaScript sniffer, worm (network worm), rootkit, fraud. Regular monitoring and study of new types of cyber attacks and tools used by hackers makes it possible to more effectively counter threats [1].

According to the indicators of the three quarters of 2019, 61 attacks were made on financial organizations, in 2018 – 92. Hackers penetrated the local network of financial organizations using phishing (74%) and malicious software (80%).The total number of transactions made without the consent of customers of individuals and legal entities using electronic means of payment in 2019 amounted to about 576 thousand units in the amount of 6.4 billion rubles. Banks compensation for transactions amounted to 935 million rubles, or 14.55% of the total amount. For operations of legal entities in 2019, 4,609 transactions were reported without the client's consent. The total amount of theft was 701 million rubles. banks reimbursed corporate sector clients about 10% or 65 million rubles[2]. The use of malicious software, phishing, and social engineering are the main ways to gain unauthorized access to user information. The problem of not being able to ensure their own information security is still relevant among users. According to by Positive Technologies experts research, 92% of web applications are not protected from attacks on users. Due to site security flaws, hackers are not only able to control the web application, but also the server, which allows them to distribute malicious software and use JavaScript sniffers to access confidential data. The trend towards increasing Internet traffic indicates the importance of this problem and the need to solve it. The use of two-phase payer authentication will improve the security of banking systems, card payments and contactless payments. Two-phase authentication involves checking two of the three elements (PIN, fingerprint, face, etc.), for example, after making several contactless payments, you need to insert the card into the chip reader, and enter the PIN or log in using your fingerprint. Most Internet services use double authentication when granting users access to their accounts, which reduces the number of attacks. Also, to reduce the number of fraudulent transactions, it is necessary to improve the level of qualification of employees in the field of information security, in order to counteract attempts to steal information, as well as electronic money.

In order to increase production efficiency, mining and processing enterprises use the latest technologies. When developing deposits, it is necessary to closely monitor compliance with environmental requirements [3]. The energy industry is no exception and is also engaged in developments in the field of energy production without compromising the environment. Today, the problems of ecology and production are closely interrelated and insufficiently studied. In addition to maintaining the confidentiality of production processes, it is also necessary to carefully treat any kind of development. New technologies and developments of leading research are subject to increased risk from the point of view of information theft from competitors. The source of access can be software infected with virus programs, or theft of access data to an

account, PC, or email. It is not uncommon for the human factor to become a problem of information security. In order to protect commercial secrets of enterprises, it is advisable to adopt the experience of the banking sector, since it is associated with increased risks due to its specificity.

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ASSESSMENT AND COMPARISON OF IMAGE BASED FRAGMENTATION MEASUREMENTS USING NEURONAL NETWORKS

The data acquisition for this project on the styrian Erzberg in Austria was part of the „Sustainable Low Impact Mining- Project“ (SLIM- Project). Besides the Erzberg also other big quarries like the “Orgiva” mine in Spain and the “El Aljibe” mine were chosen for the data collection. The Erzberg is one of the biggest quarries in Central Europe and has the biggest deposit of Siderite (an iron containing mineral, which is utilized to produce steel) in the world. The aim was to find mining solutions to improve the efficiency of the quarries and to minimize the environmental impact. [1]

Improved algorithms to determine the fragmentation of blasted rock were implemented to assess the influence of adopted blasting methods on the downstream process.

In the software “Analytical and Self- learning Programme for Mechanical Seeing” (ASPS) a software exclusively programmed for the SLIM- Project, the implemented neural networks show a self- learning character. With these neural networks, fragments with a diameter of a few centimeters up to several meters can be detected. Afterwards a sieving curve can be drawn by separating the detected stones into different sieving classes. Detecting the grain size distribution of every muck pile of every blasting site in the quarry with this simple procedure, may help to produce a more consistent quality of the blasted material and lower the overall cost of the mining process.

About 50 images of the truck unloading into the crusher were chosen to be evaluated by the software in a first test. During the image taking, the aim was to take the pictures from a spot where the cameras are aligned with the centre of the body of the truck, to minimize the image distortion. This was important because of the scaling aspect. In the images the reference length was the width of the body of the trucks. It was visible during the entire unloading process and was not connected to the camera.

By utilizing the modern Mask R-CNN (Convolutional Neural Networks) [2] algorithm, edge detection software like in already existing programmes becomes obsolete. Mask R-CNN executes an object instance segmentation and we received all required data like area, boundaries, boundary boxes and confidence intervals. [3]

The software was previous mostly tested under laboratory conditions, so the network had to be trained to be able to distinct between rock- like fragments and the background. This was

done by annotating some of the images, this means delineating fragments manually with an online freeware, programmed by employees of the Oxford University, called VIA (Visual Image Annotator).

After training this network with prior annotated images, single grains are detectable and ellipses (or circles) are fitted around the form of the fragments automatically. With this ellipse (or circle) it is possible to approximate the area and the diameter of the fragment. The more stones are detected, the more accurate the grain size distribution will be. [3]

Sieving Curves can be described by the coefficient of gradation (Cc) and the coefficient of uniformity (Cu). A further important indicator to evaluate sieving curves is the median or x50-value. This value means that 50% of the fragments are bigger and 50% are smaller than this grain size.

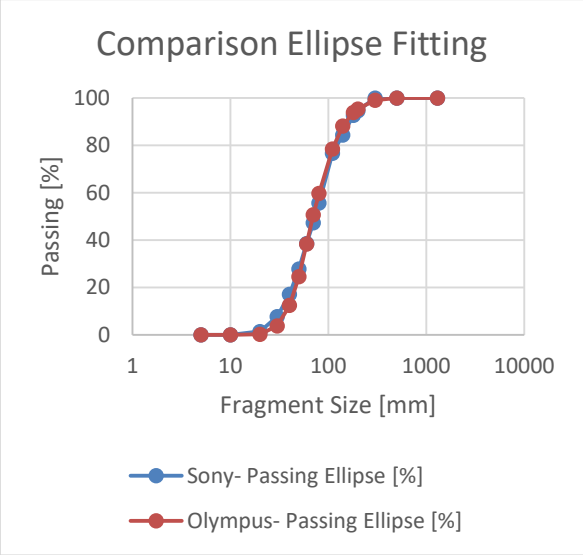

Figure 1 - Comparison Ellipse Fitting

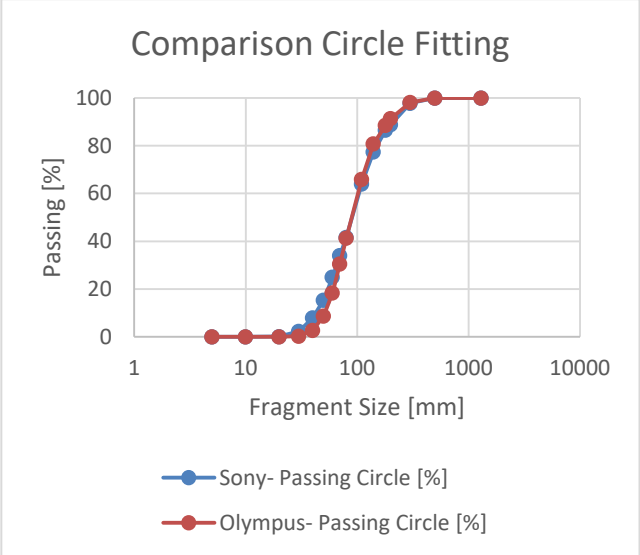

Figure 2 - Comparison Circle Fitting

The problem with the light conditions seemed to have an impact regarding the Olympus camera, because of dark spots between recognised fragments. Despite these visible problems, the sieving curves are almost equal except for the smaller grain sizes, where the programme seemed to find more fragments in the images of the Sony camera.

This first test with relatively little trainings data and just a few analysed images shows the potential of photogrammetric surveys. Not only unmanned aerial vehicles (UAVs) can be utilized for a muck pile survey, but also cameras positioned at the crusher facing the truck dumping the material. If the computing of the fragment size distribution can be automated, the quality control may happen in real time. The crusher and the following comminution stages can be adapted to the material coming in. Further on the detection of oversize rocks, or too fine material (the finer the material, the more energy went into the blasted rock), may help the chief blaster to adjust the charge concentration in future blast operations. This improvement will not only reduce crushing costs and loading time, but also the amount of the required explosives and the time and manpower needed to crush oversize rocks with an impact hammer mounted on an excavator.

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DIGITAL APPLICATIONS IN THE RESTUDY OF THE SB-AU DEPOSIT BRANDHOLZ-GOLDKRONACH IN BAVARIA (GERMANY)

The Brandholz-Goldkronach Deposit (Fichtelgebirge, Bavaria, Germany) is a unique Sb-Au-ore deposit in the Fichtelgebirge-Erzgebirge Anticlinorium [1]. In the frame of a doctoral thesis on the mineralization of this deposit, various techniques of digitizing the samples are employed and evaluated. In the Goldkronach Au-district, the last mining activity ceased around 1926 [2] and the last comprehensive work on the petrogenesis was carried out in 1992 [3]. Thereafter, only smaller studies focusing on comparative purposes or mineral description have dealt with the Goldkronach Deposit. Due to the fact that the deposit has been closed since almost 100 years, it is difficult to obtain useable sample material. An important source of material are geoscientific collections, but in this case, the samples are available for analyses only to a limited extent and can even be of historical value.

Digital documentation and analysis methods can partly replace destructive analytics or, when this is impossible, they should at least be used to conserve the state of the samples before destructive preparation. This motivates development, evaluation and adjustment of digitization procedures for ore samples and combination thereof into automated detection methods within the ESF (European Social Fund)-funded project "G.O.D.S." (Geoscientific Objects Digitization Standards). This contribution focuses on the application of specimen photography, photogrammetry, surface scanning and computed tomography to ore samples. The photography of objects in broader sense is usually applied to the sample material pre-preparation. It should be mentioned that this should be done before and after the sample destruction (e.g. cutting). However, photogrammetric or laser-scanning based spatial recording of sample material have so far been the exception in the economic geology. Photogrammetry is a non-contact measurement method in which images of an object can be used to indirectly determine its shape, as well as for deriving a 3D model of this object. Laser-scanning can be based on two different methodologies. On the one hand the running time of the wavelength of laser-light was detected and on the other hand the light radiation from different directions was triangulated. Both allows to record relief differences in the µm-range on the objects surface. In context of 3D-digitization, the laser-scanning method is therefore mainly suitable for relief detecting and photogrammetry for surface-texture imaging of an object.

Another non-destructive imaging method is the computerized transverse axial tomography (CT), that based on the penetration of a X-ray beam to the object in relation to the weakening coefficient of the individual phases inside of the object in combination with the atomic number of the atoms inside them [4].

A total of 35 samples from the Ore Deposit Collection of the TU Bergakademie Freiberg was selected for the investigation. Some of the objects were sampled by renowned researchers, such as Carl Richard BECK and Friedrich SCHUMACHER, more than 100 years ago.

Until now, photogrammetry was applied to 13 samples and CT was performed on seven samples. For the photogrammetry, a NIKON D7200 DSLR camera (24.2 MP 23.5 x 15.6 mm CMOS sensor) was used in combination with a NIKKOR AF-S MICRO 40 mm f2.8 at a constant aperture of f8. The images were taken as NEF and JPG (low compression level) files,

whereby only the JPG files were used to obtain the 3D models using the software 3DF ZEPHYR. With this software, more than 1 mil triangulation points per 3D model could be calculated.

The CT measurements were made with a CT-ALPHA device from ProCon X-Ray GmbH Garbsen. The device contains a 160 kV transmission tube and a Dexela 1512 detector (Perkins Elmer, 1944 x 1526 px resolution). Measurements were obtained at 150 kV and 85 A with 800 steps and 1.5 s recording time per image. Due to the geometrical arrangement, a 1.35 x magnification was achieved with an effective voxel size (after reconstruction) of 55.17 µm.

Digital images and models obtained from these methods can still be considered after destroying and preparing a sample. With regard to data from further analytical methods, a variety of possible application and coupling possibilities arise. Various analytical methods, such as MLA (Mineral Liberation Analysis), EPMA (Electron Probe Micro Analysis) and isotope geochemistry, were carried out as part of the doctoral thesis and further analyses are planned. We aim at combining the various analysis results within a digital model of the sample. The intention is to create one individual digital object in which all data from several digitization methods and also further analyses are embedded.

A comparison of surface models obtained from photogrammetry and laser-scanning is still pending. In principle, a coupling of both methods for surface 3D digitization is preferable.

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IMAGE STEGANOGRAPHY FOR DATA SECURITY IN MINING INDUSTRY

For data confidentiality and integrity ensuring there are two main approaches: steganography and cryptography. In case of cryptography the information is encrypted and passed to the recipient or saved on the local machine [1]. In case of steganography the information is hidden in an image-container which is passed as a regular message or saved as a simple picture raising no suspicion [2]. Data security is especially important for modern large mining enterprises because they often have several divisions in their structure which can be in different locations (regions, countries, and continents). They might also be associated with partner organizations and have various contract companies. Considering that there is a constant flow of information in large volumes between the company's divisions, partner organizations, and contractors, data confidentiality and integrity for storage, transfer and administration becomes an important security issue for the company.

Steganography in images is often used for threating such threats, because in this case, the attacker will not suspect about the existence of confidential information. But even in that case, if some kind of a pattern is used, e.g., hiding the information in successive or every third pixel, the attacker might discover the pattern and the following revelation of the secret information will cause no difficulties. To avoid such cases, it is proposed to use a pre-determined mathematical

function, unknown to the attacker, as a key to choose pixels of the image-container in which secret information should be embedded using the LSB (Least Significant Bit) method [3]. In order to for the person who is allowed to access the information, it is necessary to secretly transfer the function f (x) to him. This can be done directly during a meeting or through the RSA algorithm. The mathematical function can be changed over time to neutralize any progress made by the attacker to find the key. TIFF Format is chosen as an image-container since it is used for saving and editing large-scale and high-quality images. The TIFF format does not have to be compressed or can be compressed with a lossless algorithm, which makes this format popular for graphic designers, photographers, and in the print media. TIFF format also provides 16 bits for each color in RGB color modeled pixel, unlike the commonly used JPEG and PNG, each providing only 8 bits.

The program receives the secret message, the mathematical function, and the image-container, in which the secret information will be hidden. The secret message is converted into a binary sequence. The program reads the image, gets its dimensions, size, and color model. Depending on the color model, it is determined how many layers each pixel consists of. By calculating the number of pixels available and multiplying that number by the number of layers, we determine the number of bits for hiding. It is made sure that the information can fit in the image by comparing the derived number with the size of the secret information.

A graph of the mathematical function is created, which is imaginatively overlaid on the image, creating an array of pixels under the mentioned graph. Array of pixels will be used for hiding the secret message. Some complications may occur while overlaying the graph and the image-container: pixels under the graph might have negative value, not be an integer or even not fit within the image borders. These problems are solved by modulation, rounding, scaling or various combinations of them. During scaling, the maximum value of the function is divided by the number of horizontal pixels in the image. This gives us the scaling factor used to scale the entire graph. Sometimes, the values of the function can be negative. In such cases the value is modulated before scaling. After these operations, LSB method is used. This method substitutes least significant bits' values of the selected pixels' bytes in the image-container by the required values, after which the changes are not visible to an unarmed human eye.

As a result of proposed method, a program is created that hides confidential information in the image. The TIFF format is chosen because it provides 16 bits for each color and it can be used to store twice as much information if needed. It is desirable for the selected image-container to be colored, because in that case there are 3 bytes available for each pixel - red, green, and blue, and it is possible to hide the information in each byte. LSB method changes the least significant bits' values to the required ones in the pixel, and it is chosen because this method of encoding is not detectable by unarmed eye. The position of the pixels with the bits, containing the secret message, are seemingly random, because a graph is used for picking pixels for hiding, and therefore it is very hard for the attacker to reveal if he does not have the mathematical function or the image before the embedment.

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DIGITAL TWIN AS A DRIVER OF SUSTAINABLE DEVELOPMENT IN MINING INDUSTRY

Despite the widespread adoption of digital technologies, the mining industry cannot boast of digitalization of all processes and stages of production. This is due to the complexity of the organization of production and its specific nature. However, it is the mining industry that has the high potential for introducing digital innovations because of the increasing requirements for safety and the transition to the development of fields located in particularly complicated conditions. According to Ernst&Young experts [1], the level of use of digital technologies in the mining industry will steadily increase. As the main advantages of such an implementation are mainly seen the production increase and the operating costs reduction, while digitalization will help solve one of the central problems of mining production - increasing the level of safety and reducing specific mining and geological risks.

One of the latest technologies introduced by industrial enterprises is digital twins. Digital twins that simulate the operation of equipment or the course of individual processes have been used in production for a relatively long time and have proved their benefits [2]. However, today it becomes possible to develop digital models that illustrate the set of ongoing production processes. For the mining industry, this means not just building a computer model of the mining site to obtain information on the extraction, but aggregating all the ongoing processes and collecting data for their subsequent use. Thus, the digital twin is a specific intangible asset of an enterprise - a digital mineral asset – which exists only at mining enterprises and provide them with competitive advantages for all the stakeholders. First of all, these advantages are expressed in the possibility of a comprehensive analysis of the incoming information and its subsequent use to prevent accidents [3].

In relation to the digital twin of the deposit, potential benefits can be nominally divided into four groups based on beneficiary parties: benefits for workers, engineers, management and business owners (Table 1). However, some of them may be relevant for several groups simultaneously.

Table 1 - Benefits of using a digital twin at a mining enterprise [4]

Stakeholder	Benefits
Workers	• optimization of the division of responsibilities • reduction of time spent on searching tools and organizing a workplace • optimization of escape routes • improvement of the air pollution control system
Engineers	• reduction of geological uncertainty • reduction of mining losses and ore dilution • equipment productivity growth • improvement of the organization of repairs • optimization of energy use • optimization of underground space use • reduction of downtime • establishing empirical dependencies for use in subsequent calculations
Managers	• availability of operational information on production processes • possibility of "early" warning of losses, including through preventing damage • flexibility in decision making, including investment ones
Owner	• production safety increase • employees number optimization • increased company’s competitiveness, in particular due to the image component

This is the role of the intangible digital asset in reducing production risks. The accumulated information about the conditions of work, the properties and characteristics of the enclosing rocks allows predicting events with higher accuracy and modeling them on the basis of a large amount of data. This enables the company to predict, evaluate and reduce the likelihood of unforeseen events, such as explosions of mine gases, rock collapses and flooding of mine workings, leading to harm to human health and their death. The development of a mechanism for constructing a digital twin and calculating its efficiency is a further task that will be solved in the next part of the research.

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MATHEMATICAL STRUCTURAL RECOGNITION OF ROCKS

The University of TU Freiberg is working to establish a center for digitization in the state of Saxony and this center includes five departments The ore deposit collection, the Core sample, building and decorative rock plates, fossils, and the last project is Mathematical structure recognition using neural networks. Where this project is related to all other projects because it works to organize the database of projects and for this project also close association with the construction of rock panels because it works to create an algorithm to classify stones into three types (Magmatite, Metamorphite, Sedimentite) where this project facilitates the classification process and accelerates them. This project is based on finding patterns to facilitate identification and working with data by the public, as the identification of rock types There needs to be an expert in rocks and Earth sciences' and rock slabs and a place to put them in. Then the expert will be able to classify rocks and find important criteria for each type of rock and also this process needs a lot of time and effort to develop a classification for each type of rock, But when using the computer and mathematical structure, the classification of rocks becomes easy and fast, and it only needs the computer and some auxiliary programs such as (Matlab), and this will shorten the time and effort.

We classify rock images into three groups (Magmatite, Metamorphite, Sedimentite), using thirty images. The first group includes ten pictures of all kinds of rocks belonging to the Magmatite, the second group includes ten pictures, and the third groups also have ten pictures, and these thirty images are very few for classification and for the accuracy of classification as well, but this is a good start to create an algorithm to classify the rocks, the image group was very large "2700 x 3200" and in "Tiff" format, as this format is very accurate and also has a large size. Where we will use these images as a basis to extract patterns and features that distinguish each type separately and use these features and patterns to classify the rest of the images based on them, and one of the most important criteria and features that we relied on in classification of

images are the characteristics of the texture because they are the most accurate in classification, then we rely on the rest of the criteria such as color , Grain size and grain size distribution, which is why we first compiled images, selected edges, set the fixed size for all images, and converted them to grayscale images.

After editing the pictures, we started using computer vision algorithms to obtain texture features from each group of images where each image was represented as a number, then we used a machine learning algorithm to classify these features (numbers) for each group of images, we can test any new image by applying vision algorithms The computer and the

representation of this image as a number and the representation of this number by machine learn algorithm to see this image belong to which group.

We can test any new picture by applying computer vision algorithms, representing this picture as a number and representing this number by a machine learning algorithm to see this image belongs to any group.

We used the algorithm of the "Bag of visual words" to classify the texture and the result was positive as the accuracy reached 90%, and we are trying to increase the accuracy by adding some new features to support the old feature such as color, grain size and grain size distribution.

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ENROLLMENT OF CLOUD SOLUTION IN OIL AND GAS INDUSTRY

In this 21st century technological era, digitalization has become one of the hottest topics among organizations. It goes without saying that oil and gas industries are leaning towards future by investing in digitalization of field sites and respective processes of oil and gas production. Migration of all IT infrastructure in industry to a cloud based computing is risky but at the same time rewarding phase in overall digitalization process. This thesis will reveal all pros and cons of cloud computing enrollment in oil and gas companies and recommendations on proper deployment/introduction in cloud computing environment.

First of all it is better to define overall definition of cloud solution (computing), it is full availability of computing system resources such as data (cloud) storage and computing power via the internet and through another provider's shared cloud computing infrastructure such as Amazon, Microsoft and Google [1]. Cloud computing has several types of services depending on infrastructure requirement of a user (company): IaaS (Infrastructure as a Service), PaaS (Platform as a Service), SaaS (Software as a Service) [2]. Most suitable choice of service for oil and gas company would be SaaS – Software as a Service, because it will transfer all hardware and data monitoring activities to a vendor thus will reduce significant amount of workload and expenses from the company (client). From the economical point of view by reducing staff who maintain on premise IT infrastructure and optimizing recurring procurement of hardware power

costs will provide significant amount of budget for further investments to a new developments. Currently, oil and gas companies run all their respective IT infrastructure locally on their premises. At the same time, other companies use hybrid cloud solution that stores part of their data in the cloud and remaining infrastructure on premise. It is found to be more liability to maintain all data and IT services on premise as hardware servers age with time and will require additional resources and work to monitor servers' health and security on daily basis.

Nevertheless, upstream industry faces several technical challenges—most notably, a pronounced emphasis on data security, a reliance on extremely large data sets, and significant legacy investments in information technology infrastructure—that make a full migration to the cloud difficult at present [3]. Most of them are due to law and regulations of a specific country that company operates under. Such agreements and binding documents do not consider cloud solution aspects and how data shall be stored due to the fact that most of documents were released early 2000's. In fact, it does create complications in driving towards cloud computing environment where oil industry shall "pay per use" for such services. In contrast to security regulations, cloud solution proves that it is more resilient in Disaster Recover Plan, as it is secured not only by security barriers of the company itself but also by cloud provider that daily 24/7 monitors health of these services and simulates fastest routes to a recovery.

Full enrollment of cloud solution for oil and gas industry is achievable and more realistic as (ever) it seems. By implementing full cloud computing to an industry, it is expected to see significant results: minimum management and cost, accessibility and pay per use, reliability and data control [4]. However, it will require initial makeover of main operating agreement with governmental authority to reconsider/allow storing data in the cloud. That's is why, only due to this reason, it is highly individual case of enrolling cloud solution into a company, because of specific country's regulations and laws that company operates on (under).

As shown in thesis, at this moment oil and gas companies are not ready for a full migration to a cloud solution due to legal restrictions with data storage (depending on regions). As a part of digitalization initiate, it is inevitable future that will probably fall into place in a way that makes full cloud solution a far more attractive option for the upstream oil & gas industry in the years ahead.

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CONTROLLED PARAMETERS OF THE PETROLEUM COKE CALCINATING PROCESS IN A ROTARY TUBULAR KILN

Petroleum coke is a solid residue got as the result of oil and petroleum products processing, consisting mainly of pure carbon. Coke is a link between the refinery and metallurgical industries. It is used for manufacturing electrodes and corrosion-resistant equipment [1]. The quality of the crude oil used for the production of coke affect the degree of carbon fragments ordering in the granules of the produced raw material.

Calcined coke is produced from green petcoke by calcination. Green coke is usually calcined in tubular rotary kilns under harsh temperature conditions. The purpose of such procedures is final product quality improvement.

Calcination is a method of various types of raw materials processing by means of directed thermal action, which results induce stabilization of the substance. In order for green coke will be qualitatively transformed and got new physical and chemical properties inherent the calcined product, it is necessary to impact on the granules of the material in a special way, creating favorable conditions for the homogeneous flow of the calcinating process inside the bulk mass.

As a result of calcination volatile matters, sulfur, and other impurities are burnt from the coke, and its granularity increases. The structure of calcined granules changes, the actual density of the coke and its crystals length growth. Coke begins to demonstrate excellent electrical and heat-resistant properties.

It is possible to influence the calcination process by the adjusting the coke heating rate to the decomposition reaction temperature, the maximum calcination temperature, and the coke holding time holding the coke under the created conditions. For getting best calcination conditions, it is necessary to find the optimal size of the furnace, temperature mode and time of calcination. During determination of these parameters, it is necessary to focus on the temperature profiles of existing coke rotary kilns.

Due to the combustion of volatile matters in the reaction zone, the heating rate can increase sharply. As the heating rate increases, the porosity increases respectively [2].

The temperature in calcination zone should reach 1200 °C directly. Modern rotary kilns are designed being able maintain the appropriate temperature approximately along the half of their body's length. In practice, the time spent in reaction zone in such furnaces is quite enough for the grain size increasing and qualitatively restruction by increasing the length of the crystals.

If the optimum temperature and heating rate are found in the system, the size of the crystals and the actual density of coke will increase with increasing calcination time. The of apparent density and porosity characteristics will range increasing to a maximum over time and then decreasing slowly.

The determination of optimum calcination conditions is a complex task. The best results of calcinating should demonstrate the medium-sized grain coke. The optimum temperature and calcination time will be found based on the temperature profiles of the rotary tube kilns [3].

The search and formalization of optimal calcinating characteristics should allow to formulate the method by which green coke is calcined and converted into high-quality product suitable for the production of anodes. With the help of the formulated dependencies, it will be possible to create a mathematical model of the process inside coke rotary tube kiln. With the help of a mathematical model of the furnace, it should be possible formulate optimal control laws of the coke calcinating process.

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AUGMENTED REALITY LABORATORY «VIRTUAL LAB»

The «Virtual laboratory» project is to develop software that helps to do laboratory work and train specialists in the field of oil and gas processing equipment and chemical technology using one of the most relevant and promising technologies augmented reality [1-3].

The main goal of this work is application creation for practical training and laboratory work in technical disciplines for the development of professional competencies using interactive teaching methods based on mobile phones and tablets.

The relevance of the project relates to the difficulty of laboratory classes execution and training, especially for beginning students, directly on real expensive high-tech equipment. This is due to the danger of physical simulation of oil and gas processing at the office buildings and on campus, with strict explosion and fire rules at the organization of educational process at the technological equipment with use of hydrocarbon mixtures, as well as the possible lack of necessary and modern material-technical base.

The application management is as follows. Before proceeding to the task of laboratory work in AR, the student must register in the application database via the Internet, then select a laboratory work, after that study theoretical information and pass a test for knowledge of the material. The laboratory task is performed directly in an augmented reality environment (for example, studying and assembling elements of a tray distillation column). The lecturer can administer users and monitor the performance of work.

The application is written in the Swift 5.1 programming language in the Xcode development environment. The program is based on the Reality Kit framework. It provides direct implementation of AR objects. The Google Firebase library is also integrated, which provides technical capability for authorization, analysis and monitoring of the laboratory work stages implementation in real time by the teacher. The difficulty of optimizing the graphical part of the application was solved by converting the design models into the format used in game engines [4].

Currently, the application logic contains more than 1300 lines of code, and a dark theme has been introduced. The application supports iPhone models starting from 6s and higher, and iOS versions starting from 13.0. The prototype of the software is in the first open beta testing stage on the App Store Connect platform. The application interface is translated into English and the software is being prepared for registration.

It is planned to expand the base of interactive laboratory work. The possibility of training a neural network for hardware identification is being considered, and options for providing communication with automation tools via an OPC server are tested. According to the results of the project, it is also expected to bring a software solution that allows for the visualization of the operator screen in AR, which can facilitate work with SCADA systems and increase the efficiency of industrial control systems.

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THE RESARCH OF FUZZY TRAFFIC CONTROL PROCESSES IN GLOBAL NETWORKS

The paper considers the issues of fuzzy traffic management in global networks for enterprises of the mineral resource industry.

There is a problem of organizing communications and providing quality of service for mining units located in areas of the Far North, where often there may be no telecom operators.

Existing methods cannot fully guarantee the high quality of service. For example, the TailDrop algorithm causes network congestion, and the PI algorithm requires preliminary calculations due to the use of machine learning[1].

Thus, it was decided to develop a new traffic management mechanism that takes into account the shortcomings of existing algorithms.

The mechanism being developed was based on a fuzzy logic apparatus, which is used to describe complex technological processes and build control systems[2].

The following variables were taken as input variables: delay, daily network load, and traffic priority. The output variable is bandwidth. Each variable was assigned linguistic. Based on the initial data, the experts compiled a rule base on the basis of which a quantitative result was obtained (a clear conclusion).

Initially, in the process of modeling, triangular membership functions were analyzed. Next, modeling was performed for the trapezoidal and Gaussian membership functions in order to determine whether there is a relationship between the type of membership function used and the obtained throughput values[3].

Based on the results, it can be concluded that the throughput values vary depending on the type of function used (provided that the input variables are the same) and the maximum values are achieved when working with a triangular function.

To verify the effectiveness of the proposed mechanism, the main characteristics of the queuing system (hereinafter QS) were calculated and graphs of their dependencies on throughput were constructed. In addition, graphs of similar dependencies were constructed, but using the fuzzy logic apparatus. The results showed that the use of the new mechanism reduces the likelihood of queuing and the probability of failure, as well as increase the absolute throughput.

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ANALYSIS OF MULTILEVEL AUTHENTICATION SYSTEM

Along with the development of digital systems of energy systems, there is a problem to ensure their level of security, as the human factor is not yet completely excluded in these systems, which in turn leads to problems in the field of cybersecurity. Recently, energy systems have become one of the most important targets for cybercriminals. Disruptions in the normal operation of digital energy systems can have devastating consequences for the country's economy. Passwords as the only way to access the system are no longer reliable. Any person who enters the system is defined within the scope of his authority. There are problems for people who make decisions and have the right to make changes in the system. Currently, the use of advanced information technology has made the guessing of the passwords a fairly easy process given the growing computing capabilities of computers. Ensuring the corresponding length of password, using numbers and symbols in the password does not guarantee its reliability. In addition, there are several human factors that allow us to easily identify the password. Given the above circumstances it is recommended to use a multi-level security system to ensure access for systems containing sensitive information.

Previously, passwords and PINs are the most widely-used authentication methods for gaining access to PCs, mobile devices, and online accounts, and they are well-understood. However the traditional authentication systems are having a large number of complex passwords and are preferred for users having multiple accounts, users typically resort to using options of a simple password, which puts users at high risk if it is compromised. The traditional text password can easily get prone to shoulder-surfing attacks by just observation of password entry or any smudge attacks, by observation of residue its touch-based password or stroke gesture entry.

The ways in which someone may be authenticated fall into three categories, based on what is known as the factors of authentication: something the user knows, something the user has, and something the user is. Each authentication factor covers a range of elements used to authenticate or verify a person's identity prior to being granted access.

Security research has determined that for a positive authentication, elements from at least two, and preferably all three, factors should be verified. The three factors (classes) and some of elements of each factor are:

- the knowledge factors: Something the user knows (e.g., a password, personal identification number (PIN),security question).
- the ownership factors: Something the user has (e.g., ID card, security token, implanted device, cell phone with built-in hardware token, software token, or cell phone holding a software token).
- the inherence factors: Something the user is or does (e.g., fingerprint, DNA sequence, signature, face, voice).

The presented work refers to the second factor, where it is suggested to use a system that can confirm the identity of the person.

A system is a two-factor identification tool that uses physical equipment to identify a person.

For hardware implementation used nRF52840 dongle of Nordic Semiconductor company which presented full open source and can be used for doing similar work. The system provides connectivity for wired (USB) and wireless (Bluetooth) technologies to include larger areas of

applications. It uses the AES algorithm and asymmetric encryption technologies for encryption. The system has a special encryption section built into it, which ensures the reliability of the encryption process.

The actual programming process of USB dongle is difficult and must be done with a specially wired connection to provide the necessary programming of processor and writing special keys generated for individual persons. For the first time of user registration, it used special public key to connect the dongle to account. During the next login, user must input password then connect dongle and press button on it, to establish his identity.

The system is compatible with the requirements of the Fido2 alliance, which makes it applicable to widely used systems. It is presented by an open-source software code, which makes it possible to make changes and use it with systems developed by private companies.

The two-factor authentication key can be used for user identification in systems containing sensitive information. Authentication key using progressive encryption algorithms that provide an appropriate level of security. The multi-level security systems have been proved to be accurate and very effective in various Applications. Given the current situation, where sometimes work must be done remotely, the use of the system raises the level of security of the overall infrastructure. Most of the technologies used in the system are represented by an open-source code, which increases the scope of its application and increases the level of reliability.

This authentication key can be used for key person user authentication in management systems of energy systems and in the mining industry. It can be used also in web-based applications for remote users. Overall this can be used for all types of applications written for desktop and mobile devices.

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OILFIELD DATA INTELLIGENT PROCESSING FOR SUPER VISCOUS OIL PRODUCTION MONITORING

Modern oil and gas oilfields development management is unthinkable without intelligent information technologies use. In the period of digitalization, all processes in the oil and gas industry require the use of methods and tools that allow for processes automatic control, maintenance, and management with minimal human involvement. One of the most knowledge-intensive areas of the industry is oil production. Many companies' engineers and researchers are conducting pilot tests, develop and implement new methods and technologies for oil recovery increasing, hydrocarbons extracting, petroleum products transportation and storage. Technologies for oilfield data intelligent processing are constantly improving, as they allow to analyze the state of units and to implement management which is based on the solutions offered by machine learning. The best management methods choosing is a constant goal of development engineers, as it leads to the greater economic efficiency of production. This paper presents a statistical, neural networks-based method of super viscous oil production telemetry data processing, which is designed for intelligent monitoring of the considered technological process.

The control room of the super viscous oil production facility receives data from a variety of parameters that are controlled during the process. A large number of measured parameters is due to the fact that the process of extracting super viscous oil (the viscosity is from 15,506 to 56,337 mPa·s) is very complex. At the natural bitumen field of the Republic of Tatarstan, such

oil is produced by steam-assisted gravity drainage (SAGD) technology. In the method SAGD heavy oil is heated by steam injected into horizontal wells above the oil-bearing formation, then oil goes from a solid to a liquid state and is extracted together with water (steam condensate) by parallel to the production formation well located below the reservoir. Thus, very critical for this method of production is such parameters as the temperature regime of the reservoir, the pressure at the pump intake, the amount of steam injected, and others. Therefore these parameters monitoring is necessary; for example, a temperature deviation in the oil reservoir by just a few degrees leads to a change in the flow properties of bitumen, which can lead to a decrease in the flow into the well, failure of the pump and stopping the entire technological process.

The proposed solution is based on the system created for processing telemetry data coming from the oilfield. Consisting of a constantly learning neural network model, the system forecasts process parameters changes and provides engineers with an analysis of the current situation, identifying the causes of deviations in the workflow. The main controlled parameter is the total liquid mass flow rate of the well, which is the most significant in the entire technological process [1].

The control room of the super viscous oil production facility receives data from a variety of parameters that are controlled during the process. However, not every parameter has an equal impact on the well flow rate, so to form an adequate and not too overloaded model, several of the most significant parameters were selected as control parameters. Since the control parameter space is multidimensional (consisting of more than three parameters), the analysis results can be difficult for human perception. Therefore, in our case, the Kohonen method of neural network maps, which projects a multidimensional space of values into a two-dimensional one, is very well suited [2].

Self-organizing Kohonen maps (SOM) are part of a family of neural networks developed by Finnish scientist Teuvo Kohonen. The neural network takes control parameters as input and divides them into clusters (groups) in a given number, each of which characterizes a certain state of the well: for example, the group "high pressure, low temperature and electric motor high power consumption" or "low pressure, high temperature and low power consumption", etc. The output layer of the neural network is a controlled parameter – a well flow rate, which also passes the clustering procedure. The neural network is trained on real input and output data and then generates a forecast of the object's state (estimated future state) based on new incoming data [3]. The object states are analyzed by the process engineer and are relatively defined for the neural network as: "normal state" - with normal process indicators; "attention required" - when parameters deviate from the normal ones; and "critical state". The neural network determines the current state of an object based on whether the current measurements belong to a particular group (cluster) defined during network training. When parameter values are changed, the neural network overrides the object's belonging to the cluster and thus signals that the object's current status has changed.

Super viscous oil extracting process is very complex and contains many controlled parameters. The condition of units at such an oilfield facility also depends on many factors, due to the presence of additional process stages – boilers, steam injection wells, as well as increased requirements for the temperature regime of the extracted product. This intelligent system allows us to analyze multiple parameters in aggregate, thus characterizing the overall state of the process, and not just its parts [4]. The underlying model of the system developed based on artificial neural networks, and has flexibility, a lot of computing power and can retrain on new data when the process conditions are changing. Determining the deviation of the measured parameter values from those calculated by the model allows us to detect a specific reason for the technological deviation, which in turn lets us take the right measures to maintain the main parameter – the well flow rate – at the operating level.

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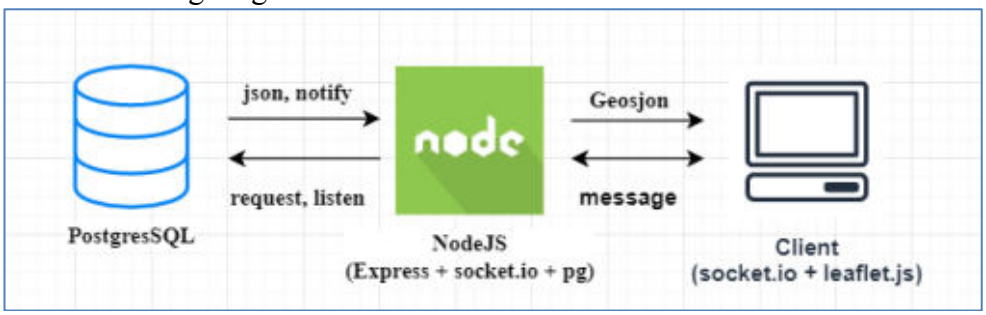
VGIS: AN OPEN SOURCE GIS SERVER FOR REAL-TIME MONITORING SYSTEMS

GIS has been significantly contributed to the development of natural resources and enviroment management and analysis. Recent advances in IoT technologies allow sensors to obtain and send the data at very high rate. Monitoring systems thefore need to be able to process, visualize, and analyze the streaming data seamlessly. This study introduces a new open source GIS server which provides real-time communication machanisms via REST API. It processes streaming data in form of JSON mesages from sensors, then provides real-time notifications and publish features to clients via Socket.io. vGIS makes use of socket.io to handle with continuous streaming and Postgres to store database and process real-time events. vGIS has been used for landslides monitoring in Lai Chau province, Vietnam.

vGIS uses the Express framework, which is responsible for receiving and responding to requests from the website. The vGIS database used is JSON format data that is transmitted from sensor devices in real-time. These JSON data are stored in PostgresSQL, the database management system is integrated to manage Geospatial data.

vGIS server processes real-time data by combining notify and listen, two methods in PostgreSQL and Socket.io, the library suite in NodeJS. Server application model will operate according to the following diagram:



When data is inserted or updated to PostgreSQL, a “notify” consisting of two components, the message and the payload, which will be sent to the server. The Nodejs Server will use the query “Listen” to listen for messages from PostgreSQL. When a message exists, the server NodeJS will use socket.io to send payload from the server to clients.

The system was built with two main functions: (1) providing mapping services in Restful API, (2) Providing real-time services.

(1) Map services allow client devices to display, query, manage features on a map (for example monitoring stations) via GET, POST, PUT, DELETE methods in HTTP protocol (Restful API). The structure of the Restful API is described through the following monitoring station information management example:

● / station:

GET: get a list of station monitoring

POST: insert a new station

● / station / {id}:

GET: get station detail

PUT: update station information

DELETE: delete station

● / station / {id} / param / {paramid}:

GET: get param detail to follow the station

PUT: update parameter bu station

Real-time mapping service allows clients to receive notifications and change the status of objects on the map, right after a change in the database management system. This service is also provided over HTTP. The structure of the service is divided into 2 components

- Check the changes in the database using the trigger and notify function with the following example:

```
DECLARE
BEGIN
PERFORM pg_notify ('message', payload);
RETURN new;
END;
```

- Notify changes in the database to the client by socket.io

The study is applied to the monitoring of soil moisture data in real-time. The monitoring area is LaiChau province, where is located in the northern mountainous region of Vietnam, which is prone to floods and landslides. Data on soil moisture will be collected through sensors located at monitoring stations. Then, the data will be transmitted to the server in JSON format and stored in the database management system.

The GIS server system is built entirely on open source technologies such as NodeJS, PostgreSQL database management system. Therefore, it is allowed to minimize the cost of building the system. Besides, the system provides services through the Restful API to allow a variety of connections using terminal services (from mobile, web, and desktop applications). Real-time alert service helps minimize loss of life and property in floods and landslides in LaiChau province.

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IBM SPSS MODELER AS A TOOL FOR PREDICTION ANALYSIS AND DATA MINING IN ORE PLANNING

From the beginning of their existence, people wanted to know their future. The original methods of prediction were prophecies and judgments. Today, science-based theories are used to determine the future, which has their justification in statistical methods. Progress and the development of consumerism pose many challenges to mining: extracting ores and ore at the lowest possible cost or satisfying demand without unnecessary waste of resources are just some of them. With increasingly advanced technology and increased market requirements, mines are forced to use modern methods and tools to predict the nearest extraction values and, consequently, future profit or loss.

One of these methods is data mining, which extracts information in such a way that it is practically useful in such areas as:

- decision support,
- forecasting,
- estimation [1].

The tool used in the research was IBM SPSS Modeler, which is a first-class solution for visual data analysis and machine learning. It allows data analysts to perform operational tasks much faster so that companies can get the benefits and results they want faster. The advantages of the program include:

- the usefulness of the tool in the process of creating predictive analysis,
- ability to import a file from various sources,
- ability to work with languages such as Python and R [2].

In the above work, the research was carried out to create a scenario of future production, i. e. to make a production forecast for three consecutive months with a 99% confidence interval using IBM SPSS Modeler. The output data were the historical data of ore extraction in tons. The model that predicts future extraction has been created in a particular way:

1. Collecting historical data.
2. Entering data into the flow.
3. Creation of a flow rate.
4. Introducing parameters and statistical methods into the program.
5. Starting the stream.
6. Choosing the best static method.

The final ejection of the conducted research was the analysis of the obtained results. In this case, the expected result was achieved as the calculated value of future production was characterized by a low MAPE value.

The future of most companies is uncertain and should, therefore, be anticipated. Without proper preparation for the coming periods, the mine is not able to use its full potential, and this translates directly into the level of profit generated. The past, defined by data from previous years, creates patterns and trends that cannot be seen or interpreted by those planning to extract without the use of advanced statistical tools. The solution to this situation is to support planners'; knowledge and experience with tools for data analysis and prediction. An example of such an instrument is the IBM SPSS Modeler, used in research, whose practical application is presented in this paper. From the extraction data collected, a stream was created based on which, using statistical methods, the value of future ore extraction had to be calculated. The streams made with the use of the program allowed:

- plan extraction for future periods with a 99% confidence interval,

- plan processes that support extraction, thanks to the mine's prediction, can plan the whole extraction process faster and better
- save resources, through the more rational use of manpower and materials used in extraction,
- support planners and their knowledge, thanks to the program's ability, the people responsible for burning up the extraction of resources can enter the input data themselves and choose the appropriate statistical method.

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SIMULATION OF TECHNOLOGICAL PROCESSES OF UNDERGROUND MINING PRODUCTION

Operational planning of mining operations, as an iterative decision-making process to ensure the volume and quality of the extracted rock mass, is subjective and is determined solely by the experience of the management of a mining enterprise working under conditions of uncertainty and a narrow time interval for making decisions for the next planning period (shift, day).

Technological processes of mining production, as objects of modeling, are distinguished by the stochasticity of the parameters of the operating environment and the multicomponent composition of technological equipment with a complex structure of inter-element connections that function in parallel over time, the statistical characteristics of which are often not possible to describe mathematically. Simulation modeling allows us fully to take into account almost all the significant factors of these processes. For the simulation model, it is necessary to reproduce the structure of the system, the sequence of events in time, adequate to real processes, as well as the properties of processes, primarily stochastic, corresponding to real laws.

For qualitative and quantitative representation of the technological process as a set of operations structurally united by objectively existing relationships, you can use the method of gate transformations of resources, as one of the methods of simulation modeling. The advantages of this method are as follows: visibility, the ability to represent continuous and discrete, deterministic and stochastic processes, the ability to account for the influence of disturbing factors on individual operations of processes, taking into account the dynamics of changes in the resources of individual operations and the process as a whole.

It is with this method that it is possible to describe mining processes as a set of continuous and discrete, deterministic and stochastic processes.

The purpose of simulation for the operation of mining faces is to reproduce the system of cleaning cycle processes based on the results of statistical analysis of the most significant relationships between the main operations and such variable parameters as the position of the

shearer in the mine face, the quality and volume of ore shipped to the conveyor in a certain period of time, the time of transporting the rock mass along the conveyor system.

In the models developed by us, the behavior algorithm of the technical system exactly reproduces the original process itself in the sense of its functioning in time and space. This simulates the elementary operations that make up the process, while preserving their logical structure and order of flow. In this algorithm, three functional parts can be distinguished: modeling of elementary operations, accounting for their interaction, and combining them into a single process.

The main operations of the cleaning cycle are represented by a system of valves (Figure1) connected to each other in a certain sequence. The valve consists of 4 sectors, of which 2 sectors have a numerical characteristic, this is its number and performance (intensity of transformations), recorded in sectors 1 and 3, respectively. Sectors 2 and 4 are designated as the inlet and outlet of the valve.

Figure 1 – Valve

Storage devices are used to display the parameters needed when switching from valve to valve (Figure2), which are represented by rectangles divided into 5 conditional cells. The first cell is the name of the characteristic feature for the transition to the valve, it records the basic data for the transition from one gate to another. Each k (j) th storage device characterizes a certain phase of resource conversion and has a minimum, maximum, and current capacity, which is denoted by Żk(j), Ẑk(j), and Zk(j) (t), respectively, where k (j) is the storage number or resource index.

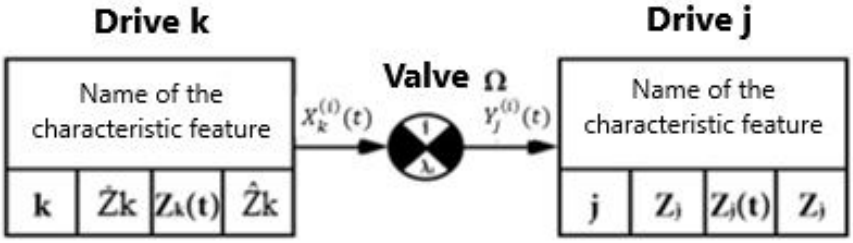

Figure 2 - Conditional graphic image of storage devices

Storage devices are divided into two types: main and auxiliary. The main displays information about the operation of the cleaning cycle, the position of the shearer relative to the start of the lava, its speed and performance. Auxiliary operations display the auxiliary operations and the time spent on them.

All this is connected to each other in a certain sequence that displays the work of the real cleaning cycle, which facilitates the perception and analysis of the processes taking place in the cleaning face.

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CYBERSECURITY IN INTEGRATED OPERATIONS: AN APPROACH SINCE OIL AND GAS DRILLING OPERATIONS

Risk forecasting and management by their very nature are evolving practices. Yet, as the business landscape continues to transform due to groundbreaking new technology, geopolitical uncertainty and an increase in public scrutiny, to mention just a few, preparing for the next major corporate risk will continue to become more challenging – and harder to predict. In this framework, Digital transformation is emerging as a driver of sweeping change in the world around us. Connectivity has shown the potential to empower millions of people, while providing businesses with unparalleled opportunities for value creation and capture. Nevertheless, operational risks associated with automation systems, no matter their operating domain, key on the engineered reliability of individual subsystems or components and upon the overall integrity and robustness of their integrated system of systems form. Experts point out that drilling rigs are not even as isolated as the industry believes them to be. Automation technologies and the digital oilfield have made drilling rigs and all the equipment onboard much more interconnected than before.

Since the industrial revolution, Oil & Gas industry has played a pivotal role in the economic transformation of the world, fuelling the need for heat, light and mobility of the world's population. Today Oil and Gas industry has the opportunity to redefine its boundaries through digitalization. After a period of falling crude prices and, frequent budget and schedule overruns, together with greater demands of climate change accountability and difficulties in attracting talent, Oil & Gas Industry can provide practical solutions. Digitalization can act as an enabler to tackle these challenges and provide value to all its stakeholders.

Integrated Operations (IO) can be defined as a solution that integrates technology, information, people, process, and organization, using online data to efficiently and effectively maximize oil and gas asset performance and value throughout the production life cycle. It could be defined as the umbrella term for technology-centric solutions that allow companies to leverage limited resources. While digitalization could be a source of positive change, there are a number of challenges that need to be overcome to realize its full potential for both business and society. In some cases, the gains from digitalization have been inequitable with the benefits not reaching those who need it most. At the same time, the exponential increase in global information flows have created new risks around data privacy and security and businesses across sectors are grappling with challenges related to changing customer expectations, cultural transformation, outdated regulation, and skill shortages – to name a few.

At a high-level Cybersecurity means understanding your systems and process, your personnel´s capabilities and limitations, as well as thoroughly evaluating your threat landscape. In other words, system owners must have a keen understanding that there will always be new threats to counter, and new technologies to harness. Worldwide, the Cybersecurity threat is real and growing. The oil and gas industry´s technological critical infrastructure has been especially hard-hit, absorbing 40% of all cyber-attacks globally (Willis, 2014. Energy Market Review 2014), yet the realities are not resonating effectively with industry executives, because many companies have yet to put comprehensive protection plans into action.

In this presentation, we will review the definitions and concepts that apply to Integrated Operations; as well as their importance in the future of the industry for increasing efficiencies and reducing costs. We will examine some existing Cybersecurity regulations, industry best practices, and standards of relevance for industrial control systems and drilling assets. Reviewing what are the main vulnerabilities that appear when implementing this type of initiative and listing the new skills and competencies that personnel in extractive industries should develop to

address these vulnerabilities. Adding discussion arguments with an approach which focuses on oil and gas drilling operations.

- Integrated Operations (IO) – Definitions
- Why Integrated Operations in Oil and Gas? – Drivers
- Core elements of Integrated Operations (IO)
- The structure of IO
- The virtual field
- IO as a business
- Key threats in the IO
- Cybersecurity
- Modern Rig OT system
- Advanced Automation & Security concerns
- The nature of the Cybersecurity threat
- New skills – New competences

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DIGITAL TRANSFORMATION OF THE OIL AND GAS INDUSTRY

Recent years for the world and Russian economy are characterized by general instability: oil price spikes, political factors, trade wars, sanctions - all this makes business not only more cautious to build development strategies, but also more attentive to the resources available in the asset. That is why increasing the efficiency of their use and optimizing logistics are the main business trends of today. D. Hickey noted there are many problems from different spheres in oil and gas industry that digital technologies may help to overcome but doesn't give any examples or figures of effect due to using technologies [1]. D. Jacoby said that one of the most vulnerable and non flexible sphere is oil and gas logistics [2] that is why in this abstract we will talk about this important area.

The transportation of products and materials for the oil and gas industry requires special equipment, strict compliance with the rules and extensive safety procedures. This often requires multiple modes and includes everything from supplies for oil rigs to hazardous materials. The increase in the distance between oil fields and refineries leads to longer delivery times and high variability in transportation times. Oil and gas companies are forced to store more insurance to prevent a shutdown in the event of a supply chain failure. Higher security and travel stocks, along with increased transport costs, increase costs. The problem is how to reduce costs and increase efficiency?

Applying innovative logistics companies minimize their costs, improve the quality of service. Modern technology allows the use of equipment that monitors the situation on the roads in any part of the city. They allow you to adjust the route online depending on the situation on

the roads [3]. This makes it possible to reduce the loss of time during transportation, complying with the specified delivery time. Most of facilities of digitalization are possible to use for reliable and responsible mining and oil and gas production (Figure 1).

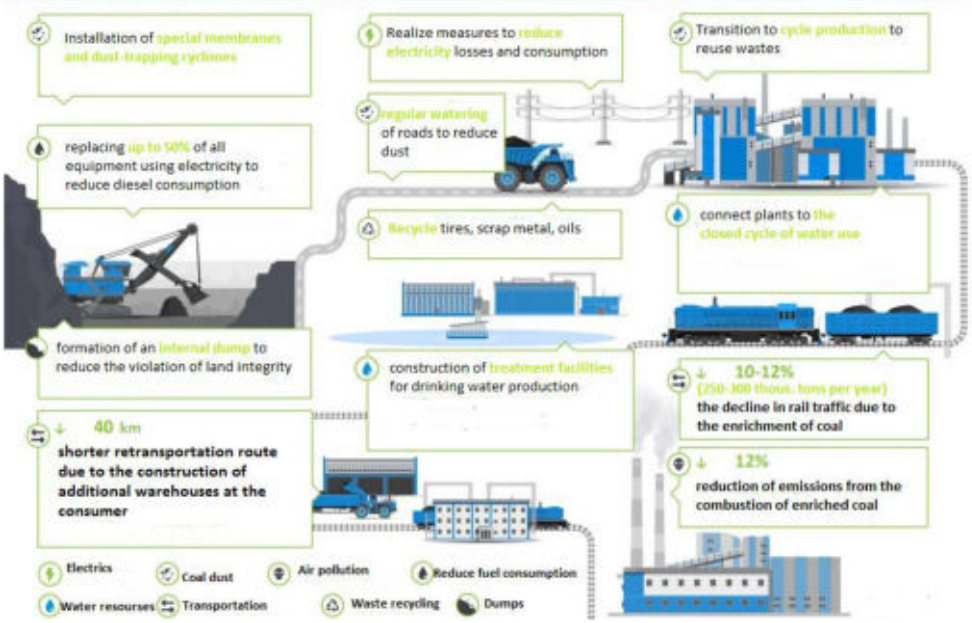

Figure 1 - Responsible to ecology mining. Source: composed by the authors

According to Mikhail Korolkov, head of Gazprom Neft's Digital Technology Center, "the pace with which unmanned aircraft are being mastered in the oil industry is becoming faster - the demand for the use of drones is growing." In this regard, in order to accelerate the development of a new direction in Gazprom Neft, a decision was made to establish a Center for Unmanned Aviation Systems Technologies based on ITSC (system integrator and software developer, a subsidiary of Gazprom Neft) [4]. A new report by insurance company AXA UK and Douglas MacNeill suggests that almost 34 billion pounds could have been saved if the British logistics industry had used driverless vehicles.

Today, the warehouse system has an automated system for monitoring and managing logistics in general. The introduction of an automated warehouse system leads to a complete reorganization of material flows: it allows you to unload and load a semi-trailer for 20 minutes in one dock without moving it. Receiving goods and picking up orders take place in the same zone and cross-docking.

Instruments of digitalization such as RFIDs, 3D printing, VR, etc. help to optimize operation process in midstream and downstream areas. For instance, LoxistiX recently introduced a real-time storage monitoring system using SamsungGearVR-based virtual reality (VR) technology.

Summing up the bottom line, the greatest potential to increase efficiency and reduce costs in the oil and gas industry are the following technologies:

- Smart logistics based on the digital twin logistics system and warehouses;
- Involving all objects in the industrial Internet of Things system and tracking RFID tags;
- Using unmanned vehicles to deliver material flow and workers;
- Standardization of contracts and the use of Blockchain to simplify customs procedures and track contracts;
- Smooth transition to 3D printing to reduce the cost of the last mile and customize production.

Thus, we can conclude that in the world and in Russia innovative technologies in logistics are developing rapidly. Investment in this area is expected to continue to grow due to the need to improve the competitiveness of companies in the market by optimizing logistics costs.

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ON THE APPLICATION OF UAV-BASED PHOTO AND THERMAL IMAGERY SYSTEMS FOR GEOTECHNICAL CHARACTERIZATION

KEYWORDS: Drones, robotics, geotechnical characterization, safety.

Increase in demand for mineral resources globally has resulted to miners exploiting minerals found deep in the earth crust using underground mining methods that require proper geotechnical studies to ensure adequate stability. Failure to offer proper stability in the right location and in a timely manner often leads to mine failure at the crown or walls of underground openings due to increased stresses occurring along discontinuities. Collapse of underground mines have devastating effects such as damaging of mine machinery and injury or death of personnel which ultimately affects productivity and financial aspect of companies. In order to prevent such havoc, geotechnical characterization has been conducted using physical measurements by miners and geologists. Unstable stopes are unsafe for miners to access in order to carry out geotechnical studies, especially after blasting, exposing them to occupational hazards due to rock falls, rock bursts and caving. However, the development of 'fourth mining industrial revolution', mining researchers are studying robotics to replace workers with robots in risky operations (Marshall et al., 2016). This study demonstrates usage of drones embedded with photogrammetry and thermal imagery measurement systems as a geotechnical tool for underground geotechnical mapping after blasting of Kuranze underground gemstone mine in Taita. This system enables capturing of geological structures in the rock mass to conduct numerical analysis and geological modelling in order to determine the necessary support systems.

High amount of stress subjected to a rock mass results to movement or enlargement along geological structures found within the rock mass that enables penetration of air around the loose rocks (Prendes-Gero et al., 2013). The penetrated air engulfing the loose rock normally has temperature difference compared to that of the rock mass, creating distinct contrast between the intact and loose rocks. Study by Iverson & Signer (2014) successfully utilized thermal cameras to locate lose ground in mines due to temperature difference. The study illustrated how thermal cameras can effectively identify loose rocks in unsafe and inaccessible underground stopes. To improve this concept, this study uses a drone embedded with obstacle sensors, light source and thermal imagery as a geotechnical tool for geotechnical characterization of underground stopes. Being compatible with needed accessories, the DJI matrice M100 drone is used for this research together with DJI guidance sensor, light emission diodes and imagery instruments (thermal and imagery cameras).

High resolution digital pictures and videos of the stopes was obtained using DJI zenmuse X3 due to its ability to transfer live recording to the monitoring devices and storage card for saving

files. This camera model was preferred due to its wide field of view that enabled capturing the whole set of geological structures present in a given zone. Great resolution thermal images were captured using DJI zenmuse XT thermal camera having 8mm lens. This enabled capturing thermal information of the rock and rock mass to identify anomalies for cracks identification. For safe and effective navigation of the drone in underground opening, the guiding system was used composed of visual stereo cameras and ultrasonic sensors. To provide illumination for capturing images and navigation, 11 lumens per square meter was used. Exportation and analysis of thermal imageries was done using FLIR Research IR which later allowed querying radiometric information embedded in those images. Analysis indicated that better gray scale provided better details for image analysis than from colored scale which had blurred images. Thermal imagery was draped with the photogrammetry model from same zone to merge them into one model and later imported into Split Engineering's Split-FX software to identify geological structures.

This research has proven effective usage of drones as a geotechnical tool to safely identify hazardous geological conditions in underground mine at a faster rate by providing real time data. This technique was able to examine post-blasting operations immediately after blasting, therefore saving time. Geotechnical characterization was accurately done and necessary supporting systems were safely installed to allow further mining in that stope.

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DEVELOPMENT OF TOURISM IN KAZAKHSTAN THROUGH THE USE OF MODERN INFORMATION TECHNOLOGY WITH AUGMENTED REALITY

Human-computer interaction is a dynamically developing field of science. Continuous improvement of technology leads to the possibility of innovative user interface paradigms.

The globalization of virtual reality has led to the introduction of the new term "augmented reality" into scientific circulation. While current user interface technologies are mainly focused on human-computer interaction, augmented reality with the help of computer technology offers an improvement in the human interface and the real world.

The emergence of the information society, which forms a digital, virtual reality with specific social, cultural, consumer practices, has largely led to innovative processes in the field of tourism.

The massive use of information technology in a dynamically changing world has become a necessary condition for the individual to participate in economic activity and the socio-cultural sphere. Changing the pace of life, the explosion of information and the emergence of new standards of behavior, moral and ethical principles (sometimes substantially contradictory to the traditional ones), a new understanding of the quality of life make us look differently at one of the important components of human life - the sphere leisure.

The specific characteristics of the information space are due to the variability of such processes in it as interaction in the process of joint activity, competition. The nature of

geopolitical competition is changing most significantly in the information space because of the struggle for the possession of a more developed information resource, for the achievement of information superiority, which opens up better control over the competitor's information resource.

The purpose of the study is to analyze the modern development of information technologies in the tourism industry, to study the impact of augmented reality on the emergence of innovative tourism products and to consider the prospects for the development of virtual information space.

Objectives:

- explore the features of modular excursions and technology augmented reality;
- describe the practice of using augmented reality technology in the socio-cultural sphere using tourism as an example;
- to analyze the market of excursion services in the city of Karaganda and determine how much it is possible to use the technology of augmented reality in the process of developing excursions;
- to develop an information system structure with interactive visualization technology using augmented reality tools, designing a tourist route.

Hypothesis: The use of new technologies in the tourism sector of Kazakhstan, such as augmented reality, improves the accessibility of cities of Kazakhstan for international, including local tourists, which will accordingly increase the number of tourist flows.

The object of research in the thesis is computer methods of information processing. The subject of the research is an information system with interactive visualization technology using augmented reality tools. The theoretical basis of the thesis is compiled using scientific and research literature on modern information technology, journalistic and Internet resources. The experimental part of the work was carried out using a set of development tools for tracking Qualcomm Vuforia and development tools Unity.

The modular principle of the development of the excursion program is formulated and justified (decomposition). The technology for creating an interactive excursion using the modular principle has been developed.

The practical significance of the thesis is presented in the form of an analysis of the need for the development of innovative tourism in the city of .

The structure and scope of work. The dissertation consists of introduction, four chapters, conclusion, list of references, applications.

The first chapter provides an analytical review of augmented reality technology and the potential for its mass application. The concept is formulated and areas of application of augmented reality are given. The application of the technology for visualizing three-dimensional objects in a real environment is analyzed. The main disadvantages of modern augmented reality systems are formulated. In conclusion, the research task is formulated.

The second chapter provides an analytical review of the available tools for developing augmented reality. Search and analysis of tracking tools. An optical tracking method based on marker recognition was chosen. Qualcomm Vuforia was chosen as the tracking engine for use in research.

The third chapter describes the development of an information system with visualization technology using augmented reality.

The fourth chapter describes the application of the developed system on the example of the areas of landscape design and trade. Models of interaction between a producer of goods and a mass consumer are described using augmented reality. The comparison results illustrate that the application of the scientific approach during development allowed us to provide a noticeable gap in performance from competitors.

The conclusion reflects the main results of the study and summarizes the overall result of the work.

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DIGITALIZATION OF ACCOUNTING FOR POTASH ORE MINING FROM MILLS IN ON-LINE MODE

At present, the practice of objective and documentary fixing of the volume indicator of the ore mined per shift (day) from a specific face is formal. Records of the amount of ore mined in the relevant logs of the mining section of the mine are made by the master of the fulfilled shift after he arrives at the premises of the trim section, which occurs 30-40 minutes after the end of the previous shift, and the next shift is already beginning to work. This procedure is conditional and the recorded data are not reliable due to the lack of the ability to directly measure the amount of ore mined at the end of the shift. Accounting for this kind of data is carried out by employees of the surveying service of the enterprise only every decade. In recent years, little attention has been paid to this problem, since enterprises were satisfied with the data provided by the surveying service in this mode. The situation changed when all panel belt conveyors were equipped with ultrasonic level gauges that fix the on-line level of ore on a moving belt and give level readings in graphical and digital forms (trends) with a discretion of 5 seconds. However, a quantitative assessment of the volume of rock mass according to these data is impossible without appropriate statistical processing of these trends. Their subsequent statistical processing presents the possibility of obtaining more accurate indicators of the amount of ore mined per shift.

Having analyzed the trends and found out certain patterns it would be possible to determine the weight of ore mined. So, the essence of this work is to determine the location of the combine at each point in time and establish what operation it is at the end of the previous shift, which will allow to forecast the amount of ore mined in the next shift. The ore from the face is fed to the face conveyor, which transports it to a crusher located in the energy train. After passing through the ore crusher, pouring onto a panel conveyor, the ore forms a conical flow. Moving along a panel conveyor, the ore passes under an ultrasonic level gauge, the task of which is to measure the height of the ore flow on the belt. The trends are formed from data coming from a sensor located on a panel conveyor (up to 50 m) from the place of ore transfer to the main conveyor. The sensor records the readings (the height of the embankment of ore on the conveyor) with the conveyor running every 5 seconds. These readings are recorded and stored on the server and, using the appropriate software, converted into analog form (graph - trend) for the convenience of visual perception of information.

After statistical processing of data, you can notice the cyclical nature and similarity of data in certain sections of the technological cycle in certain periods of time. For further processing, the work schedule of this mountain section and the panel itself are taken into account, the faces of which are analyzed. Also a lava passport to analyze information on the geological structure of a given section and a technological scheme for excavating the lava under study is used for the analysis. To process the trends, it is also necessary to take into account such a factor as the distance from the place of formation of the ore flow to the sensor, since it is located at a great distance from the combine and this distance changes over time (as the panel is worked out). It is also necessary to take into account the time of ore passing through the face conveyor when the combine moves along the lava.

As the sensor measures the height of the ore flow, you can find the cross-sectional area by breaking it into the correct figures. Knowing the cyclical nature of the sensor's measurements, as well as the constant speed of the conveyor belt, we can determine the ore flow length per cycle (5 sec), knowing the bulk density, we can calculate the ore volume per cycle (5 sec). The further construction of the flow in 3D occurs on the basis of typical sections, knowing the instantaneous height of the ore flow every 5 seconds. Next, the closest typical section is selected, which is recalculated through the proportion for a given height, integrated over time and a 3D flow contour is obtained, which, with a certain probability, determines the weight of the rock mass coming from the face.

As a result with the introduction of a digitalization system for ore mining accounting on-line and analyzing its operation, it is possible to predict the amount of rock mined in a given period of time, as well as make decisions on choosing a management strategy that minimizes the discrepancy between the planned and current average weighted ore quality. This system will provide the mine management with the opportunity to monitor in real time the quantitative and qualitative characteristics of the ore discharged from the faces.

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DEVELOPMENT OF FINITE ELEMENT MODELS OF GAS FORMING PROCESS OF TI ALLOYS STRUCTURES

It is shown that the combined technology of gas forming and joining by pressure in the solid phase is used to produce large-diameter torus billets made of titanium alloys for production of pipelines' bends of the desired size. The technology allows reducing the cost of products by increasing the productivity of the manufacturing process and by applying new design and technological solutions. The possibility of using the SIMULIA Abaqus software package for modeling gas forming of titanium alloys in superplasticity conditions with uneven heating of the billets is considered.

The wide use of titanium alloys in mineral processing processes requires improving the technology of manufacturing equipment and spare parts from this expensive material. Kilometers of pipes of the circulation system of technological solutions made of titanium alloys connect processing plants and enterprises producing nickel, copper and other metals. A promising technology for the production of titanium products is gas forming in superplasticity conditions combined with pressure joining in the solid phase [1]. It allows to reduce the cost of products not

only by increasing the productivity of the manufacturing process, but also by using new design and technological solutions. It is possible to obtain elements of titanium pipelines, bends, transitions by cutting into dimensional parts of formed billets of the tor type. The technology is progressive, eliminating numerous operations of hot stamping, straightening, welding. High plastic properties of titanium alloys are realized under conditions of superplasticity.

Calculating the forming parameters is a complex task. Strain stability is provided by temperature-velocity conditions determined by heating and changing gas pressure over time. In the case of free forming of a sheet billet, the metal thickness deformation depends on the conditions at a particular point: temperature, deformation rate, metal properties and etc. This leads to a significant difference in the thickness of the metal of the resulting stamping. To regulate the deformation on the billet, various methods are used: variable thickness of the original billet, reverse molding, structure preparation, and other methods [2,3]. In this study, we propose a method for regulating by creating a variable temperature field of the billet, which allows you to control the temperature and speed parameters of metal deformation. A variable temperature field is created when the tooling and billet are heated by adjusting the heater temperature by zones.

The calculation methodology was worked out when forming spherical parts, as the simplest when forming. SIMULIA Abaqus was chosen as the main finite element complex for modeling. This software product is used for modeling the gas forming of titanium alloys by foreign authors [4,5]. The tasks of this study are included: choosing the dimension of the problem and the type of element for modeling the gas forming of a titanium hemisphere made of VT6 alloy; selection of the solution procedure for modeling the process both in isothermal conditions and in conditions of uneven heating of the billet; assessment of the applicability of the rheological models of the material available in Abaqus/Standard; assessment of the capabilities of the built-in pressure control algorithm.

It is proposed a promising technology for the production of pipeline elements and bends with a diameter of 50...250 mm made of titanium alloys by gas forming under superplasticity conditions combined with a pressure joining in the solid phase. It allows to reduce the cost of products not only by increasing the productivity of the manufacturing process, but also by using new design and technological solutions. The potential possibility of modeling superplastic molding of complex products using shell elements in the SIMULIA Abaqus software package is shown. Comparison of the results of the calculation and experiment shows a satisfactory convergence with a difference of 5-7%. A model is constructed to assess the effect of uneven heating of the billet on the thickness difference and other parameters of the non-isothermal gas forming process. The positive effect of cooling of the central part of the billet on the thickness distribution along the wall of the final product is shown. The software Abaqus/Standart allows to calculate the optimal parameters of the gas forming process necessary for its implementation.

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MULTIFUNCTIONAL CRUST BREAKER OF AUTOMATIC ALUMINA FEED SYSTEM OF ALUMINUM REDUCTION CELL

The crust formed on the surface of the melt in the feed hole interrupts the regular supply of alumina feed to the electrolyte. In order to provide an alumina supply to the electrolyte, crust breaker devices are used. Automated crust breakers are part of the automated alumina feed system. If the crust is not broken, and the monitoring is not carried out, the continuation of the alumina supply will lead to the accumulation of alumina on the surface of the crust. The current level of automated control of primary aluminium production does not make timely adjustments to the technological parameters of the electrolytic aluminium reduction process, such as temperature, cryolite ratio, bath and metal level. Automatic process control has significant inertia due to the large number of manual operations and large intervals between measurements of process parameters. In order to solve these problems, it was decided to start developing an exhibition stand «Multifunctional Crust Breaker of Automatic Alumina Feed System of Aluminium Reduction Cell».

The purpose of developing of the multifunctional crust breaker is to improve the efficiency of controlling the process of aluminium production in aluminium reduction by developing and applying technical solutions for continuous automatic monitoring of technological parameters of the electrolysis process in aggressive conditions of primary aluminium production [1].

The tasks assigned to the automatic alumina feed system are as follows: monitoring the process of breaking through the crust, determining the levels of electrolyte and metal, determining the melt temperature, the resistance of the electrolyte, determining the cryolite ratio (CR), and managing the alumina feed depending on the CR value [1].

The short immersion time of the crust breaker allows it to be used not only as a device for breaking the crust, but also as a mobile platform for sensors, avoiding a prolonged stay in an aggressive environment, and provide regular automatic measurements of the process parameters. In this regard, it can be considered as a multifunctional device [2, 3].

It is suggested to use two modes of operation of the device: at high and low pressure. Utilization of these two modes reduces air consumption. The low-pressure mode is used by default for direct stroke of the rod. If the pressure in normal mode was not enough to break the crust, then a second attempt in high-pressure mode will be used to break the crust. The process is controlled by a PLC that monitors the breaking status. The reverse stroke of the piston is performed only at high pressure.

To measure the depth of immersion of the crust breaker chisel requires the use of a position sensor installed on the pneumatic cylinder. The position of the rod is measured by a sensor using a magnetic ring mounted in the piston inside the pneumatic cylinder.

In order to detect the touch between the surface of the bath and the surface of the metal, an electrode must be installed on the crust breaker. The other electrode must be installed in the cell itself. These electrodes must be supplied with a voltage of 24 V. When the chisel is lowering into the electrolyte, the distance between the electrodes and the electrical resistance is changing. The crust breaker itself must be isolated [4].

It is assumed to use a low-inertia termal sensor (chromel-alumel thermocouple) to measure the temperature of the electrolyte. It should be installed inside the chisel of the crust breaker and be connected with an armored, heat-resistant cable.

Implementation of a multi-functional crust breaker device will allow automatically monitor crust breaking process and measure process technological parameters. The use of the device will also allow to feed alumina to the electrolysis baths without precipitation on the bottom of the cell while alumina feed rate is close to the theoretical maximum. Implementation of this device will also allow to modernize existing and develop new control systems for the electrolytic aluminium reduction process.

The application of the developed stand of the multifunctional crust breaker in education will allow students to study the design of the crust breaking device, understand pneumatic and electrical circuits, practice PLC programming skills, as well as learn alumina feed algorithms. The stand can be used as a training simulator for employees of specialized enterprises to improve their skills.

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DIGITIZATION OF THE MULTI-COMPOSITIONAL STORKWITZ CARBONATITE DIATREME (DELITZSCH COMPLEX, GERMANY)

The Storkwitz diatreme is a highly complex carbonatite body of the Late Cretaceous Delitzsch Complex in north-western Saxony, Germany. The Delitzsch Complex is characterised by ultramafic lamprophyres and carbonatite dykes and diatremes, emplaced into Precambrian to Early Permian volcanic and sedimentary rocks, covered by Tertiary sedimentary successions [1]; [2]. The lithology of the complex varies from rauhaugite and fenite aureole to ultramafic and alkaline lamprophyric intrusions and dykes, accompanied by the formation of diatremes of variable composition [2]. The final stages of magmatism are represented by beforsite and alvikite dykes. The multi-component nature of the Storkwitz diatreme can be attributed to numerous injections of compositionally varied carbonatites and the formation of polymictic breccia [3].

For a better understanding of the development of the diatreme, detailed petrographical observations and imaging methods on extensive drill core material (starting with the drilling SER De 7h/86) were applied. The combination of microscopic images and macroscopic high-resolution

2D -images was used. Identifying the components (xenoliths and intraclasts) and analysing the pattern of their distribution in the 2D and 3D images of drill cores should enable obtaining textural information of the minerals within the rocks.

In order to obtain 2D pictures of maximum petrographic information value, we evaluated several macroscopic imaging approaches using digital cameras of different properties and sensor sizes. The comparative study aimed at derivation of standards for photography of geological (especially drill core) samples, given differences in size, optical properties (controlled by mineralogy and surface preparation of the samples) and surface geometry (e.g., high relief). This determines requirements to the camera technology, including resolution sharpness, depth of field, but also handling and costs of the equipment.

We tested cameras with an APS-C, a full-format and a medium-format image sensor. A Canon EOS 550 D with an 18 MP APS-C CMOS 23.6 × 15.6 mm sensor and a Canon EOS 6D Mark II with a 26.2 MP CMOS 36 × 24 mm full-format sensor were used in combination with a Sigma MACRO 2.8/105 mm lens. The third medium-format model was a Hasselblad H5D-40 with a 40 MP CCD 43.8 × 32.9 mm sensor coupled with a Hasselblad HC MACRO 4/120-II lens. The experimental set-up includes a table stand and two lightning sources to generate constant lightning conditions (white balance 5000 K). To compare the different camera models with each other, series of pictures were taken for each sample, with different exposure times and apertures, at a constant ISO 0f 100.

Due to their high application possibilities and high depth of field, because of the smaller sensor dimensions, the two Canon cameras are ideal for geological samples with a high relief, especially the Canon EOS 6D Mark II model. Series of pictures obtained with them can be used for generation of highly accurate photogrammetric models of the samples. The Hasselblad H5D-40 camera with higher sensor dimension shows an excellent resolution in a small depth of field and is therefore very suitable for flat and polished samples.

Further investigations using μ-EDXRF, Hyperspectral Imaging (HIS) and LIBS for chemical and mineralogical information, to be carried out at the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), in combination with the high-resolution images will provide more insights into the composition, shape and geometry of the diatreme body and contribute to new petrogenetic interpretations.

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THE DEVELOPMENT OF AN IOT-BASED ENERGY-MANAGEMENT PLATFORM

Nowadays, significant changes are taking place in the electric power industry, which are mainly associated with digitalization, the penetration of the Internet of things (IoT) and smart ways of managing various sectors of the economy. Energy is one of the key areas contributing to the development of society, which is the basis for the functioning of other areas of the economy. One of the modern and effective tools for improving energy efficiency at the level of national economies is the management of demand for electricity consumption. The mechanism for managing demand for electricity has significant potential for increasing energy efficiency for the Russian economy and the world [1].

The paper considers and proposes a platform based on the IoT technology in the demand response (DR) of electricity, which works on the basis of integrating Internet connections into various installations, equipment and devices and further connecting these devices to intelligent networks and using the data transmitted by these devices to make meaningful and effective decisions. In the context of an intelligent network, this means the distribution of computational information throughout the infrastructure [2] - from embedded sensors in the blades of wind turbines that control their pitch, rotation and function in real time depending on wind conditions, to substation control systems that quickly respond to abnormal events and minimize network downtime. This platform is an effective tool to reduce prices in the electricity market during peak hours, when less efficient and expensive generating facilities are used to cover electricity demand. In general, the effect of the use of DR programs with an integrated IoT is: reducing the cost of generating capacities, increasing the capacity of transition lines, which allows more consumers to be supplied with electricity without additional capital invest, increasing the reliability of electric power systems and reducing accidents, increasing the life of the power grid equipment.

However, the real value of the platform based on the IoT technology in the demand DR of electricity is that it is possible to realize the potential of the data that resides in existing, unrelated infrastructures. After collecting data on each element of the power supply chain, system operators can use analytics, simulation models and “what if” scenarios to create more accurate forecasts from the state of the network to weather conditions. Potential estimation of demand response is to quantitatively estimate the load capacity that are able to participate in demand response [3]. It is a prerequisite for quantitative analysis of demand response, and is the theoretical basis for practical application and software development of demand response. Data mining of the real-time power consumption of customers is currently a hot research topic in the field of demand response potential estimation.

The aim of the proposed work is to introduce a secure and interoperable DR platform that will assist Aggregators (or other relevant Stakeholders involved in DR business scenarios) in their decision-making mechanisms over their portfolios of prosumers. This novel architecture incorporates multiple strategies and policies provided from energy market stakeholders, establishing a more modular and future-proof DR solution.

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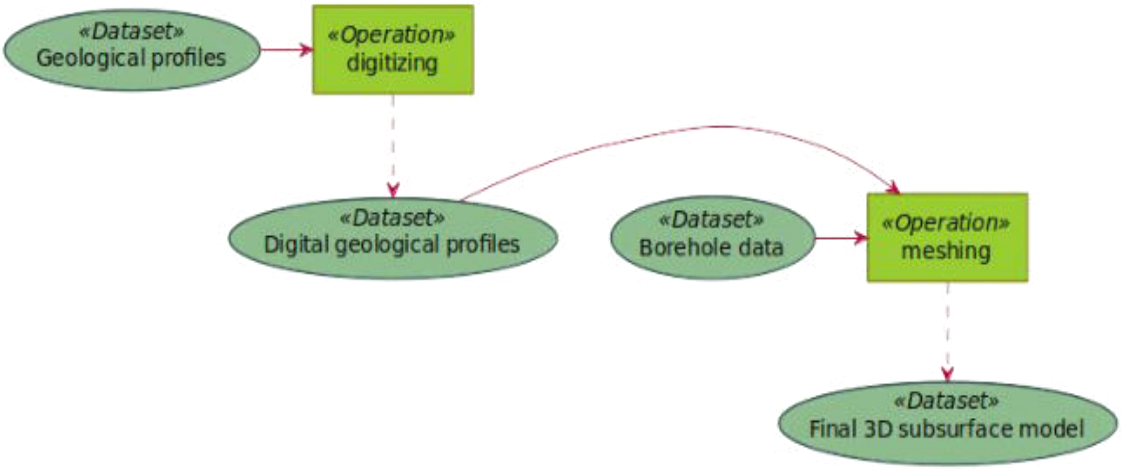
GEOHUB: A DATABASE SYSTEM FOR MANAGING REPRODUCIBLE GEOMODELS

Geoscientific models are used by the vast majority of geoscientists today. Those models are used to answer different questions. These can be simple questions like “Which structure has the subsurface at a specific location?”. They can potential be safety related like “Is it safe to build a tunnel here?”. Or those questions could influence important long term decisions like “Where should we store our radioactive waste in such a way that it does not leak for some millions of years?”. With the ubiquitous usage of geoscientific models, it is crucial to understand and estimate the validity and applicability of a certain model for a specific problem. To answer this question it is required to understand at least which data and methods were used to construct the model and how the construction process worked. This requires that the construction process is reproducible by an independent person, that was not involved in the initial construction of the given model. Current tools like GoCAD [1], ArcGIS [2], PostGIS [3], and GST [4] are used to create and manage geoscientific models. None of them is able to store geoscientific models in a reproducible way. In this contribution, we will present “Geohub”, a database system which is able to store geoscientific models in a way that their construction process becomes reproducible by others.



From a theoretical point of view the construction of a geoscientific model can be seen as a directed hypergraph, where each node corresponds to some dataset used to construct the model. Each node can have as much as one incoming and an arbitrary number of outgoing hyperedges. A hyperedge describes an operation applied to datasets attached to the tail nodes producing the dataset attached to the head node. Nodes without any incoming hyperedge are input datasets, like measurement results, initially provided to construct the model. Nodes without an outgoing hyperedge represent the final results of the construction process. All other nodes are intermediate results created and used during the construction process. Figure 1 shows a simple exemplary construction hypergraph. Dark green nodes represent datasets, light green squares represent operation hyperedges, while edges representing dependencies between datasets and operations. Given such a representation of a construction process of a geoscientific model, we develop with Geohub a technical system that enables the reproducible storage of such models.

For reproducibility of the complete construction process, it is required to store the following information:

- Structure of the construction hypergraph
- Datasets for each input node that are used to construct the model
- Abstract machine-executable operation description for each hyperedge

The initial version of the final geoscientific model stored in Geohub is then constructed by executing the operations in the order defined by the construction hypergraph. Any later attempt to reconstruct the model using the same input datasets and construction process is handled in the same way. This allows others to reproduce the construction process itself. Additionally, this allows for utilizing the same construction process to a changed input dataset producing a similar model out of changed data. This method places a few assumptions onto each operation:

1. Operations are executable without human interactions by a computer
2. Operations are deterministic functions, executing them twice with the same input datasets results in the same result
3. Data required to execute operations need to be available.

From a technical point of view, Geohub follows a micro-service software architecture. A client web app is used to interact with a main service. The main services contain the major part of the business logic, that is used to manage all required datasets in different locations. Metadata and data related to the construction hypergraph are stored in a relational database system. The actual geoscientific datasets are stored is a service managed location at the file system. Operations are described as user defined services using a simple text file-based format based on docker containers. This allows using almost all existing tools, that are commonly used to construct different kinds of geoscientific models as part of a reproducible construction process.

With Geohub we present a novel approach to managing geoscientific models in a database that allows reproducing the construction process later by others. We solve the technical challenges of building a reproducible construction tool. This is done by providing a way to describe the technical environment for each external applications. The execution of these applications is monitored in detail regarding data manipulation while constructing the model.

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PREREQUISITES FOR CREATING DIGITAL CORE TECHNOLOGY BASED ON LASER ULTRASOUND DIAGNOSTICS

Currently, there is a global digitalization, starting with simple social and ending with complex technological processes of various industries. For example, the world's leading mining companies invest heavily in the development and application of modern technologies in the field of automatization, energy and drilling systems in order to increase the level of production and environmental efficiency, reduce the use of manual labor, costs and energy consumption. The

main problems facing mining companies today are the volatility of raw materials prices, rising costs of extraction and processing, environmental problems, lower global demand and growing risks to health and safety [1, 2].

The main tasks of a comprehensive solution to these problems can be formulated as follows: improving production efficiency through the intelligent collection and use of data, introducing innovations related to the use of technologies and computer applications, that are already actively used in other industries, expanding the use of information technologies (IT) together with technological optimization of old methods, the introduction of new technologies in connection with the increasing requirements for environmental protection at the facilities for extraction and processing of raw materials.

The expanded use of IT along with the technological optimization of old methods should be integrated, that is, from the stages of exploration of mineral deposits to their processing.

Digital Core modeling allows one to study the physic-mechanical properties of studied rocks, as well as carry out mathematical modeling of various physical processes, for example, the flow of liquids in a porous medium, from fracture and so on [3-4]. The use of three-dimensional models of the sample allows one to evaluate properties such as porosity, permeability, size, shape and volume of particles, surface area of pores and other impurities, and provide 3D visualization of the internal structure of the geomaterials.

To study the physical and mechanical properties of rocks, destructive testing methods and non-destructive methods are used. Destructive - determination of the ultimate strength under uniaxial compression, determination of deformation characteristics, etc. Nondestructive - computed x-ray tomography to study the internal structure.

Also, to study the structure of geomaterials is ultrasonic non-destructive testing, which, like X-ray tomography, can provide information about microstructural and morphological characteristics (grain size, size distribution, texture, microporosity and micro-timing), but at the same time measure such physical - mechanical characteristics of materials, such as local density, local moduli of elasticity and shear, Poisson's ratio. These data are used in various settlement packages, such as Plaxis, Fidesys, Midas and others.

This paper presents the prerequisites for creating an integrated method for studying rock properties based on laser-ultrasonic diagnostics and further use of these properties for transferring the obtained data to calculation complexes.

The use of unique scientific installations-laser-ultrasonic flaw detectors developed by Russian scientists, their modernization and the creation of new optical-acoustic transducers will make full use of all the advantages of ultrasound: to conduct 2D and 3D visualization of the internal structure with a resolution of up to 100 microns [5], to detect microcracks and stratifications, micropores, microinclusions and other defects with the simultaneous measurement of physical and mechanical parameters. This paper provides an example of a study of the elastic properties of rock samples and their structural and texture parameters using laser-ultrasonic diagnostics.

In the future, it is planned to create an automated complex for obtaining a three-dimensional structure of full-sized cores with a diameter of up to 63 mm and a length of up to 1 with the possibility of identifying pore space, measuring local density, porosity, elastic modules, developing special software packages for more visualization of the resulting formation and its digital storage . It is assumed that the cost of the developed equipment will be almost ten times less than that of X-ray tomographs with almost the same amount of information received, the measurement speed will also increase. Thus, laser ultrasonic structural spectroscopy is one of the research complexes of the method of constructing the technology of "Digital Core" technology.

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MODELLING OF THE TORSION TEST OF CYLINDRICAL SPECIMEN WITH THE HELP OF INVERSE METHOD

The paper proposes a solution of the problem of cylindrical specimen torsion using the QFORM 9.0 software package, based on the theory and finite element technique for the analysis of materials forming problems (MF), and the inversion technique. The method of testing materials by torsion has been known since 1930 [1]. The torsion method has been used to study the technological properties of materials under cold and hot deformation; it is used to obtain a hardening curve (flow), which is the basis for constructing a rheological model of the material.

Currently, several versions of the implementation of the torsion method are known: the method of torsion of a tubular sample, the method of torsion of a continuous cylindrical sample, the method of torsion of a conventionally tubular sample. The use of continuous cylindrical samples, instead of tubular ones, allows one to obtain a large deformation. However, the torsion of cylindrical samples has several disadvantages: the uneven distribution of deformations along the radius and length of the sample, which, in turn, varies with time; the possibility of propagation of deformation on the fillet of the sample, which may affect the angle of its twisting. Localization of strains during torsion of continuous cylindrical samples is also possible.

Processing the experimental results obtained using the method of testing the material by torsion can be performed using one of the methods: the graphical Nadai method [2], the Field and Bekofen method [3], the Khoddam method [4], and the inversion method [5]. The most promising method is the inverse method, since it allows one to take into account the disadvantages inherent in the processing methods of the test results listed above. The inversion method allows a high degree of accuracy to explicitly determine the material model. At the same time, the simplifying assumptions made when processing the results of experimental studies (the torsion method, the compression method, the tensile method) used in the following to determine the material model are neglected.

In the work, finite element modeling of torsion of a continuous cylindrical specimen made of steel 20H (GOST 4543-71) was carried out. The results of computer simulation are compared with the results of a full-scale experiment. Based on the application of the inversion method, the material model — the model of a plastic body with strain hardening — has been adjusted. The resulting material model is suitable for application in case of cold deformation of 20H steel at a temperature of 20 ° C within the range of deformation values from 0.005 to 2.5.

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SYSTEM RESEARCH OF MULTIMODAL CARGO SHIPPING OF THE NORTHWEST FEDERAL DISTRICT OF RUSSIA

There is considering transport system of the Northwest Federal district of Russia, in this paper. This theme has crucial meaning as increasing volumes of production have significant impact on the growth in demand for transport and logistics services. Furthermore, Northwest transport consumes a major percentage of the various industries products. As well as it contributes to the competitiveness of the regional economy. Modern cargo transportation takes place according to a multimodal way what is carried out with the participation of several modes of transport which are controlled by a common operator from one dispatch centre and are carried out according to one transport document and where the modes of transport interact on the basis of logistics. Thus, an integrated multimodal transport network is a critical factor for companies to successfully execute their supply chain processes both domestically and internationally. The study of the transport activity of the district was carried out for the period from 2015 to 2018 based on review of official statistics data publications [1].

The analytical part of the work presents the collected data set and their further analysis. In the process of analysis there was found that the dynamics of the development of the market of transport and logistics services is positive [2]. The volume of freight transportation, in general, for all modes of transport for the three-year period from 2015 to 2018 increased. At the same time, the volume of foreign trade freight traffic is 12 % of the total volume in Russia, and the values of the volume of transported for export are quite large (73 % in the region), the share of imports is almost three times less. This means that the transport balance is positive, which, in turn, determines the economic condition of the region as stable. Also, the dynamics of changes in cargo transportation by type of transport demonstrated the leadership of maritime transport in the region, whose volumes grew by 46% [3]. This increase may be due to a favorable geographical location and an increase in the cost of transportation by other modes of transport. Nevertheless, the lack of positive dynamics among other modes of transport can be explained by a number of problems. The main problems of the transport and logistics complex of the Northwest region are the lack of terminals and service facilities and the low capacity of sections of the transport infrastructure with powerful cargo flows.

Based on the data obtained during the analysis of the transport infrastructure of the Northwestern Federal District, the oil terminal “Big Sea Port of St. Petersburg”, which is involved in multimodal transportation, was chosen as an example. Next, a simulation was carried out in the GPSS World environment, directly, of the unloading section, carrying out cargo reception on the river [4]. A factor analysis was also carried out for two response functions: load factor and average number of busy channels. As a result, it was found that the terminal is not

functioning effectively enough. The factor plan for the load showed the high significance of the parameter - the number of berths. During statistical tests revealed that the model is stable and adequate.

The next step was to optimize the functioning of the unloading system of the oil terminal, which receives cargo along the river. The optimal mode of operation of the system was achieved by increasing the number of berths and increasing their capacity, namely, by reducing the service time by 0.8 times.

Thereby, the obtained indicators provide 92% of service, which is an acceptable level of cargo unloading in the terminal and indicate the effectiveness of the proposed improvements.

In conclusion, the aim of this work has been achieved successfully. A system research of multimodal cargo shipping of Northwest region has been conducted. Furthermore, there has been identified the main areas of development, as well as has been analysed the operation of loading / unloading cargo terminal.

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DIGITAL PLATFORM AS A MEANS OF OPTIMIZING THE PROCESS OF INTEGRATING ELECTRIC VEHICLES INTO ELECTRIC POWER NETWORKS

The General trend towards digitalization of energy systems and the use of energy saving technologies based on information technologies is gaining momentum in the world. Digitalization and intellectualization of electricity distribution and consumption processes both at the level of the average user and at the level of enterprises is the basis of the energy transition. In the last five years, there has been a significant development of digitalization technologies. Information technologies are widely used in various industries and due to their advantages become the main technologies of modern society and agglomerations. The introduction of IoT and digital technologies contributes to the transformation of cities into smart cities that improve health care, traffic and transport, power grid management, people's daily lives and agriculture.

Next, we consider the need to create an algorithmized digital platform for the development of electric charging networks of road transport and to optimize the load on the current power grid complex. In modern conditions, this platform can become an example of a mechanism for public-private partnership and the development of environmentally friendly transport. The purpose of the platform is to provide users with up-to-date information about the state of the electric vehicle battery, reduce the cost of creating a network charging infrastructure for electric vehicle transport, automated resource accounting for power supply companies, and other services. The use of information technologies to combine the processes of economic relations in the field of energy sales services will attract funds for infrastructure development by

increasing the load factor of generating capacities and unloading power centers. In the article, the authors propose a digital platform architecture using modern technologies such as IIoT, Vehicle-to-Grid (V2G), Machine learning, Big Data [1].

Using electric vehicles as an energy storage device can cover fluctuations in the consumption schedule using V2G technology. However, for efficient operation and distribution of vehicles, their integration is necessary not only in the electrical system, but also in the information space of smart city management. The information system will send requests to charging stations to return electricity from the connected car to the network when demand is high (in the morning and evening), and consume electricity when demand is low (in the middle of the night to night). In studies of cities such as Saint Petersburg underlines the difficult situation with the available network capacity of the power sources [2]. Charging infrastructure services that are not integrated into the information space of electric distribution networks may worsen the situation or lead to unnecessary spending on expanding infrastructure capabilities, which will lead to a low load factor. With the help of electric vehicles and V2G technology, it is possible to redistribute consumption volumes between the night minimum and highs and thus smooth the consumption curve. In addition to distribution by day zones, platform-based solutions can achieve territorial distribution based on the load factors of power centers.

The platform assumes that the exchange of information between the power system and the consumer will be carried out by transmitting information from sensors that read such indicators as: power consumption and power generated (if available), intelligent devices such as power converters and "connected" electric vehicles are integrated into the system.

All data in encrypted form using 5g high-speed data transfer technology is transmitted to the main server, where a digital twin of the power system is formed based on the incoming data, this will allow predicting and preventing system accidents in the future. The high-speed communication channel from the main server to the information server receives actual data on the load of power centers and the power grid complex as a whole, as well as data on road traffic. On the other hand, the user selects a destination in the mobile app, and data on the destination and the state of the electric car is sent to the computing server, where the algorithm selects and reserves a Parking space for the user next to the destination. An information server is also needed to collect data about each user's trips and daily routine in order to create an individual profile of electricity consumption. A significant role in the architecture is played by localization of the user in the cyberphysical space in order to predict his actions, since actions generate consumption. This will help optimize the user's interaction with the platform in the future. At the same time, it is necessary to assess the reliability of the rebuilt network model in terms of redundancy and load management, as well as the stability of the system with distributed generation [3].

Today, it is not enough to focus only on physical interactions, especially when implementing cybersecurity mechanisms and managing big data to manage energy savings in smart cities. Transformation and digitalization require new methods and technologies for successful interaction and understanding of the entire cyber-physical system. Formation of system of development management and distribution of generation and consumption of electric vehicles should be based on the following principles: reducing the burden on infrastructure, increase the utilization of the statutory maximum generation, maintaining the reliability and safety of electric network, maintaining the quality of electrical energy, increase the life cycle of infrastructure and equipment, ensuring information security, platform and data.

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PROTOTYPE OF A SIX-AXIS ROBOT MANIPULATOR

The constant growth of requirements for automation of production is currently causing attention to mechatronics and robotics. Accordingly, modern specialists should have the skills to work with similar systems. For educational purposes, at the department "Energy, Automation and Computing Engineering" of the Karaganda State Industrial University, a prototype of a six-axis robot manipulator with partial printing of robot parts on a 3D printer was developed and assembled.

The implementation of such a project had 3 goals - to reduce the cost of acquiring an expensive robotic device, to teach students the stages of development and creation of such devices, to instill in students the skills of additive technologies.

After analyzing the existing mechatronic complexes, a choice was made in favor of a robotic arm, as the most popular equipment on the market of robotic and mechatronic complexes used in various industries.

The robotic system consists of four main parts: a platform, a working body, a mechanical arm, and a control system. These parts, in turn, consist of a set of parts. The most difficult part in its structure is a mechanical arm, consisting of links with a separate drive and a control system. A robot was designed that has six links - a six-axis one.

Some parts of the robot were ordered through an online store, and the other part was made using two 3D printers available at the department - TEVO Black Widow and a printer delta.

The printing process consisted of the following steps:

- creating a digital three-dimensional model;
- processing a digital model for printing;
- slicing a digital model into separate layers with the conversion of data into instructions for the operation of the printer (G-codes);
- directly print.

Thus, using CAD tools and special Cura software (free software for converting three-dimensional models into G-code and then printing them on a 3D printer), a 3D-printing model was obtained from a two- dimensional object, using which structural elements were printed six-axis robotic arm.

The Arduino microcontroller was selected as the control device, which is programmed in a special programming language based on C / C ++. The choice of this microcontroller was due to the following: it is a simple and open platform for inexperienced users, you can connect various sensors to Arduino, and many different libraries are available for Arduino. The Arduino Mega board, based on the ATmega2560 microcontroller, was chosen.

As a gripping device, the low-profile pneumatic gripper of the MHF2 series model MHF2-8D1 was chosen.

In the process of carrying out the research work, the following stepper motors of the six-axis robot manipulator were selected according to the required parameters: Nema 17HS19-1684S-PG5 is located on the first axis of the robot manipulator and rotates the platform; Nema 23HS30-2804S-PG47 is located

on the second axis and rotates the shoulder joint; Nema 17HS19-1684S-PG19 is located on the third axis of the robotic arm and rotates the shoulder console; Nema 11HS20-0674S-PG5

is located on the fourth axis and expands the forearm console; Nema 17LS19-1684E-200G is located on the fifth axis of the robotic arm and rotates the wrist joint; The Nema 14HS13-0804S-PG19 is located on the sixth axis and rotates the gripper hinge. Based on the requirements for a driver for controlling stepper motors, the Microstep Driver ST-6600 was selected.

The final stage of the project was the development of an operating algorithm, programming and tuning of the robot manipulator. The algorithm for the formation of the automatic control program involves the input of a reference trajectory, which the manipulator will adhere to. In the process of forming the program, you can preview its functioning. At the end of input of the initial data, a program file is generated.

Thus, the implementation of the educational research project allowed us to strengthen the material and technical base of the department and get the students the necessary professional competencies.

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THE SYNERGY OF BLOCKCHAIN AND LOW-CODE TECHNOLOGIES AS AN INNOVATIVE TOOL TO IMPROVE THE SUPPLY CHAIN IN THE MINING INDUSTRY

In a market economy, the commercial success and profitability of companies are largely determined by their ability to implement innovations [1]. Openness to innovation has become one of the key measures of competitiveness and a synonym for it. Therefore, innovation should be seen as a new idea in a given environment, which does not have to be directly related to invention, but should be able to assign the attribute of novelty or at least mean the introduction of novelty [2]. Market and technological changes in the world are caused by the development of consumer awareness. Automotive or FMCG are just some examples of industries investing in new innovative solutions for the implementation of processes providing goods to customers. Due to its specificity and numerous environmental and geological aspects, the mining industry often cannot use ready-made solutions available on the market. It is noted that in the mining industry new technologies are implemented much less frequently than in other industries.

In this article the author describes research devoted to the search for a solution to improve the full supply chain in the mining industry, also taking into account external participants of the process. The main goal is to improve the transparency of processes, the possibility of monitoring the path of goods in the supply chain from the moment of obtaining the raw material to delivering it to the customer. The concept also aims to implement and/or improve key indicators such as:

- unit cost - cost/tonne,
- forecast - operational planning of delivery on time - just in time,
- stocks - the amount of capital frozen in stocks, the smallest necessary amount of stocks,
- EBIT - operating profit,
- digital strategy - company development, investing in new technologies,
- security vs. bumper.

The project involves the use of two of the most successful technologies such as blockchian and low-code enterprise app. Gartner, the world's analytic-consutling agency, has conducted research which shows that both technologies will dominate the market of technological solutions in the coming years. It was found that by 2024, three-quarters of large enterprises will be using at least four low-code development tools for both IT application development and citizen development initiatives. And also by 2024, low-code application development will be responsible for more than 65% of application development activity [3]. The solution proposed by the author is an innovative concept not described in previous scientific

publications. The synergy of low-code enterprise app and blockchain technology is an innovative combination. The possibility of implementing it in the mining industry proves the flexibility and efficiency of the solution. Moreover, the author assumes the scalability of the solution and the possibility of its application also in other industries.

Blockchain technology was created in 2008 and is often associated with the cryptovalut environment [4]. However, for over a decade the technology has been developed and a new version dedicated to business projects has been created - rationalization of internal and external process transactions. Thanks to appropriate configurations and selection of patterns, it creates a secure network of blocks, in which the transaction data of performed business processes are saved. The technology does not work independently. The author proposes to support the block-chain paltform by implementing solutions in the form of business applications, which are built thanks to the low-code platform. Low-code technology has been developing since the 1990s. However, at the turn of the last decade few low-code anterprise app platforms were created. They are dedicated to creating solutions aimed at process optimization. Considering the modernity and topicality of low-code teamwork, there are not many literature items on this subject. Today's professional software developers have many tools at their disposal that increase their productivity and efficiency while empowering them and their teams to generate better applications faster. Better apps faster, however, is just the starting point for low-code. In reality, these tools offer a number of advantages to organizations who are looking for a range of different value propositions from their software. Today, modern enterprise low-code platforms can tackle the toughest of modern enterprise applications - from complex, multicloud workflows to elaborate application modernization initiatives [5].

The results of the author's research prove the possibility of combining technologies in terms of technological parameters. Moreover, it is stated that the concept is an innovative solution for global mining. In the further part of the research, the author together with the project group will create the first prototype solution. The project will be supported by strategic partners like IBM Blockchain Platform and Low-code platform by Novacura Flow. The project will be implemented with the participation of one of the largest representatives of the mining industry in Poland.

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USING AUGMENTED REALITY SYSTEM FOR MAINTENANCE AND REPAIRING PUMPS

Oil pumps are the highly significant equipment in oil and gas industry. But unfortunately Oil pumps are the cause of significant numbers of emergency in a plant. There are a several types of pump failures. [1] It is mechanical failures (it is a wear factor, mechanical defects etc), control system failures (work in power intensive mode, power system failures etc, operate in outside working areas) and hydraulic system failures (incorrect pump selection etc).

All of these types of failures significant decreases a profit and an efficiency of an oil plant. For example, according to statistic, the Russian enterprises have lost about 4 billion rubles and more than 500,000 tons of oil. [2]

The one of the ways of decreasing oil pump failures is oil pump maintenance. A modern industrial enterprise usually uses three methods of maintenance: by schedule, by operating time and by actual state. Maintenance of pumps according to its actual condition is most preferable, since in this case maintenance is carried out only as needed. However, if the list of parameters by which the decision on the need for maintenance is made is not complete, the pumps may fail abruptly.

The possibility of timely repairing a defect in the operation of oil pumps may be related to some problems: the lack of spare parts, the lack of competent personnel who can repair the defect, and the errors that were made during maintenance. [3] These problems will help solve the introduction of a special system of maintenance of pumps based on augmented reality. The technology of augmented reality will allow to visually demonstrate the stages of work during maintenance, indicate the method and place of fastening the main parts, give the specialist additional information about the pumps. This significantly reduces the time and quality of pump maintenance.

This laboratory unit consists of two pumps, two tanks, a heat exchanger, a pipeline system and valves, sensors and actuators. The working liquid in this unit is water. It pumps from the first tank into the second tank and heats in the heats exchanger.

In the system, process parameters are displayed in real time. This is the one windows princip. An operator shouldn’t switch between any systems He or she able to check parameters using only one screen and one system. It is very useful and comfortable for operator. The process parameters are located near the equipment where they are controlled.

The AR system shows how the pump must be taken down. To remove, it is necessary to unscrew two bolts from both sides and proceed to further maintenance at the workplace. A 3D model is provided for the worker, which can be moved, rotated and zoomed in order to be able to consider possible «inconvenient places» in more detail. At the top of the screen displays the name of the person conducting the service, and the elapsed time necessary for analysis and optimization. The system highlights the parts of a pump which must be caught attention of worker, and also shows which tool it is desirable to use at this stage.

The efficiency of this system can be really estimated during the experiment. There are the 3 groups of worker. The first one make repeating without any system using only paper documents, the second one uses the automated control system, paper documents and expert help by phone and the third one uses the AR system. The expected value of efficient of this system: maintenance cost will decrease by 25 percentage accident damage control will be followed down by 70 percentage unplanned outage will depreciate by 35 percentage and capacity will increase by 20 percentage. [4]

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DEVELOPMENT OF TECHNICAL MEANS AND TECHNOLOGY OF INTERACTIVE DRILLING ANALYSIS AS PART OF THE SYSTEM «SMART MINE»

During the development of the rock mass, the acquisition of information on the ore body boundary, the content of the useful component, the volume of the rock and the laying material makes it possible to analyse the development of the ore body, To make adjustments in the direction of ore mass development and the organization of ore flows and carrying rocks to the surface.

At present, several methods are known for determining the type of rock during mining operations.

There is an instrument for the analysis of rocks on the basis of the dust produced by the blast process of the rocks. The main source of dust is an area of rock adjacent to the explosive charge, which is exposed to a stress wave above the rock strength limits. In explosion, the dust rises from all surfaces and mixes in air. This is one of the disadvantages of this method, as information about the rock behind the radius of dust formation is lost, and all the dust after the explosion is mixed in the air, preventing the breaking of the limits of the ore body.

Acoustic emissions as a way of analysing rocks. Acoustic emissions arising in the working zone of the drilling tool are represented by low and medium energy impulses. As a consequence of this feature, vibration sensors that detect sound impulses are not applicable in this case because of the suppressive acoustic interference caused by the drilling rig drive and other auxiliary equipment.

In order to carry out the analysis of the type of mining in the drilling process, a drilling unit is proposed which will make it possible to assess the physical and mechanical properties of rocks during drilling of wells and rib hole in the impact-rotational drilling mode.

The drilling unit consists of a bit, a drilling column, in which a sensor is mounted which perceives the compression deformation at the moment when the impact pulse is applied to the bottom. In the form of a sensor, can be used a piezometer, which generates an electrical signal when the drilling column is compressed. An electrical signal is transmitted in real time by means of a transducer to the electronic system of the unit and to the computer where it is analyzed. The signal value depends on the type of rock. It is proposed to use the elasticity as a parameter of the properties of the rock as a parameter related to the hardness of the rock and determining the value of the elastic reaction of the rock to the force impact [1]. For example, the elastic deformation of the host rocks will be different from that of the ore body if there are differences

in their hardness. This will make it possible to clearly delineate the boundaries of the ore mass and adjust the direction of development. The introduction of such technologies in the development of ore array can be the initial stage in the development of «Smart Mine» system, in which all data is digitized and the possibility of optimization and control of all processes taking place, in particular the optimum organization of ore flows, which contain useful components.

The developed technology and drilling unit are patented as «Method of determining the strength of rocks during drilling and device for its realization».

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DEVELOPMENT OF DIGITIZATION STANDARDS FOR BUILDING AND DECORATIVE ROCK PLATES

The Geoscientific Collections of the TU Bergakademie Freiberg comprise several sub-collections, including the Mineralogical, the Stratigraphic and the Petrological collection. Within the Petrological collection, about 2000 polished building and decorative rocks plates from all over the world exist. Starting from a selection of these plates, standards for digitization of building and decorative stones have to be developed, designed as a base for an automated algorithm [1] of rock classification. In this context, different imaging approaches [2] are evaluated and methods are established for acquisition of computer-readable information on petrographic characteristics such as texture, colour, grain size and distribution and so on [3].

The first step was in doing comparative tests of various imaging techniques, which have been performed on selected samples of rock plates. The techniques used include digital cameras, flatbed and overhead scanners, digital microscopes and a profilometer (a surface measurement device, which combines functions from many other techniques such as microscopes, laser scanning and contour measurement devices). It has been found out, that scanners, microscopes and the profilometer have been found superior to cameras because of minimization of optical lens distortion, minimization of disturbing daylight and, thus, of the problem of reflectance by certain minerals in the rock. On the other hand, the available microscopes and the profilometer were not equipped with platforms suitable for the usual size of rock plates (250 x 160 x 20 mm), so that the flatbed scanner RICOH Pro C5100s was chosen for the acquisition of digital images. The light lamps of the scanner, which function on the basis of the RGB colour space [2, 3], don´t cause high reflection, because their emitted light ray strikes 90° perpendicular to the polished surface of the rock plates. Also a highly true colour image is achieved, which also applies to brightness and contrast. So flatbed scanners provide very good photographic qualities for rock plates and ensure independence from always changing daylight in different working rooms. While images, obtained with microscopes and profilometers, need large storage space and a highly advanced computing system due to their high resolution quality, pictures from flatbed scanners do not rely on such expensive technologies. A disadvantage of the scanner is its glassy surface, which can be damaged by the heavy and hard rock plates, so careful working is needed. Another disadvantage is the scanner resolution, which is sufficient for petrographic and mathematical description but much inferior to that of microscopes or profilometers. However, the flatbed scanner has proven to be a fast and easy-to use device for obtaining digital images of good and, most importantly, standardized quality. The imaging with the scanner is done as follows: the plates are placed with the polished surfaces on the DIN A3-format glassy platform

of the scanner. In addition, a standardized colour checker card by X-Rite is laid near to the sample. Then the scanner is covered, so no distorting daylight enters the highly reflective surface or influences the colour, brightness or contrast of the rock plate. Then certain parameters on the control console have to be chosen. These parameters include: DIN A3 format, allowing the simultaneous digitization of several rock plates at once, thus minimizing storage space on computing systems; gloss photos because of the polished highly reflective surfaces of the rock plates; 600 dpi (dots per inch), which is the maximum available resolution possible; and the target file format TIFF (Tagged image file format), in order to prevent alteration of the initial resolution. Up to now, around 135 rock plates have been digitized in this way.

Post-processing of the so generated digital images was done with the image editing program ImageJ in order to derive statistical parameters such as colour arithmetic mean and standard deviation. ImageJ depicts the colour distribution in the form of histograms [3], which are also informative with respect to grain size-, brightness- or colour distribution and their differences on macroscopically similar rock plates. These data as well as other petrographic characteristics such as texture, grain size and so on are recorded in a supporting data base.

A question arose if certain areas from polished surfaces of the rock plates are sufficient to describe the whole rock. This is not the case as differences in colour arithmetic mean of the smaller area and that of the whole surface as well as the exclusion of certain components in the smaller area, which could be important for correct classification, show. Hence, it is not recommended to analyse a restricted area. Rather the whole surface of the rock plates should be included in the image analysis and further research, because all components are covered up so. In the next time, other image analysis programs are going to be tested for their suitability for describing petrographic properties such as grain size and shape mathematically.

Colour measurements have been done with a mobile photo spectrometer, which functions on the basis of the CIELAB colour space [3]. The advantage of this method is its consideration of the human colour vision recognition [1, 3] and therefore its device-independence: it defines colours independently of how they are created or displayed. However, mineral grains smaller than the measurement area of the device (5-8 mm) limit the applicability of the photo spectrometer. Hence, a scanning method for this device has to be developed, so the entire surface of the rock plate can be measured. This could be achieved with a tripod-like automated framework, which allows raster movement for the photo spectrometer on the rock plate. Further investigation will be done in the next time on this topic.

As a byproduct, digitized rock plates shall be made available in an online database, and a digital map of building and decorative stones of Saxony is planned to unite occurrence data, geological and perhaps historical information and digital images of Saxon rock plates from the Petrological collection of the TUBAF. The virtual map should allow the user to show the information and components by clicking on regions of the shown map, on a pop up list or by typing in a searching line. Further cooperation with suitable companies or institutes is going to be made in order to implement this specific Saxon map.

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SUCCESS FACTORS FOR DIGITIZATION CENTERS AS A BASE FOR A FUTURE FACILITY DIGITIZING GEOSCIENTIFIC OBJECTS

Digitization is becoming increasingly important for the economy and the society. In 1997, the Bavarian State Library pioneered by founding a digitization center. They began systematically transferring their stock of books into digital formats. What started out by hand with an output of 300 books a year has now matured into a technological industrial process that enables digitizing up to 12,000 volumes per year [1]. In the meantime, a large number of such facilities has emerged over time. These digitization centers revolutionize access to education and culture and generate new opportunities for use [2]. Following the first approaches of digitizing text-based knowledge, more and more organizations have specialized on digitizing objects of art, engineering, humanities and natural sciences. However, up to now there is no digitization center that explicitly deals with and is specialized for various types of geoscientific objects. This is a grave oversight because the mining industry remains a strong industry that can only benefit from such a facility. Against this background, we intend to create a Geo-Digitization Center in Freiberg (Saxony). When designing this digitization center, technical, economic and structural aspects of establishing a digitization center must be taken into account. Although previous research provides some insights into the processes of building digitization centers [1;2], further studies are required to shed more light on conceptualizing digitization centers in general and a geo-digitization center in particular.

To address this research gap, we aim at deriving success factors from best practices of existing digitization centers. In particular, we performed a benchmark analysis based on interviews with digitization center experts. Expert interviews represent a very valued instrument for such research settings [3]: Given that only few digitization centers exist thus far, there is little access to knowledge in this field. The interviews that we performed serve to use the valuable knowledge base of the few experts in the field.

We conducted 9 interviews from August to December 2019 with experts from different German digitization centers. We carried the expert interviews out by telephone in order to reduce the time, personnel and financial expenditures for traveling [4]. Using a structured guide, we asked the interviewees explicitly about the technologies used for digitization, the organizational design, recruiting preferences, management, publishing digital models, as well as the digitization center as a building. We transcribed all interviews and subsequently, we quantified our data using a coding book.

Based on the reported best practices and on our statistical analyses, we derived the following success factors: First, with respect to the technologies used for digitization, the combination of two- and three-dimensional digitization technologies is of utmost importance. Combining technologies allows to benefit from the respective advantages of the individual technologies (e.g., photography, laser scanning and photogrammetry) and thus, enables covering several application areas. Second, with regard to the organizational design, we found that using specific technologies as criterion to assign employees to teams is better than using object types as criterion. Structuring the organization based on specific technologies is advantageous because employees can concentrate on particular technologies, which, in turn, offers them the possibility to become experts and to apply their knowledge to different object groups. Third, concerning recruiting preferences, we found that applicants for jobs in digitization centers should have a broad general interest in the topic of digitization as the main criterion above anything else. Any expertise in this area is an advantage. Essential basic technical knowledge is the basis for working in a

digitization center. In contrast, specific professional requirements to the applicants are difficult to establish and pursue and should therefore be kept general. Fourth, with respect to management, the need for quality management represents a crucial success factor. We observed that a quality management department is essential in the object digitization process. This department should check the quality of the digitized object after digitization, if possible, but also at several points in the process to ensure the highest possible quality for the output. Fifth, concerning the publication of digital models, the interviewees generally recommend offering online access to the digitized objects. Digitized objects should be made available online to interested users and partners through a dedicated digital platform. Finally, as far as the digitization center as a building is concerned, experts consider the construction of a public showroom to be absolutely sensible. Temporary or permanent showrooms make the work of a digitization center accessible to the public and customers as well as partners. In doing so, they also create an advertising platform for the facility, which can be further strengthened through marketing measures on social media. At this point, it is possible to integrate the latest technologies, such as virtual or augmented reality. According to our interviewees, virtual and augmented reality solutions are success drivers regarding the attractiveness of a digitization center and in the digitization process. By identifying these success factors for digitization centers, we provide valuable insights for practitioners who plan to found and run digitization centers. Simultaneously, we pave the way for future research that should replicate and extend our study based on a larger sample to potentially derive further success factors and to gain a deeper understanding of what makes digitization centers successful.

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TELECOMMUNICATION TECHNOLOGY AND DIGITAL TRANSFORMATION

Telecommunications technology refers to distance communications, such as radio, telephone, television, satellite, microwave, data communication, and computer networking. Modern telecommunication is centered on the problems involved in transmitting large volumes of information over long distances without damaging loss due to noise and interference.

The basis of relatively noise-free and distortion-free telecommunication is the binary signal. The simplest possible signal of any kind that can be employed to transmit messages, the binary signal consists of only two possible values. These values are represented by the binary digits, or bits, 1 and 0. Unless the noise and distortion picked up during transmission are great enough to change the binary signal from one value to another, the correct value can be determined by the receiver so that perfect reception can occur.

Analog-to-digital conversion begins with sampling, or measuring the amplitude of the analog waveform at equally spaced discrete instants of time. The fact that samples of a continually varying wave may be used to represent that wave relies on the assumption that the wave is constrained in its rate of variation. Because a communications signal is a complex wave,

its rate of variation can be measured by the frequencies of oscillation of all its components. The difference between the maximum rate of oscillation (or highest frequency) and the minimum rate of oscillation (or lowest frequency) of the sine waves making up the signal is known as the bandwidth (B) of the signal. Bandwidth thus represents the maximum frequency range occupied by a signal.

For a sampled signal to be stored or transmitted in digital form, each sampled amplitude must be converted to one of a finite number of possible values, or levels. For ease in conversion to binary form, the number of levels is usually a power of 2. In digital transmission of voice, 256 levels are commonly used because tests have shown that this provides adequate fidelity for the average telephone listener.

Digital transformation is the process of using technologies to create new (or modify existing) business processes and customer experiences to meet changing business and market requirements.

Unlike digitization, digitalization is the business process of the technologically induced change within industries, organizations, markets and branches. Digitization of business and organizations has induced new business models , new eGovernment services, electronic payment, office automation and paperless office processes, using technologies such as smart phones, web applications, cloud services, electronic identification, blockchain, smart contracts and cryptocurrencies, and also business intelligence using Big Data. Digitization of education has induced e-learning.

The academic discussion surrounding digitalization has been described as problematic as no clear definition of the phenomena has been previously developed. A common misconception is that digitalization essentially means the usage of more IT, in order to enable and take advantage of digital technology and data. This early definition, however, has largely been replaced by the above definition, now linked to holistic views on business and social change, horizontal organizational and business development, as well as IT.

Session 7. EQUIPMENT, VEHICLE MAINTENANCE AND ENERGY EFFICIENCY AT THE ENTERPRISES OF THE MINERAL RESOURCES SECTOR

Innovations and prospects for the developments of mining mechanical engineering

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APPLICATION OF THE ROPE METRO IN THE MINERAL RESOURCE COMPLEX

The essence of the project: Creation of an innovative cableway, the activity of which is to solve the problems of freight transportation in the mineral resource complex. The presented development allows for the transportation of goods at predetermined distances. Cableways allow you to easily overcome obstacles such as rivers, gorges, deserts, etc. The connection of mountain hills allows you to ensure the transportation of goods to areas inaccessible to land transport.

The cable car - suspended transport road - consists of a drive, tension and intermediate stations-stops, supports and three ropes along which a moving car moves.

The cable car route occupies a minimum of ground areas, does not cross traffic and human ground flows, is environmentally friendly, easy to maintain and fits beautifully into the natural landscape. In addition, neither the terrain, nor objects located on the ground, nor communications of all kinds interfere with its penetration.

Stations of the cableway suspended transport can be located near or in the zone of the mining complex, creating a closed route for transporting freight flows.

The cable metro easily, without additional costs, allows you to deliver a large amount of cargo at any distance, to any, even hard-to-reach areas of the region, at any time of the day.

The cable subway can be operated at temperatures from + 40 ° C to - 40 ° C; in case of adverse climatic conditions, preventive maintenance measures are provided. At the same time, the construction of an overhead transport road is much cheaper than the development of any other type of transport, since it does not require the construction of roads, underground work, expensive vehicles and does not violate natural beauty.

The timeline for the construction of the cable metro is minimal. The cost of its construction pays off in the period up to 12 years.

The ropeway does not require operators for each rolling carriage; for the operation of the ropeway, a minimum number of specialists are responsible for transportation and maintenance. When transporting the extracted raw materials on land transport, there are risks associated with the human factor, which can significantly affect the speed and safety of the cargo. In mountain deposits, there are impassable and life-threatening sections of the path of vehicles.

The second destination of the rolling road are sightseeing and tourist applications.

Since in some cases there is a movement of the zones of extraction of raw materials, previously constructed roads and transport routes are idle and not operated. Cable cars are in great demand in the tour and tourism industry; a large number of tourists want to see natural beauty from a height.

Passenger cabins with a capacity of up to 30 people are hung on the constructed line for the transportation of goods. The circular visibility of the cabins allows you to conduct tours of the areas where the cable car is laid, bring residents and visitors to the ski resorts, lakes and historical places, demonstrate to tourists the beauty and grandeur of mountains, fields and forests, the natural potential of the region.

The presented type of cargo transportation is an actual solution to transport problems for the mineral resource complex. Transportation of mined raw materials by cable car reduces the cost of laying roads and paying drivers, which improves the efficiency of the mining complex.

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MATHEMATICAL MODELLING OF THERMOVORTEX HEAT TRANSFER IN AIR COOLERS

Air cooled devices which are currently used are characterized by scarce economic efficiency largely caused by the low heat transfer coefficient. A method for increasing their efficiency by means of stable system of vortices creating the “Tornado” effect, forming the process of thermovortex heat transfer. Thermovortex decrease in the temperature of the cooling air leads to the increase of temperature difference between the cooled gas, the tube walls and the cooling air, and the effective value of the Reynolds number Re_{ef}, caused by the “Tornado” effect, and, as a result, to the increase of its thermophysical similarity criterion. Helical vortex generator allows to increase the heat transfer coefficient up to $\alpha = 108$ W/m^2·K.

The idea of the efficiency upgrading of ACHE heat transfer is based on the use of a stable eddy turbulent motion of cooling air in the form of a “Karman Vortex Street” created by serrated cooling elements of tube bank finning made in a form of an Archimedean spiral of “Helical turbulators” type mounted on heat-exchanging tubes which could form a stable system of vortices, interacting with ACHE tubes and creating the “Tornado” effect. [1]

The problem of increasing the ACHE heat transfer is solved by swirling the cooling air with the spiral elements of serrated elements, which leads to a significant decrease of cooling air static pressure due to its intense spin and an increase in the period of cooling air contact with a bank of finned tubes. [2] The studies of the mechanism of the stable “Karman Vortex Street” interaction in a helical vortex generator confirm a significant decrease in static pressure through the intense eddy motion, which leads to a considerable drop in the temperature of the cooling air, according to the Clapeyron’s theory. [3]

Based on a hypothesis of an influence dominant of the circulation flow velocity in a helical vortex generator on the reduction of the cooling air temperature, a mathematical model of thermovortex heat transfer in the air cooler (AC) has been proposed. A design of a multi-row single-cut tube bank with the finning in a form of an Archimedean spiral combining the best properties of disk and pin cooling elements of air cooled heat exchangers (ACHEs) has been introduced.

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IMPROVING THE STABILITY OF WALKING EXCAVATORS AND OVERBURDEEN SPREADERS

Excavators and spreaders on walking propellers are considered to be some of the heaviest mining machines. Their operational weight can reach more than 600 tons. That is why, the issues of ensuring their stability are important not only from the point of view of economic efficiency of application, but also from the point of view of safety.

When assessing the stability of excavators and spreaders that work on walking propellers, it should be taken into account that, first of all, these machines operate on technogenic support foundations that are significantly deformed at relatively low ground pressures, and that their physical and mechanical properties vary significantly depending on weather conditions at technology sites.

Secondly, when an excavator or a spreader is operating in one place, when the supporting platform is only a round base, it should also be taken into account the fact that the loads from the working equipment are periodic dynamic in nature. These loads are transferred to the bearing base, which experiences their impact and is deformed.

A special mode of operation of these machines, requiring analysis of their stability, is a walking process. It can be nominally divided into the following phases: lowering the skis , lifting the machine, moving it relative to the fixed skis, followed by lowering to the support base, lifting the skis. After this, the cycle repeats and the machine moves one step, the length of which is several meters. The loads on the supporting base during the walking cycle are redistributed between the supporting base and the skis both in magnitude and in places of their application. The reference area changes its shape and dimensions during this cycle and depends on the scheme and design of the walking mechanism.

The authors has developed algorithms for analyzing the stability of excavators and overburden spreaders on walking propellers, as well as technical proposals for the modernization of their supporting bases.

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MODELLING AND EXPERIMENTAL VERIFICATION OF DYNAMIC PROPERTIES OF HEAVY MACHINE TOOL BODIES

Good vibration damping is one of the basic dynamic characteristics desired for cutting machines and determines the quality of the surface to be machined. Vibration damping is particularly important for self-excited vibrations, which are difficult to predict at the design stage and occur during the cutting process with specific, often imposed cutting parameters. Therefore, knowledge of this feature of the supporting structure of a machine tool is important already at the design stage. This also applies to heavy machine tools, which are often manufactured individually. The approach to the design process in this case is often without a prototype construction phase and design improvements.

The authors' observations of special machines, not produced in series, show that this often happens too late. This means that when the machine is started up and due to the self-exciting vibrations that occur, it stops machining with the cutting parameters required by the user [4,5]. The machine prototype must be the final product for economic reasons.

The most common material used for machine tool bodies is cast iron in its various varieties. This is mainly due to good damping properties, as well as features related to technology of making even very complicated shapes. Some machine tool supporting structures are also made as welded steel. They are characterized by lower weight while maintaining the same stiffness, as well as much lower damping. For this reason, attempts are made to improve the damping properties of steel bodies by filling cavities with polymer concrete and creating so-called hybrid bodies. Monolithic polymer concrete bodies are also used [3].

This article is intended to answer the question of how to approach the body design methodology so that the dynamic characteristics of the superstructure can be reliably assessed at this stage. The focus is also on hybrid bodies as developmental.

The authors' research is based on examples of special heavy-duty machines, based on which a methodology of experimental research was developed with the use of academic primitives in the form of beams imitating an example of a machine tool support beam. Under the proposed methodology, the following beams were developed and manufactured: steel beam in the form of a rectangular pipe, steel beam filled with polymer concrete and beam made as a polymer concrete monolith.

The beams were tested using experimental modal analysis. The results were obtained by means of frequencies and dimensionless damping coefficients assigned to specific forms of the beam's own vibrations.

The next step was to perform model tests using FEM. FEM simulation studies of beam vibrations were carried out in the same way as experimental studies. For this purpose ANSYS was

used. The research included modal analyses, transition state analyses and analyses of responses to harmonic force. As in the case of the experiment, the free suspension of the beams was adopted. The extortion, depending on the type of analysis, was assumed in the form of a unit pulse for the analysis of transient states, or sinusoidal alternating force for the analysis of

harmonic extortion responses. The purpose of the simulation studies was to answer how damping coefficients forthis type of structures should be taken.

Beam models have been prepared as solid models, which, apart from coating elements, are most often used in modelling machine tool structures. Analogously to experimental research, the analyses were carried out imitating free suspension.

The material properties of the models relating to both dynamic and static characteristics were selected in such a way that the results of the simulation tests correspond to the results obtained in the experiment. This approach resulted from the large scattering of material data observed in the literature concerning polymer concrete and from the lack of knowledge of polymer concrete characteristics obtained during the preparation of experimental models.

The comparison of the results of experimental research with the results of simulation studies was carried out in order to finally obtain information about the possibilities of credible simulation of this type of phenomena. The comparison of obtained damping for particular forms of vibrations and beams is presented in Figure 1.

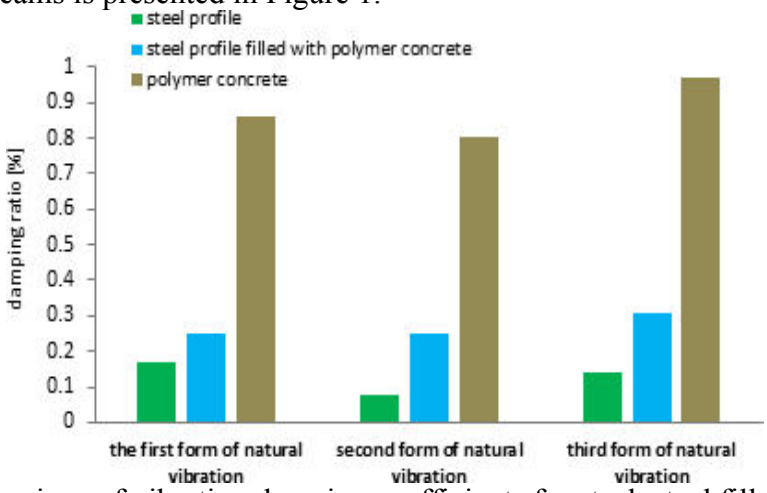

Figure 1 - Comparison of vibration damping coefficients for steel, steel filled with polymer concrete (hybrid combination) and polymer concrete casting [1,2]

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THE EFFECT OF GEAR WEAR ON THE ACCURACY OF THE ROTARY FLOWMETER MEASUREMENT OF INDUSTRIAL WATER CONSUMPTION

Key words: rotary liquid flowmeter, wear resistance, calibration, tooth gap.

Ensuring the accuracy of calibration and studying the causes of the measurement instrument error is the first step for evaluating its technical condition. The resulting increase in error in comparison with previous measurements allows to evaluate the mechanism of the flowmeter's wear and tear and its impact on measurement accuracy. Maintenance or repair work on the flowmeter allows you to reduce this impact and assess its maintainability.

Ensuring the accuracy of measurements is an important task in metrological, scientific and technical fields. Referring to the theme of measurement error may seem to be a recurring one, if we speak only about its conceptual and theoretical approach. However, from the practical point of view, the reduction of the error corresponding to a systematic error is a characteristic of the drive gear mechanism wear, mainly visible in the positive displacement flowmeters. It is here that theory plays an important role, helping to interpret the phenomena occurring [1]. On the basis of metrological definitions systematic error is characterized by the difference between the mean value and conditionally true value of the measured value under conditions of repeatability. This error is caused by various reasons, among which are errors of the measuring instrument, errors of the production process, as well as wear and tear that it experiences during operation. [2, 3]

The gear manufacturing process, also varied and standardized, depends on different conditions. In particular, the tooth spacing, the spacing of the rotation axes and the tooth width largely determine the quality of the work with the minimum tooth gap. In other words, a measuring instrument, such as a liquid flowmeter, must have high accuracy, which is taken into account in the error resulting from the measurement made by the flowmeter. In turn, gear wear results in a change in the size of the teeth. Its value increases in the same proportion as the measurement error of the measurement made with devices subject to wear conditions. However, the irregularity that is present in this wear is reproduced in the transmitted motion, and therefore the systematic error varies.

In most measuring instruments, mechanisms that operate under friction are an important part of their control or display. In particular, positive displacement flow meters have a large number of parts that are subject to wear and tear. Shafts, slide bearings and gears play an important role in this respect [4]. These parts are subject to high mechanical stress, corrosion and friction, so their wear and tear has a significant influence on the accuracy of the measuring instruments. For these reasons, maintenance and calibration must be strictly observed.

After normative calibration of the flowmeter the relative error of the flowmeter exceeds (0.21, 0.22 and 0.31) % of the maximum permissible error of ±0.5 %. After re-testing, the errors were maintained at the values exceeding the allowable ones.

Meanwhile, the repeatability rate, although still high at 0.14%, remains within the permitted value, less than 0.16%. This result indicates a need for maintenance or repair.

During the inspection of the flowmeter interface it was found that the ratio of rpm per liter was anomalous from 0.588 for 15 shaft turns and 0.594 for 30 turns. This data indicates that the transmission ratio in the counting mechanism is variable and requires technical intervention.

After examining the counting unit, it was noted that the main gearboxes support a gear ratio equal to the unit. However, wear, abrasive wear, fractures and pitting of tooth surfaces make it necessary to check how the tool affects its normal operation. For this purpose, an evaluation of the perimeter gears of each wheel was carried out based on the operating manual

[1]. The length of the ¨K¨ teeth has been checked as shown in Figure 1 and compared with the theoretical value of ¨K¨ used as a reference.

Figure 1: Checking the gear teeth ¨K¨ using a universal caliper

This pinion, which corresponds to the measuring device, must be characterized by high accuracy, precision, and the gap between the teeth must be in the range (from 0.014 to 0.030 mm). However, an analysis of the results of its inspection leads to the conclusion that:

1. Comparison of the K-value of each wheel with the reference is variable, so the accuracy of the mechanism is insufficient and is reflected in a high value of repeatability during calibration.

2. The deviation of each wheel takes the opposite sign, which reflects an increase in the gap between the teeth. Considering the corresponding modes as the deviation value corresponding to each wheel, it is indicated that the toothed gap reaches values close to 0.05 mm. This value is above the upper limit of the standard range for this mechanism and characterizes the wear of this gear crown. Fundamental reasons are the reason for the increase in systematic errors.

3. The above conditions indicate the need for replacement or repair.

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THE RESULTS OF EXPERIMENTAL STUDIES OF THE PARAMETERS OF EMERGENCY BRAKING PROCESS FOR VEHICLES OF CATEGORY M_1

Road traffic accidents, unfortunately, are an integral part of road transport operation and are among the leading causes of mortality in peacetime. According to the World Health Organization (WHO), road traffic accidents result in the deaths of more than 1.35 million people around the world each year and leave 50 million people with injuries. About 170 thousand road traffic accidents annually occur in the Russian Federation, as a result of which people of employable age and children under 16 die and get injured. Currently, many producers constantly upgrade active car safety to improve road safety and reduce the number of road traffic accidents. In particular, the design and operational properties of the brake system, aimed at braking efficiency and prevention of traffic accidents, were significantly improved, for example, in

addition to the existing elements – Anti-lock Braking System (ABS) and Electronic Brake Distribution (EBD) system – the Brake Assist System (BAS), aimed to minimize the braking distance and increase vehicle deceleration, was additionally introduced. Thus, it is not exactly correct to use in expert practice the averaged values of steady-state deceleration and its rise time, established by the All-Union Research Institute of Judicial Examinations of the Ministry of Justice of the USSR more than 40 years ago, as well as standard ones in accordance with TR CU 018/2011 "On safety of wheeled vehicles" in calculations for vehicles, equipped with ABS, EBD, BAS systems, since the results obtained can be unreliable.

In connection therewith, to improve the reliability and objectivity of experts' conclusions during the reconstruction of road traffic accidents, clarification of the steady-state deceleration and its rise time, as well as the development of methods for reconstruction of road traffic accidents according to the parameters of braking process for vehicles of category M_1, equipped with ABS, EBD and BAS systems, are required. In order to determine the actual values of the steady-state deceleration for vehicles of category M_1 and its rise time, taking into account such factors as x_1 – the wheel-to-road cohesion coefficient; x_2 –vehicle loading; x_3 – the presence of ABS, EBD, BAS systems; x_4 – the tire seasonality type; x_5 – the presence of a trailer of up to 750 kg, an experimental study was conducted. The experiment was carried out in road conditions, according to GOST 33997-2016 and using the "Effect-02" test instrument. Based on the studies, a comparative analysis between the experimental values and the recommended ones, which confirmed the regularity of influence of the studied factors on the actual value of the parameters of emergency braking process, was carried out. An example of a comparative analysis is presented in Figure 1.

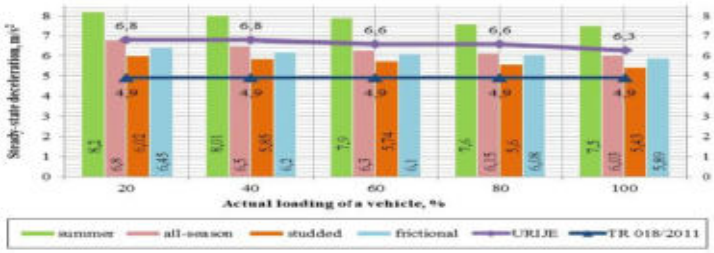

Figure 1 - Comparative analysis of experimental and recommended standard values

From the graphical analysis it follows that the values of the steady-state deceleration of a vehicle and its rise time regularly change. The difference in values, in contrast to the standard ones, is on average about 20%. Therefore, the expert's opinion, for example, when calculating the stopping distance, may vary within the same range, which results to unreliable conclusions with respect to the studied subject matter during the reconstruction of road traffic accidents.

During theoretical and experimental studies performed, the authors substantiated the expediency of introducing into the main calculated dependencies the coefficients that correct the steady-state deceleration Kj_{sd} of a vehicle and its rise time Kt_{rt}, used in expert practice, taking into account the studied factors according to the formulae:

$$Kj_{sd} = \frac{j_{sd}^{f} = f(x_1, x_2, x_3, x_4, x_5)}{j_{sdn}} \quad (1)$$

$$Kt_{rt} = \frac{t_{rt}^{f} = f(x_1, x_2, x_3, x_4, x_5)}{t_{rtn}} \quad (2)$$

The practical significance of the coefficients that correct the steady-state deceleration Kj_{sd} and its rise time Kt_{rt} for vehicles of category M_1 is based on the fact that using them in the calculated dependences will improve the accuracy in the calculations and ensure the reliability of experts' conclusions during the investigation of road traffic accidents.

Thus, the experimental study confirmed the hypothesis formulated concerning the regularity of influence of a combination of factors on the formation of values of the steady-state deceleration and its rise time for vehicles of category M_1, and the correction coefficients are practically significant, since it render possible to clarify the parameters of braking process for

vehicles of category M_1, to increase the accuracy and reliability of experts' conclusions during the reconstruction of road traffic accidents.

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ANALYSIS OF FAILURE OF VERTICAL PUMP SHAFT USED IN LATERITIC MINERALS PROCESSING

In this research, the factors that led to the failure of the vertical cantilever pump shaft , used for slurry transfer in mineral processing, were analyzed.A fracture field test and a characterization of the material were performed, which revealed that the fracture coincided with a sudden change in section in the impeller settlement zone as probable causes of the fracture. A verification of the design of the shaft was carried out, which revealed that it does not possess adequate mechanical resistance, since there is a low safety coefficient and little fatigue resistance for dynamic load conditions, which lead to the premature and catastrophic failure of the shaft, an issue also observed in the stress distribution analyzed by the finite element method.

The shafts of the vertical cantilever centrifugal pumps used for the transfer to dam reservoirs of lateritic ore tails, in their design are manufactured from ASTM A 693 type 630 steel, which in its performance are subjected to a combination of torsional, bending and tensile stresses, which added to the internal conditions of the material lead to an increased possibility of failure. According to [1] and [2], the main cause of shaft failure, in general, is a sudden change

in section. These shafts studied are recovered by inserting an AISI 321 steel threaded pin, although this was not a satisfactory solution due to the demanding working conditions in the pin's lodging area, which induces them to break frequently. The objective is to redesign the geometric configuration for the TOYO pump shaft to guarantee mechanical and fatigue resistance, in accordance with the requirements of the process in which it works and determined by means of finite element analysis.

The breakage of the TOYO pump shaft, used in the transfer of slurries and fluids [3], is of permanent interest due to the economic losses and circumstantial consequences that it implies; therefore it is important to discard if the failures are associated to difficulties of the material used for its manufacture or to problems related to the construction, geometry or insufficient mechanical resistance.

In accordance with [2 and 3], in the characterization of the mechanical behavior of the alloy used in the manufacture of the shaft supplied, field test to the fracture and chemical analysis were planned, for which samples of the damaged shaft were extracted, coming from the failure zone and from the free failure zone.

The design methodology proposed by [1] was applied, which included the calculation of torsional moment, preliminary diameter of the dangerous section of the shaft, parallel deflection due to bending, and axial force affecting the failure section. In addition, the procedure was applied to verify the torsional stiffness and vibration resistance of the shaft. Finally, a finite element analysis was carried out to determine the stress distribution in the areas of maximum concentrations, which made it possible, with the use of the von Mises-Hencky-Goodman method, to predict breakage more closely.

The determination of the project diameter (of the dangerous section) was carried. For this purpose, the equivalent moment was initially calculated, taking into account the maximum bending moment (754.7 N-m) and the torsional moment (590 N-m); resulting in a value of 957.95 N-m. The admissible material stress was then determined, taking into account the material yield stress. The result of the preliminary output diameter was 48.79 mm. The value obtained by the project design was normalized to 50 mm, when compared with the value established by the shaft manufacturer, it is evidenced that the shaft analyzed not offer sufficient mechanical resistance under the loads to which it is subjected due to the pump's operating conditions.

In the finite element simulation for the shaft, it can be seen that the equivalent stresses of von-Mises reach maximums of 59.67 MPa in the change of the radius, an area in which the stresses are concentrated radially in the settlement diameter of the impeller, precisely where the failure occurs. These results are lower than the yield stress of the material, which implies that under static conditions it is capable of resisting, however, its dynamic working regime affects, in thE long term, the durability of the shaft.

The mechanical characterization and the determination of the chemical composition, of the alloy used in the manufacture of the shaft, ruled out the influence of the possible metallurgical variations of the alloy elements present in the material and of the manufacturing variables as a probable cause of the breakage, The main reason for the failure of the shaft, under study, is the abrupt notch in the impeller's settlement band, which leads to a reduction in resistance, which causes a progressive crack to appear, resulting in the premature and unexpected fracture due to fatigue.

Modify the design of the shaft by changing the notch in the impeller's seat band so as to reduce the stress concentration effect and the detrimental effects on the material's fatigue strength and functional safety.

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TENTATIVE EXPERIMENT ON ROCK BOLT MANUFACTURED BY ADDITIVE MANUFACTURING TECHNOLOGY

3D printing is an additive manufacturing measure and this method is a revolutionary technology that is can very likely change our cognition in terms of manufacturing [1-2]. It is believed that this type of procedure can greatly shorten the trial and error time when designing a metal workpiece. The existing literature has proven that 3D printed metal components have finer microstructures than traditionally manufactured parts, and most importantly, the yield and ultimate strengths can also be improved via 3D printing [3]. In terms of bolt printing in coal mining or rock mechanics, however, only limited research exists [4].

This study proposes a new manufacturing technology to innovate traditional research approaches regarding bolting. Three bolts composed of different manufacturing materials—aluminum alloy (AA), die steel (DS) and stainless steel (SS)—are successfully 3D printed, and the desired geometric profile is achieved with high precision. Prior to printing, the digital file of the prototype (PT) bolt is obtained by a 3D laser scanning system, which is then processed to be recognizable to a 3D printer. Afterwards, mechanical tensile tests and digital image correlation (DIC) tests are carried out. The mechanical testing results indicate that the AA bolt has a relatively low strength, whereas the ultimate strength and stiffness of the DS bolt and SS bolt are greater than those of the PT bolt. It is worth highlighting that the peak strength of the DS bolt is approximately twice that of the PT bolt; thus, the advantage of the DS bolt is emphasized.

In detail, a 3D scanning system was adopted to obtain the 3D digital model of the rock bolt; the system was produced by Creaform Inc. in Quebec, Canada. After scanning, the model was processed and then exported as an '*.stl' file (stereolithography). The scanned digital bolt has good consistency with its PT, and the .stl file can be recognized by a 3D printer.

The 3D printing process was accomplished by an iSLM 150 printer, which was produced by ZRapid Tech in Suzhou City, Jiangsu Province, China. Three bolts were printed from difficult materials: stainless steel, aluminum alloy, and die steel. The reason for choosing these materials is that they are relatively cost-effective and their mechanical properties are supposed to be close or higher than those of the PT bolt. Tensile tests were conducted and a summary of all specimens is described here. First, the mechanical performance of the PT bolt is not very prominent when compared with that of the DS bolt and SS bolt. This behavior is reflected not only by the stiffness before the reaching the peak load but also by the value of the peak load. However, the overall performance of the PT bolt is better than that of the AA bolt in terms of both the peak load and elongation. Second, the elongation ability of the PT bolt is the best, followed in descending order by that of the SS bolt, DS bolt, and AA bolt. Third, no yield process can be observed in all 3D printed bolts, while for the PT bolt, this process is well marked along the curve as the loading force reaches 94.0 kN accompanied by a displacement range of 15.54-18.25 mm.

The loading curve for the PT bolt is common and can be divided into five stages: adaptation stage, elastic stage, yield stage, strengthening stage, and necking stage. This trend is not obviously different from that observed in traditional tensile tests of steel bars; thus, this trend is further discussed further herein. However, the curve development for the 3D printed bolts can be roughly divided into two types. The first type is a three-stage trend exhibited by the DS bolt and SS bolt, of which the normal adaptation stage, elastic stage, and softening stage can be

observed; these stages are eventually followed by specimen failure. The second type is exhibited by the AA bolt, wherein a linear increasing process is prominent throughout the testing process. If the linear section of each curve is segregated and treated as the stiffness of each bolt (i.e., the ratio between load and displacement), then the stiffness values for the PT bolt, AA bolt, DS bolt, and SS bolt are 7.63, 5.31, 15.99, and 11.33, respectively.

The PT bolt has a better performance than the 3D printed bolts as the PT bolt exhibits larger elongation. However, the bearing force of the PT bolt is relatively lower than that of the DS bolt and SS bolt. If the geological setting is not dynamic or does not involve high in situ stresses, then the 3D printed DS bolt and SS bolt can exhibit a better performance that the PT bolt in reinforcing a rock mass.

In view of the DIC results, the vertical displacement field exhibits a segmented pattern as the tension force increases in the later stage, and the density of the color tapes also increases. The wave pattern is also observable, which has a close relationship with the load source direction and can predict the bolt rupture position.

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STUDYING THE EFFECT OF NICKEL CONTENT ON THE DURATION OF THE TRANSFORMATIONS AND THE APPOINTMENT OF OPTIMAL HEAT TREATMENT MODES

The main structural material for the manufacture of large critical products are Cr-Ni-Mo-V steel compositions having a unique combination of through hardenability, uniformly high mechanical properties over the entire cross section of parts, high strength with high ductility and toughness.

The intermediate transformation of austenite is accompanied by the formation of a needle-like relief similar to martensitic. Terrain studies indicate a slow growth of α-phase crystals during the intermediate transformation. The low crystal growth rate of the α-phase bainite suggests that it is determined by the diffusion removal of carbon from the growing crystal into the surrounding austenite.

An integral element of the intermediate transformation of austenite is the diffusion redistribution of carbon. The low growth rate of α-phase crystals and the diffusion redistribution of carbon during the transformation suggest that the growth rate is determined by the rate of carbon removal from the growing crystal at its front as a process leading to relaxation of internal stresses. A decrease in the carbon concentration in front of the front of the growing α-phase crystal and stress relaxation provide the possibility of a martensitic $\gamma \rightarrow \alpha$ transition during the transformation of austenite in the intermediate region.

An increase in nickel concentration increases the stability of austenite and shifts the upper boundary of the transformation to lower temperatures. The tendency of the γ phase to

hypothermia increases and its stability increases; the upper boundary of the transformation decreases and all lines of the diagram are shifted to the right.

The structure of steel in general form as a result of the intermediate transformation may consist of a martensitic α-phase, residual austenite, and carbide particles.

An increase in the nickel content in the steel composition contributes to an increase in the incubation period before the onset of austenitic-pearlite transformation. The time before the implementation of the pearlite transformation of steel of composition No. 1 with 1.57% Ni is 1 hour, steel of composition No. 2 with 2.80% Ni is 2.1 hours, steel of composition No. 3 with 3.68% Ni is 27.8 hours.

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CAD, CAE ANALYSIS TO IMPROVE AXIAL DRUM SEPARATION PARAMETERS

KEY WORD: drum, screen, trajectory, turnover frequency, feed rate.

The rotating screen drums are largely used in most powder handling and processing industries. The impacts of rotating screen drum parameters (angle of inclination, rotating speed, and product flow rate) on the sieving efficiency and on the shaping effects were investigated. Based on these research, we analyzed one particle within a drum screen, and determined its physical and geometrical trajectory string parameters, and measured diameter and length ratio, and the standard angle values were pragmatically tested by MSC ADAMS.

The process of material separation is a very complicated granular materials dynamic phenomenon, many factors affect it such as: particle size of the material, shape, size, density, mechanical design. The main representatives of researchers in this field are many scientists such as Levenson.LB, Cundal.P.A, Bridgwater. As well as the design solution of the sieving equipment retains its traditional form, therefore it spends high energy during sieving the material, also no design solution has been developed to stimulate the flow movement of granule. In order to solve these problems first of all, I intend to define the new idea that I put forward. It is an option to lengthen and optimize the traffic trajectory of single granule in the eccentric drum. The results were compared with the granule movement trajectory in the drum with traditional design. The basic dimensions of the eccentric drum that based on the survey as follows. The value of the basic dimensions of the drum is determined by the following ratio.

$$D \geq 14 \cdot x_{max}; h \leq 2 \cdot x_{max}; \beta_{max} \leq 90^0$$

Including: if materials that to be included in the drum is $x_{max} = 15$ mm, if the ratio of drum length and diameter (L:D) and (3:1) it is 630:210. Using this ratio, I developed the model of test drum, showed in Figure 1, 2, Table 1 the area change and volume that to be rated on the granule drum sieving surface, depending on the parallel angle.

In order to confirm the above idea, defined the length of granular motion trajectory in the drum took data specifications form MSC-ADAMS program. Modeled the granule motion using MATLAB program.

Used instantaneous single granule motion data obtained with the help of MSC-Adams software. Further using the above data, generated a three-dimensional trajectory form in the MatLab program and processed the results.

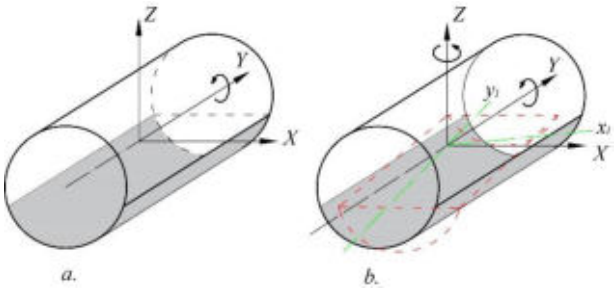

Figure 1

Table 1

№	Drum parallel angle^{o}	Site m^2	Volume m^3	S area %
	0	0.415	0.0218	
1	1	0.424	0.0228	2.1 %
2	2	0.432	0.0238	4.09%
3	3	0.44	0.025	6.02%
4	4	0.448	0.026	7.95%
5	5	0.456	0.0271	9.87%
6	6	0.464	0.0282	11.8%
7	7	0.4715	0.0293	13.6%
8	8	0.4788	0.0303	15.37%
9	9	0.4861	0.0314	17.1%
10	10	0.4931	0.0325	18.8%
11	11	0.5	0.0336	20.4%

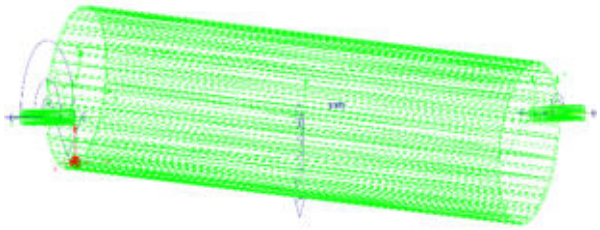

Figure 2 - MSC ADAMS program axial drum physical model

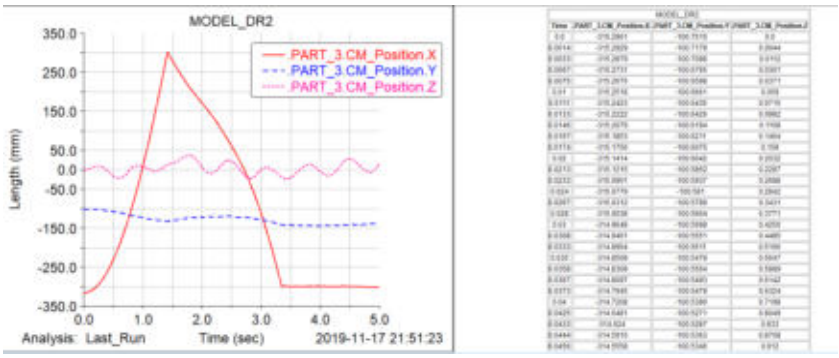

Figure 4 - Ggraph, coordinate value of XYZ axis location of the granule that is moving in the axial drum

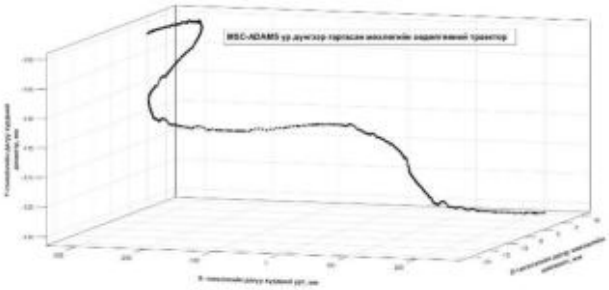

Figure 5 - Granular motion trajectory established by test results (tested for 20 minutes)

Conclusion:

1. Until now drum sieving equipment retains its traditional form, therefore there is urgent need to find new design idea and solution.

2. CAD program analysis shows that the virtual value of the workspace has increased by up to 20%, so there has the possibility the life time of the granular can be lengthened.

3. As a result of CAD and CAE analysis also the simulation result, the length of the trajectory that is moving in the parallel drum equipment was increased until 14-26% from traditional axial rotation design. (For example: length of the trajectory granule that is moving in the traditional design drum is 1003.14 mm, but when compared at an angle of 7^0itbecame1218.2 mm. The result shows 21% rise).

4. In the future, the proposed design project should be tested and confirmed in real conditions.

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APPLICATION OF CRYOGEL IN THE OIL INDUSTRY

The oil industry currently plays an important role in the Russian economy. According to statistics for 2019, the share of petroleum products was about 54% of the total volume of export deliveries, which determines the need to maintain a high level of quality and safety in the production of such a valuable resource, in large volumes coming from the Northern regions of the country. Extreme conditions create a number of specific problems in oil production on the shelf of the Northern seas and in permafrost zones, which actualizes the development of materials with unique properties to solve problems aimed at improving the efficiency of the oil industry.

One of these materials is cryogel. Cryogel is a nanostructured cryotropic polymer material produced from oil and gas. Its development was carried out in Russia, and although the discovery was relatively recent, it is already used in various industries, in biotechnology, in medicine, etc. Being environmentally friendly and non-toxic materials, cryogels have already found their niche and are used in biotechnological developments and medicine [1, 2]. Of a relatively small number of polymer materials, polyvinyl alcohol cryogels are the most promising and in the coming years will be widely demanded materials, primarily in the Arctic zone as the main means of anti-filtration elements and blocking screens that protect hydraulic structures and various types of industrial reservoirs and reservoirs from water entering (filtering) through the walls of dams and the bottom, which destroys them over time. In permafrost conditions, due to their relatively high melting point (above 70°C), they are used for grouting [1, 3] and hydro - and thermal insulation of various construction sites and structures. There are certain prospects for cryogels in the development of new technologies for trunk oil transportation. Its wide possibilities are obvious when developing production wells. The use of this material in oil production will help to combat the sinking of the soil, which occurs due to its thawing around the wellhead and will contribute to the elimination of near-well craters.

The technology of polymer production is one of its advantages - it does not require the use of special equipment or expensive substances. Cryogel is obtained by dissolving the polymer powder in water, after which it is frozen and then thawed. The last two actions form a cycle that is repeated several times in order to obtain more elastic properties. It is also possible to introduce

fillers in the form of sand, clay and other additives to obtain the necessary properties. It is advisable to use these gels in extreme cold conditions during oil production, and they should be used to eliminate the formed funnels. The service properties of cryogels (mechanical and thermal) are determined by the molecular weight of the polymer and the degree of its acetylation, the composition of the components and their concentration in the initial solution. An important role is played by the technology of its production, modes and methods of cryogenic treatment of initial solutions. It should be noted that repeated Cycling of freezing - thawing processes contributes to the strengthening of cryogel and stabilization of its properties. When receiving cryogel, its self-hardening is observed in the production process. This property contributes to a long service life of the material. The largest increase in the elastic modulus of cryogels occurs after the first 2-5 cycles of freezing-thawing, then its value is stabilized [4]. The peculiarity of cryogels, according to which an increase in the number of freeze-thaw cycles is accompanied by an increase in the elastic modulus, makes it very promising, which makes it especially effective for practical industrial use of cryogels in regions with a harsh sharply continental climate in the Northern latitudes of Russia, Siberia and the far East [5]. The growth in the use of cryogel in industry is due to its resistance to low temperatures, good structural-mechanical and hydrophobic properties. These properties will depend on the composition, that is, on the components and their concentration. For example, the modulus of elasticity will increase by almost 10 times with an increase in the content of the main substance-polyvinyl alcohol from 5% to 15% and is determined by the degree of its acetylation, as well as the number of production cycles. It should be noted that this material is a non-toxic substance, that is, its production and use will not affect the environmental situation in any way.

Thus, due to a number of advantages of cryogels (simplicity and affordability of production; unique properties that determine the wide range of applications in permafrost zones; harmlessness in production and use for people and the environment; resistance to various environmental influences), it should be concluded that cryogels have all the necessary properties for use in the oil industry in permafrost conditions. The ease of production and low cost of components open up a wide range of applications for this material.

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SMALL DIAMETER SINGLE-CONE DRILL BIT WITH NEW ROLLER DESIGN AND THEIR APPLICATION FEATURES FOR BOREHOLES DRILLING

The main characteristic of the drilling process is rock fracture resistance value, which determines its energy intensity, drilling speed and other indicators. Fracture resistance is determined both by the properties of the rocks and by the method of rock destruction and working tool design. During impact drilling rock breaking occurs as a result of drilling tool kinetic energy conversion into the deformation work on borehole bottom. Rock breaking efficiency depends on the mechanical properties and design of the drilling tool. Today the process of roller-cone drilling most of experts associate with rotation of the roller-cone, installed on console pin, which is mounted on the console leg of the bit body [1]. Such construction of a roller-cone drill bit has disadvantages due to the limited stiffness of such structure. That is why development of a new rock breaking tool is an important task, since borehole drilling with three-cone drill bits often has high level of drilling rig vibration, which decreases drill rotational speed, feed force and drilling productivity. The presence of three inclined drill bits that fixed in the body of popular today three-cone drill bits reduce the rigidity of the entire design and limits the ability to transfer rock breaking shock pulse energy to borehole bottom.

In this paper instead of three-cone drill bit the new single-cone drill bit design considered [2]. The main feature of these single-cone drilling bits is the presence of only one roller-cone cutter mounted on a single vertical console leg of drill bit body. The principle of operation of these drilling bits is used by authors in the prototype drill bit selected for comparison with conventional three-cone drill bits, resulting in new method of drilling.

Proposed single-cone drill bit design has complicated working processes, that were needed deep research. Also considered other complex processes associated with generation of rock breaking shock pulses when rolling cone with its hard-alloy teeth rolls over borehole bottom. Single-cone drill bit design with vertical pin allows to transfer axial force directly to the roller-cone cutter, and a vertically mounted roller pin is used as a surface of support for the roller-cone cutter, that helps to convert the moment of drill bit body rotation around the borehole axis to the destructive moment of roller-cone cutter teeth impact into another borehole plane. Such drill bit allows implementing the new two-bearing method of its operation. In developed single-cone drill bit, there are two types of contacting surfaces: flat surfaces between the housing (body of the drill bit) with inclined surface and the end surface of the roller-cone cutter; spherical surfaces between the outer surface of the vertical pin and the inner surface of the roller cutter. The single-cone drilling bit with vertical pin allows to transfer axial force from the bit body through its inclined end surface directly to the end part of the roller cutter. The vertical pin, obviously vertically mounted in the bit body, is used as the bearing point of the bit body for the roller-cone cutter, which helps to transform bit body rotation moment to another plane and allows creating destruction on the face of bore-hole. A coupling with an external thread and an internal spherical surface that holds the roller cutter on the spherical surface of the vertical pin is screwed into the roller cutter. The cutter is reinforced with hard-alloy teeth. The drilling was carried out on a drilling test stand successively at first with 76 mm in diameter single-cone drill bit with vertical pin on the rock sample with strength f = 8 from the scale of professor M.M. Protodyakonov. Studies were conducted using a two-factor experiment. At the same time, technological and dynamic process parameters were recorded. The mechanical drilling rate was determined by measuring the segment of borehole drilled in the limestone block and the time

spent on drilling. Penetration depth of the drill bit per one body rotation and electrical power spent on drilling, energy intensity of the drilling and other drilling parameters was determined by waveforms obtained and recorded via strain gauge sensors.

Operation method of such single-cone drill bit allow to develop them for boreholes with diameter of less than 76 mm. Drilling with a single-cone drill bit showed its advantage over the three-cone drill bit in drilling speed more than 1.9 times. Drilling energy intensity is about two times lower and dispersion of longitudinal vaibrationes on average less than 20 times [3], [4]. And this result obtained with approximately the same technological indicators. These studies can be used to develop a small-diameter drill bit with behavior like in hydro pulse drilling, but all forces forms on borehole bottom. A new method of drilling with direct transformation of drill bit rotation into impact pulses at borehole bottom. The positive moment of new method lies in increase of borehole bottom working square in 3 times due to transition from the bottom to spherical one.

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DISPATCH OPTIMIZATION SYSTEMS FOR ENERGY EFFICIENCY AND LOW CARBON EMISSIONS IN OPEN-PIT MINES

KEYWORDS: truck transportation; energy consumption; immune algorithm, ant colony optimization, system optimization.

Optimization of the control system for truck transportation can effectively reduce energy consumption and carbon emission in production management, which is critical to mining companies. To enhance the system capability, this paper focuses on the challenge of coordinating transportation routes and production tasks at the loading and unloading points of open-pit mine

operations. First, this research identified the costs of industrial truck transportation by the combination of documented operation patterns and GPS data to detect the deficiencies in the dispatch system. Then, we established the minimum energy-consumption model for the many-to-many road-network-optimization problem through the comparisons of Ant Colony Optimization (ACO), Max-Min Ant System, (MMAS) and Immune ACO (IACO) algorithms. Based on the comparison, we focused primarily on the IACO algorithm, built the optimization system, and implemented it in an open-pit mine for validation. To verify the feasibility of the model and avoid the local optimum, this research constructed the optimized truck-routes using 1,000 iterations on each of these three algorithms and finalized the parameters and effectiveness of the IACO algorithm. The implementation results show that the IACO algorithm is able to decrease the transportation distance by an average of 61,831 km per truck annually. The energy consumption is reduced by $57,261.20 per truck annually, which is an estimated $2.86 million of savings from cleaner production per year for a medium-sized company. Therefore, the outcomes prove that the MECM with IACO algorithm can optimize energy efficiency and reduce carbon emissions while meeting the production goals.

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COMPUTER SUPPORT FOR DESIGNING CUTTING HEADS FOR BOOM-TYPE ROADHEADERS

Boom-type roadheaders have been used since the early 1950s in underground mining to drilling roadways. This is especially true in hard coal mines for which these machines were initially designed. They were used for drilling coal excavations, i.e. in soft rocks. With the technical development of roadheaders, the scope of their use in mines expanded. This was associated with an increase in their power, mass and size. Currently, the largest of them are used for drilling excavations in hard rocks, with cross-sectional dimensions adapted to current requirements resulting from ensuring adequate ventilation and transport conditions and resulting from the space required for high-performance underground mining machines. The ability to effectively cut hard rocks meant that these machines are also used today, although to a limited extent, for tunnelling and other underground architectonic objects (e.g. garages) in civil engineering. The overall construction of the boom-type roadheaders has not changed significantly over the decades. However, the design and manufacturing technology of this type of machine are continually being improved. This results from the need to meet the growing expectations of users in the field of ensuring high efficiency of drilling roadways and tunnels, with the lowest costs, and ensuring high reliability and availability of this type of machine. On the other hand, the manufacturing costs are minimized, hence the need to optimize the construction of roadheaders and the use of materials with increasingly higher utility properties for their manufacturing.

Rock mining is the basic working process of roadheaders. In the case of boom-type roadheaders, it is carried out by cutting with picks arranged on the side surface of one (axial) or two (transverse) cutting heads. These cutting heads are set in rotation by the drive system. At the same time, they are moved along the heading face of the roadway or tunnel in accordance with the adopted mining technology. During this movement, the picks cut the rock. Conical picks embedded in pick holders welded to the side surface of the cutting head body are commonly used here. An important feature that distinguishes boom-type roadheaders from other roadheaders is that the cutting heads have small dimensions to the cross-sectional area of the

drilled excavations. By placing them at the end of the movable boom, it is possible to drill roadways and tunnels of any shape and size of their cross-section.

It has been known for a long time that the arrangement of picks (number and manner of their arrangement) on the side surface of the cutting head significantly affects the efficiency and effectiveness of rock mining in the heading face of a drilled roadway or tunnel. This applies especially to hard rock mining. Hence, cutting heads are designed for specific conditions of use of a roadheader (mechanical properties and geological conditions of excavated rocks). Designing a pick system appropriate to the given operating conditions is only possible using computer tools. In addition to the classic CAD software, that the designer has at his disposal, it is necessary to use a dedicated computer software in the design process. It enables quick development of the technical solution of the cutting head suitable for the adopted input data and its migration to CAD software in order to prepare its technical documentation and manufacturing technology. The designer faces a real challenge because, at the stage of developing a pick system on the cutting head, which is the starting point for further design work, he must take into account many factors, including those related to the environmental conditions in which the roadheader will work. These factors, especially the mechanical properties of excavated rocks and their variability in the cross-section of the excavation and its length, are most often not fully recognized. This information and their credibility are crucial at the stage of formulating construction assumptions for the designed cutting head. They should be determined based on a geological survey of the area in which mining works will be carried out, and possible experiences resulting from previously conducted mining works in a given area.

In addition to the functional requirements that the designed cutting heads must meet, the conditions arising from the technical and technological capabilities of their implementation must also be met. Due to the complexity of the design task and the multitude of factors affecting its effect, classic methods of optimizing the construction of cutting heads are of little use. Therefore, in engineering practice, computer methods are widely used to assist the designer in the decision-making process of choosing the preferred technical solution due to the adopted design criteria. Considering the utilization requirements for cutting heads of modern roadheaders, the selection of a pick system from a specific set of technically feasible solutions should ensure first of all [1]: minimization of the average load value of cutting picks, minimization of dynamic load in the cutting system, maximization of mining efficiency and minimization specific energy consumption. A fundamental criterion that should be taken into account is also the anti-resonance criterion. One of the important components that are revealed in the dynamic load spectrum of the roadheader's cutting system is the pick frequency. This frequency results from the angular velocity of the cutting head and the number and arrangement of cutting picks on it. The pick frequency should be outside the area of mechanical resonance in the roadheader structure [2]. The resonance phenomenon leads to increased intensity of roadheader vibration, resulting not only in the disruption of the cutting process but also in reducing the durability of roadheader components as a result of fatigue overloads. However, this analysis requires information on the dynamic properties of a roadheader, including the values of the natural vibration frequency.

An important component of the dedicated computer software used in the design process is the numerical simulation of the rock mining process with given mechanical properties by the designed cutting heads. It is based on mathematical models of the process of rock cutting with roadheader picks. There are many different models of this type based, among others on the finite element method [4], the discrete element method [5], neural networks [6], or breakout graphics analysis [3]. Multi-variant numerical tests of pick systems on the designed cutting head (generated manually or automatically) provide information on the course of the mining process carried out in the assumed external conditions, the size and nature of a load of cutting picks, dynamic loading of the cutting heads drive and other roadheader mechanisms responsible for the implementation of the mining process, power demand, efficiency and energy consumption of this process. The results of the simulation of the mining process are computer approval of individual

solutions of the pick systems of the designed cutting head. A comparative analysis of these results is the basis for choosing the best solution for the formulated objective function (criteria).

The results of theoretical and experimental research on roadheaders used for 30 years at the Department of Mining Mechanization and Robotisation of the Faculty of Mining, Safety Engineering and Industrial Automation Control at the Silesian University of Technology constituted the basis for the development of developed continuously software Kreon to support the design process of the cutting heads of the boom-type roadheaders. This software is a convenient computer tool that not only allows rapid prototyping of pick systems of the designed cutting head and their computer evaluation but also enables designing the shape of the side surface of the cutting head body for the adopted pick system. The Kreon v.3.1 software in the latest version already at the stage of choosing the pick arrangement allows assessing the technical feasibility of the given solution. This is particularly important in the aspect of robotization of the cutting heads manufacturing process and preparation of welding technology for pick holders to the side surface of the cutting head body using industrial robots. These analyzes are carried out using 3D modelling. The article presents the most important functional features of this software and discusses the principles of designing cutting heads with its use. Kreon v.3.1 software is used in the design process of cutting heads for roadheaders manufactured by Famur S.A. – a leading manufacturer of mining machinery in the world.

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OPTIMIZATION OF INTELLIGENT SCHEDULING OF AUTONOMOUS VEHICLE IN STRIP MINE

With the deterioration of mining conditions of mineral resources, the increase of labor costs and the frequent occurrence of safety accidents, traditional mining methods are developing into unmanned mining technology. This research focuses on the many-to-many road-network-optimization (M2M-RNO) problem in truck transportation, which is a major energy consumer and the leading carbon emitter among supply chain activities [1-2], aimed to improve the

utilization rate of driverless truck in open pit mine and realize 24-hour continuous safe mining. Truck transportation is an important link in open-pit mine production management， thus reasonable control of truck transport energy consumption and carbon emissions is an important measure to protect resources and environment in the context of low-carbon economy[3-4].

After a comprehensive analysis of the feasibility and development stage of mine truck driverless, this paper proposes to design the mine truck driverless system from the perspective of perception processing, decision-making planning, bottom control, information supervision and so on.

In order to reasonably allocate the truck transportation of unmanned mine, realize the cost reduction and efficiency increase of mining enterprises, and solve the multi-objective demand of truck transportation scheduling management.

Under the low carbon constraints， the problem of fuel consumption， carbon emission cost and truck activation cost are optimized for open-pit mine truck transportation. Considering multiple transportation routes and production tasks between each loading point and each unloading point， the minimum energy consumption model of open-pit mine trucks under energy consumption and low-carbon constraints were established. Then the model was solved by IAS algorithm， the energy consumption of truck transportation was optimized， and three different objective functions were compared.

Finally， the optimization model is verified by an example， and the results show that the ISA algorithm is better than ACO and MMAS in solving the transportation problem of open pit. The case data shows that the optimization model and method can greatly reduce the transportation energy consumption and carbon emissions, reduce the number of trucks, reduce the operating cost of mining enterprises, and provide a guarantee for the construction of resource-saving and environment-friendly mines.

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REVIEW METHODS RECOGNITION OF THE COAL-ROCK INTERFACE FOR THE AUTOMATION OF LONGWALL SHEARER OPERATION

High production efficiency, high quality of products, low production costs, as well as variety of assortment and the facility of changing the production profile are the main goals of most companies. Since the beginning of the history of industry, innovative solutions have initiated revolutionary changes in industry, also entailing economic and social changes radically changing people's working conditions and lifestyles. Four industrial revolutions may be distinguished over the years. The first revolution took place in the 18th and lasted until the mid-19th century. The most important achievement of the first revolution was the replacement of

charcoal with coke, which contributed to the development of metallurgy, the invention of the steam engine and the construction of a mechanical loom that shortened the production process eight times. The second revolution started in the 19th century with the invention of electricity and the assembly line created by Henry Ford which significantly accelerated the production process, dramatically changing the face of the automotive industry. The third industrial revolution began in the 70s of the 20th century with the development of partial automation of production using programmable controllers with memory and computers. By introducing such technology, it was possible to automate processes, so that production could take place without human intervention. Currently is the fourth revolution witch characterized by the use of information and communication technologies in industry. Fourth revolution based on the achievements of the third industrial revolution. Digitization and computerization of production allows the creation of cyber-physical systems from which smart factories will develop. Machines in these factories will communicate and make decisions automatically, and people's participation in the production process will be kept to a minimum. [1]

Hard coal is the most common and widespread fossil fuel on earth. Coal mines extracting hard coal in the current market situation, deal with multiple challenges of both technical and economic nature. Globalization in the energy raw materials market, increase in competitiveness of foreign markets, and growing coal imports forces producers to increase their mining efficiency. One of the main goals for production plants which want to maintain their position on the market as well as for their engineering and technical staff is improving the work organization and the degree of use of production resources, which will allow the increase of work efficiency. Coal production is associated with a high risk of work due to the difficult underground work environment and numerous natural hazards. To achieve safe and efficient production in coal mine plants, it is necessary to improve work automation in order to minimize the number of crew needed in the most dangerous sections of the process line.

In order to increase the level of automation in hard coal mines, the focus was on the longwall shearer as one of the most important elements of the production line. Accurate recognition of the cutting pattern is a prerequisite for developing an automatic coal extraction system from the longwall. The article presents an overview of coal and rock identification methods and possibilities thanks to which the above systems can be used for automatic mining of a coal seam by a longwall shearer. Recognition systems are based on various methods using available technologies. With the help of sensors installed on the longwall shearer it is possible to recognize coal and rock. One of the detection methods is the method using natural gamma rays. Based on the conducted research, it was found that the rocks surrounding coal contain some amounts of natural radioactive isotopes whose values are higher than the values detected in coal.[2] A sensor detecting gamma radiation is installed on the mining arm of the longwall shearer by measuring the natural radioactivity of the rock located in the roof-rock.[3] Another method that the article focuses on is the method using acoustic waves generated by the cutting bits. The difference in compressive strength of coal and rock causes that when cutting, the bits installed on the cutting heads emit a different sound. This method is based on recording the sound of rock or coal mining, and isolating noise from the recorded sound, such as the sound of scraper conveyor or engines operation. Extracting the features of the signals and introducing them into the neural network makes it possible to distinguish cut rock by a shearer.[4] The method using accelerometers installed on the cutting arms or mechanized casing and measuring the vibrations arising similarly to the method using the acoustic sensor is based on the difference in rock hardness.[5] The obtained signals extract their characteristic features that go to the neural network. Another method is to use a thermal imaging camera that measures the temperature of cutting bits. When mining gangue, the bits heat up more than when mining coal, which allows for recognition of the rock being mined. In addition to the above methods using sensor data and neural networks, it is possible to use radar detection. Radar detection used the reflection of the electromagnetic wave at the interface of coal gangue to detect the thickness of the top coal.

Difficult working environment in the wall, such as the presence of coal or stone dust limiting visibility, the presence of water, high noise generated by working devices, reveals the advantages and disadvantages in the above methods. Some of the methods also have advantages such as their high detectability of the combination of coal and rock, ease of installation or price. However, the methods also have drawbacks such as a problem with the separation of generated noise in a method using vibration or sound sensors. The image in the infrared camera may not be sharp or distorted by water cooling of the cutting body and some of the existing systems are too expensive and economically unprofitable for use in mines.

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NEW TECHNOLOGIES FOR DIAGNOSING TRANSMISSIONS OF MINING MACHINES DURING THEIR MAINTENANCE

The progressive development of the mineral raw materials industry, and with it the complexes of mining machines, which are its main driving force, leads to an increase in their unit capacity, improvement of the design, systems for their diagnostics and maintenance during operation to minimize the risks of failure of these machines and avoid losses caused by shutdowns of such equipment.

As a result of a review of the strategies for maintenance and repair of mining machines, it was found that the most progressive maintenance strategy is the actual state. The main difference between the FSO system and the PPR system is the use of continuous monitoring of the technical condition by non-destructive testing methods and new technologies for diagnosing transmissions of mining machines during their maintenance. As an analysis of operating experience has shown, the main cause of failure of mining excavators is the increased wear of resource-determining tribo-conjugations of transmissions.

During the operation of mining machines to ensure the normal operation of excavators, in severe conditions of their operation, the lubricant must guarantee the separation of the contacting surfaces, prevent scuffing and seizing, and reduce the wear rate. The choice of the appropriate type of lubricant for the mining excavator and its individual mechanisms is crucial for the operating condition of the machine, but the choice of the lubrication system is equally important. An innovative solution in this matter is to ensure the delivery of the lubricator to tribological conjugation through the channels of the lubrication system, according to its state, determined by the value of the acoustic signal of friction, controlled in the range of ultrasonic frequencies. Why

it is advisable to use on-board diagnostic systems that allow you to record the acoustic range signals to assess the status of career equipment systems during its operation.

As a result of the studies, the possibility of assessing the condition of the working surfaces of mining machines, in general, without disassembling the gearbox, was confirmed. An innovative solution in this matter is to ensure the delivery of the lubricator to tribological conjugation through the channels of the lubrication system, upon receipt of the acoustic signal of the ultrasonic range in a friction pair.

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A STUDY ON THE EFFECTIVENESS OF WATER JETTING DEVICES WITH DETERIORATED JET-FORMING COMPONENTS

One of the most progressive ways of using the energy of thin high-speed jets is hydro-jet cementation (GSC) of rocks. Research on the process of hydro-jet cementation of rocks is a very difficult theoretical issue. The suspension jet-massinteraction depends on a number of arbitrary factors, some of which are very difficult to take into account. The GSC research of rocks was pursued with the help of experimental statistics, which provides for experimental studies with subsequent grapho-analytical analysis of experimental data using methods of probability theory and mathematical statistics [1 - 3].

A special-purpose test facility was developed and installed at Tula State University for research in waterjet technologies, which made possible the change of experimental parameters in a wide range of values.

The experiments were carried out on various rock samples with uniaxial compression strength σ, MPa. The mass embodiedby the GSC method was pursued with varying the diameter of the hole of the jet forming nozzles d from 0.002 to 0.005 m, the rotational speed of the drill string n from 0.1 to 0.5 $s^{-1}$and the pressure of the water-cement suspension P from 40 to 60 MPa. The cementation depth h, m was used as an indicator of the efficiency of the GSC process. During the processing of the experimental results, calculation dependences were obtained to determine the rational speed of movement of the jet forming nozzle relative to the processed rock mass Vп, m/s.

$$V_п = 5\times10^2 (Pd / h)^2\sigma^{1,5}$$

It is established that this formula is valid for any applied relevance from the investigated range of the diameter of the jet forming nozzles.

The rational speed of moving of the jet forming nozzles is relative to the treated rock mass corresponds to the maximum increment bulk chain of the processed rock mass.

The presence of a rational movement speed of the jet forming nozzle relative to the treated rock mass is explained by the fact that, at minimum values of the speed of movement, the processing depth is maximum, but their product tends to zero. A similar pattern is observed at the maximum speed of movement of the device. In this case, the processing depth of the mass is minimal, and their product again approaches zero.

Thus, the calculation dependence allows one to justifiably assign the value of the process mode parameters of the GSC of rocks - the velocity of the jet forming nozzle in order to ensure the maximum increment rate of the volume of the processed rock mass at given energy characteristics of the equipment used.

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IMPROVING THE RELIABILITY OF AUTONOMOUS POWER SOURCES BY UPGRADING THE COOLING SYSTEM OF THE ENGINE

Reliable use of autonomous power sources based on internal combustion engines is only possible if the mechanical power source is in working condition. Among the main internal combustion engines, which significantly affect the reliable and energy-efficient operation of the engine should be distinguished cylinder-piston group with the most heat-loaded part among the parts that make up the combustion chamber of the engine - the piston. The high temperature of the piston of the engine is the cause of a number of negative operational and environmental negative consequences. The first group should include the influence of the high temperature of the piston on the rate of oil uptake in the groove, coking and as a result of sedimentation. Incorrect distribution of loads between rings, which leads to loss of tightness of the combustion chamber. The breakthrough of the exhaust gases leads to an increase in the lubrication of the piston, which in turn leads to an increase in the friction force and an even greater increase in the temperature of the piston. These phenomena can lead to the formation of burrs and the jamming of the piston with the stop of the generating set.

Ensuring modern environmental and economic requirements is only possible with the use of high-speed engines, characterized by high temperatures of combustion processes. Based on the above, it is possible to conclude that the creation of a system that has stabilized the required piston temperature to ensure high operational and environmental performance is an important scientific task.

The solution to this problem is possible by intensifying the heat transfer to the environment through the use of forced oil cooling.

When considering the design of autonomous generators that are most commonly used in complex power generation systems, a separate group of generators should be identified, based on a single-cylinder, four-stroke, internal combustion engine with a displacement of 200 cm3. This type of equipment does not have a forced oil lubrication system, which does not allow it to be used to cool the piston according to traditional schemes.

The purpose of this study is to develop a system of forced oil cooling of the piston engine of an autonomous power source.

The developed system of forced oil cooling of the piston of the engine of the autonomous power supply allows to stabilize the parameters of thermally loaded parts, which allows to provide modern operational, environmental and economic requirements by using the forcing of the engine of the power supply of the autonomous power supply [1].

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CONSIDERATION OF THE INFLUENCE OF AGGRESSIVE CORROSIVE MEDIA ON THE STRESS-STRAIN STATE OF CYLINDRICAL TITANIUM ALLOY SHELLS

Titanium alloys are widely used in construction for the manufacture of structures and structures in the oil and gas, aviation and rocket industries. This is due to the fact that titanium alloys have a wide range of useful properties, such as: high resistance to destruction, low specific gravity, high mechanical strength and heat resistance, plasticity at low temperatures, etc. Titanium alloys, initially not susceptible to the type of stress state, in the process of exposure to corrosive media, obtain properties of different resistance, which change over time. This leads to increased fragility and early destruction [1].

The purpose of this work is to study the influence of an aggressive environment on the mechanical properties of the TS5 titanium alloy. The relevance of the task is that the research sample is presented in the form of a cylindrical shell, and there are practically no works devoted to these structures made of materials subject to hydrogenation. Therefore, we update the well-known theories and models for calculating structures operated in hydrogen-containing media for calculating a specific task.

The object of research is a circular cylindrical shell made of TS5 titanium alloy, loaded with an internal pressure of 5 MPa and has a rigid seal around the perimeter. The length of the shell is 3 m, the radius is 0.5 m. The location of any place on the middle surface of the cylindrical shell is determined by Gaussian coordinates α_1 and α_2, in consideration: u – the axial displacements, v – the tangential displacements, w – radial displacements under the effect of a transverse load q, as illustrated below.

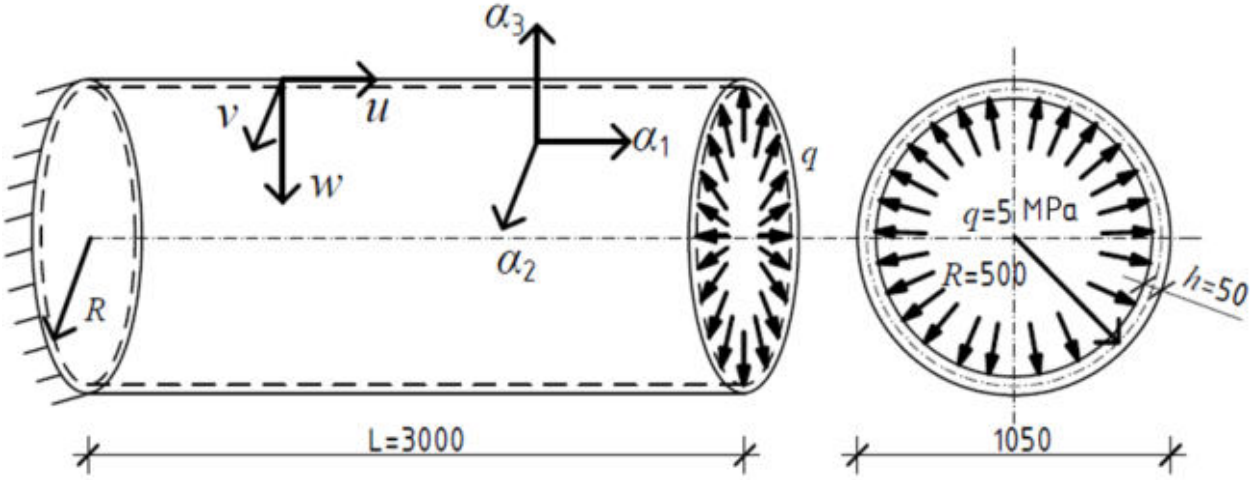

Figure 1 – Shell design scheme

During a certain period corresponding to a large concentration gradient of aggressive media, there is an intensive change in the nature of the stress-strain state, reaching 20% for

stresses in compressed and 24% in stretched zones. Fluctuations in the stresses obtained in the work of Ovchinnikov I.G. and Kirillova L.A. [2] reach slightly different values and make up 15% and 34%, respectively.

Thus, the model of gas saturation influence constructed in this paper is based on the approaches of constructing the determining ratios of different-resistive materials proposed in the works of Treshchev A.A. [3] This approach has a sufficiently flexible mechanism for accounting for different-resistivity and demonstrates high accuracy of agreement of the obtained theoretical predictions with experimental data on the deformation of a wide range of materials under difficult types of stress state.

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DYNAMIC CHARACTERISTICS OF TRAIN WINDSHIELD SYSTEM IN MINERAL RESOURCES TRANSPORTATION

KEY WORDS: windshield system; Mode Superposition Method; enter into a tunnel; train in open air; Fluid-structure Interaction; Mineral resources transportation

The fluid-structure interaction dynamic characteristics is often a key constraint factor for complex flexible composite structures travelling at a high speed. This paper innovatively proposes a high-efficiency analysis method for the fluid-structures interaction dynamics of such structures. The research object of this paper is a train windshield system in mineral resources transportation, which consists of a folding shed inner and outer windshield and a cavity. It is difficult to accurately describe the material and connection parameters. The main work of this paper is to use aerodynamic simulation calculation and windshield structure modal test as input conditions, based on modal superposition method, difference integration method and gas thermodynamic equation, a fluid-structure interaction analysis model is proposed innovatively. The variable step size Runge-Kutta method enables efficient time integration. Based on this method, the comprehensive performance of fluid-structure interaction vibration under the condition of different speeds of the train windshield system running and passing through the tunnel is studied. That is, the force and displacement of the inner and outer windshield structures and the change of the cavity pressure between the windshields under different working conditions. This research can provide an effective method for analyzing the fluid-structure interaction problem of train windshields in mineral resources transportation.

The model uses the measured modal data to accurately describe the dynamic characteristics of the structure, taking the aerodynamic loads F applied onto the structure as input, and using the modal superposition method to establish the structural fluid-structure interaction model of the modal data of the actual measured structure by taking the aerodynamic effects of the cavities into consideration. The fluid-structure interaction model is used to calculate the dynamic response of the structure.

Establishing the equation of motion for the nth-order mode of the structures are represented by

$$\ddot{y}_n + 2\xi\omega_n\dot{y}_n + \omega_n^2 y_n = \frac{p_n}{M}. \tag{1}$$

$$[p] = [u]^T \{f\}. \tag{2}$$

where y_n is the nth modal coordinates of the structure, is modal damping, is the nth natural frequency of the structure, $[M]$ is structure mass matrix, $[U]$ is modal matrix of structure, $\{f\}$ is generalized external force vector.

The differential equation of motion (1) of the multi-degree-of-freedom system has been obtained before, and the differential equation of motion of the nth-order mode can be represented as a matrix form of the equation (2).

$$\begin{Bmatrix} \dot{Y} \\ \ddot{Y} \end{Bmatrix} = \begin{bmatrix} 0 & 1 \\ -\omega^2 & -2\delta\omega^2 \end{bmatrix} \begin{Bmatrix} Y \\ \dot{Y} \end{Bmatrix} + \begin{Bmatrix} 0 \\ F \end{Bmatrix}. \tag{3}$$

The integral numerical solution is based on the Runge-Kutta method [2]. The ode45 function in MATLAB uses the Runge-Kutta method to solve the motion differential equation [3] of the structure under aerodynamic loads through ode45, and compute the displacement response.

For the model presented in this paper, the model consists of two cavities and inner and outer windshield structures. The displacement expression for the inner and outer windshield structures over time can be expressed as

$$W(x, y, t) = \sum_{i=1}^{N} \phi_i(x, y) q_i(t). \tag{4}$$

where $W(x,y,t)$ represents the displacement of the point on the windshield with coordinates (x, y) over time t, $\varphi_i(x,y)$ represents the ith mode of the point where the coordinates are (x, y). $q_i(t)$ represents the displacement of a point in modal coordinates varying with time t.

The pressures F_1 and F_2 subjected to the inner and outer windshield structures can be expressed as

$$\{F_1(t)\} = \iint_{S_1} \left(\{P_o\} - \{P_1\}\right) dxdy. \tag{5}$$

$$\{F_2(t)\} = \iint_{S_2} \left(\{P_2\} - \{P_1\}\right) dxdy. \tag{6}$$

$\{P_o\}$ represent the pressure of the external aerodynamic loads. $\{P_1\}$ is the pressure of the cavity 1. The pressure of the cavity 2 is $\{P_2\}$. The change in the pressure ΔP in the cavity can be expressed as

$$\Delta P(t) = -\frac{P\Delta V(t)}{V + \Delta V(t)}. \tag{7}$$

V represents the volume within the initial cavity. P is the pressure within the initial cavity.

The change in volume within the cavity is ΔV. The external load vector in the motion differential equation and the state vector of the system can be obtained.

In order to investigate the dynamic response by selecting different measuring points on the windshield, this paper selects different measuring points of the same windshield of the same train for investigation. For the 55 measuring points on the outer windshield, according to the different directions according to the direction of the train. Assume that the initial state of the outer windshield is static and the initial velocity of the train is zero. After the train is running, the windshield generates a dynamic response under aerodynamic loads. The average value of the displacement after the windshield vibration is stabilized by using this model as shown in Figure 1.

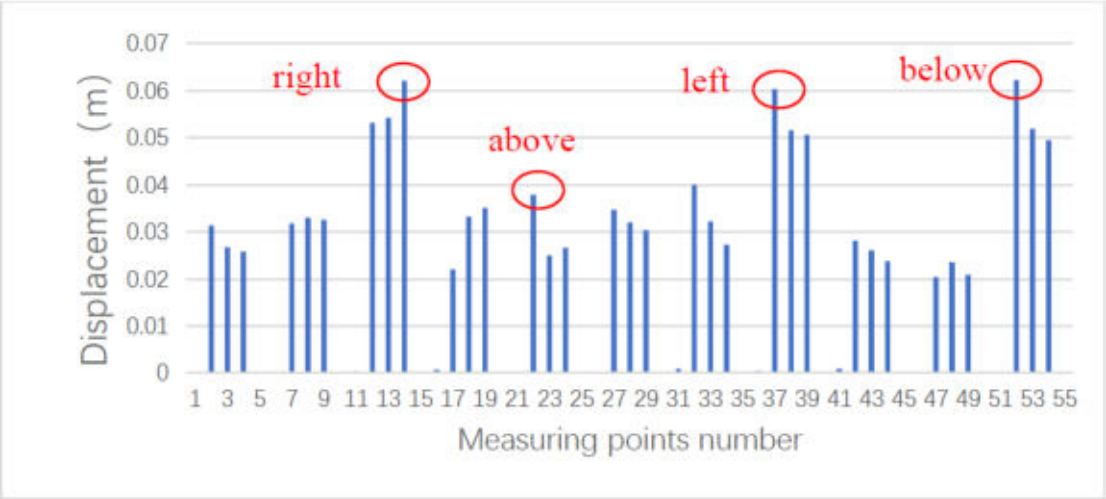

Figure 1 - Average value of the absolute value of the external windshield measuring points

It can be seen that the displacement of the measuring points near the joint between the windshield and the vehicle body is extremely small compared to the displacement near the middle of the windshield . The displacements left, right and lower parts of the outer windshield are significantly larger than the upper part.

The theoretical method proposed in this paper is to take the aerodynamic loads on the outside of the structure as input, and use the modal superposition method to establish the structural fluid-solid interaction model of the measured structural modal data to calculate the dynamic response of the structure. The theory can also be used to study the force , velocity and displacement of the inner and outer windshield structures under different working conditions and the change law of the cavity pressure between the windshields, which provides an efficient and powerful evaluation tool for the dynamic design of the windshield. Since the mineral resources railway transportation industry currently does not consider the interaction of aerodynamics and windshield structures when designing the inner and outer windshields, the importance of this study is self-evident.

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COMPUTER SIMULATION: THE TRAFFIC SIGNAL CYCLE TIME OPTIMISATION

KEYWORDS: Air Pollution, signal timing, traffic signal monitoring of the city.

Emissions of motor vehicles, one of the most important air pollution sources in the city, are emerging as a growing problem in large-scale cities. Traffic flow is mostly interrupted at Intersections in local traffic especially at city centers. Emissions of these points, where traffic behavior is changed and vehicles stop and go, are higher as compared to uninterrupted flows. In this study, current state emissions at Ulaanbaatar city of 120 Intersection were determined by SIDRA INTERSECTION software. Then, new emissions are determined by the same software

after improvement in signalization. As a result of the study, fuel consumption and pollutant emissions were calculated before and after improvement.

The transport sector is one of the most important contributors with an impact of about 16% on greenhouse gas emissions [1]. The major source of greenhouse gas emissions related to transportation is automobiles and trucks because of the large number of vehicles. These sources constitute more than half of the emissions in the sector [2]. Road and street intersections force vehicular traffic to slow down and stop.

The study was conducted in Ulaanbaatar/Mongolia which is a city that has high traffic intensity. It is known that the number of vehicles in Ulaanbaatar has increased by 18.3% in the last 10 years [5]. As a result, it was concluded that one of the main sources of air pollution in city center includes traffic related emissions. In this context, determination of traffic emissions' contribution to air quality, especially at intersections, is importance in terms of taking proper precautions.

The study was conducted at the 120 Intersection which is working days and busiest hours. The intersection is one of the busiest intersections in Ulaanbaatar [6]. At the intersection with high traffic load, especially at peak times, travel times increase and vehicles queue. As a result, vehicle emissions are increasing considerably. A view from the air of the intersection is given in Figure 1 and a view modeling of intersection 120 is given in Figure 2.

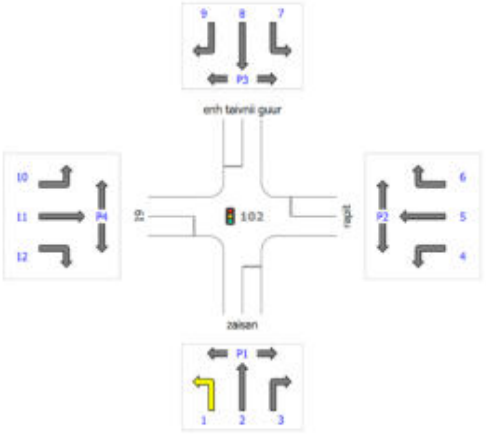

Figure 1 - 120 Intersection view from the air

Figure 2 - Modeling of intersection 120

Video recording was performed between 08:00-09:00 in the morning and 18:00-19:00 in the evening and vehicle volumes were determined for each lane. The volumes were entered at SIDRA for modelling. Traffic volumes in the morning and at the evening for all approaches 1, 2, 3… and 12 are given in Table 1.

Table 1 - Traffic volumes in the morning and at the evening for all approaches

Lane	*	1	2	3	4	5	6	7	8	9	10	11	12	Total
Morning	L.V	406	822	573	258	741	967	548	502	192	416	714	477	6616
	H.V	7	18	6	5	10	12	12	12	15	7	17	7	128
Evening	L.V	283	806	409	232	864	502	561	515	49	285	748	372	5626
	H.V	6	10	10	4	24	25	18	7	6	8	19	17	154

*L.V: Light vehicle, H.V: Heavy vehicle

As can be seen from the table, more than 90% of all vehicles are light vehicles or passenger cars. The results of the morning and evening observations show that, 2nd row has the highest and 4nd row has with the least load.

There are a number of parameters that must be entered in the program for the modeling. These are; intersection geometry, traffic data and signaling data. These data were obtained from studies conducted at the field and they were entered to the program for the morning and the evening along with volumes. The phase diagram of the current situation and the cycle time (120

sec) were also entered. Thus the current situation analysis of the intersection was completed. Then a new cycle period was determined. A new analysis was carried out with the new cycle time for the morning and the evening hours, as all other data remaining the same. By changing the cycle time it was aimed to improve intersection. The emission values obtained for six different analyzes were compared.

Within the framework of national greenhouse gas emissions inventory studies, the use of energy, industrial processes, solvents and other products, agricultural activities and waste emissions can be calculated using the approaches recommended in the International Climate Change Panel (IPCC) Guidelines [7].

The application guide offers three different formulas for calculating emissions namely Tier 1, Tier 2 and Tier 3. Emission factors to be used in calculations can be obtained directly from the EMEP/EEA Emission Inventory Guide published by the European Environment Agency [8]. The conventional method of preparing emission inventory is to multiply the emission factors by the activity statistics and the number of vehicles. In this study, emissions were calculated by using SIDRA software instead of the conventional method.

SIDRA is a microsimulation model for realistic assessment of road traffic conditions using in-traffic vehicle data or user defined drive cycles. It uses a power based vehicle model to estimate fuel consumptions and emissions of carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbons (HC) and nitrogen oxides (NO_x). It is ideal to compare traffic and travel conditions before and after intersection and road improvements [6].

SIDRA Intersection software classifies vehicles as “light duty” and “heavy duty” when performing fuel consumptionand emission calculations. Fuel consumptions and emissions at the intersections are calculated for standard driving cycle which consists of cruise, deceleration, idling and acceleration [9].

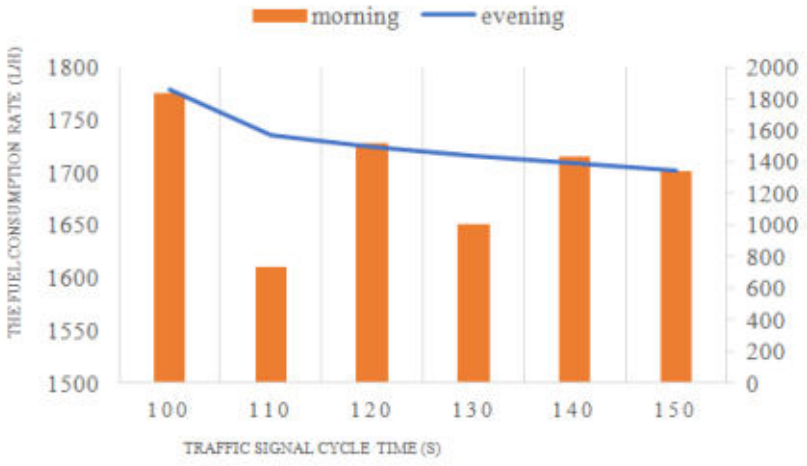

Figure 3. Fuel consumption in the morning and evening at the intersection

When the morning and evening fuel consumptions rates and emissions were compared, it could be seen that, morning results are higher than evening results for all parameters.

This is due to higher volumes in the morning hours. Moreover, vehicles start and stop, results in higher fuel consumption rates and higher emissions. Future research on emission calculations based on signalization improvement, are very important in terms of environmental and economic considerations.

The most outstanding result in our study was that, the signalization improvements at the intersections have reduced the amount of emissions significantly. Furthermore, it can be said that this software is more advantageous than the conventional calculation methods to prepare emission inventory. In the conventional method, the road type is selected as urban, rural or highway and it is assumed that vehicles travel at a constant speed.

In SIDRA, vehicles are not assumed to be at a constant speed, otherwise slowdown and stop-and-start movements are also taken into consideration. Hence, the emissions calculated by

this software are thought to be more sensitive. The values obtained by the software can be compared with field studies to make a better evaluation.

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IMPROVED EFFICIENCY OF TECHNOLOGICAL PREPARATION OF MANUFACTURING TECHNOLOGIES IN DIGITAL ECONOMY

Abstract. The modern development of manufacturing technologies is associated with the transition to the digital economy. At the same time, the introduction of the leading engineering skills and fundamentally new approaches to the design and technology of engineering complexes play a large role. So the article highlights the directions of creating an intellectual system for planning technological preparation of manufacturing technologies.

The transition to the digital economy is continuously associated with the modernization of manufacturing systems, and a change in approaches to the organizational and economic support of manufacturing processes, including a change in management methods for all stages of the product life cycle. For increased efficiency and flexibility of the developed technological process, the equipment should be adapted for rapid reconfiguration to produce various types of products. With the functioning of manufacturing systems, a quick transition to the manufacturing of new products should be ensured through operational technological preparation, including the development of technological processes, control programs, and operational-scheduling. To do this, it is necessary to increase the scientific potential, as well as introduce new competencies for manufacturing and engineering personnel. The digital potential of the company (depending on the use of a comprehensive software package, computer technology, well-qualified personnel, etc.) determines its competitive position in the market. Therefore, knowledge of modern computer technology, software, the ability to apply them in practice become mandatory skills of qualified personnel [1].

The transition to digital manufacturing is a totally new approach to product design. This approach is based on a multi-level hierarchical approach using targets, resource and designing and technological limitations, intelligent assistant systems and a digital automation platform. Their combination and strict internal informational correlations make it possible to create digital doubles of both products and manufacturing at all stages of design and technological preparation. It provides the development of virtual stands and polygons for digital testing of individual parts and assemblies.

The created scientific principles and formalized models of the multi-nomenclature technological processes planning system provide a solution to the problems of complex intellectualization of the technological preparation of manufacturing technologies. This makes it possible to simulate many possible technological processes for manufacturing specified products. The developed methods allow us to formulate recommendations on improving the design of the product to change the technological equipment and processing methods in order to ensure the manufacturability and increased efficiency of the manufacturing system [2]. The creation of digital counterparts ensures the minimization of full-scale tests and a decrease in the time to market for products. At the same time, knowledge and skills are especially important for product developers who must have the skills to create design documentation in electronic form and to create model prototypes in a virtual environment.

In modern conditions, the software of computer-aided design systems for the design and technological preparation of manufacturing should be very highly developed. Otherwise it would be impossible to achieve an increased productivity and quality of work of designers and engineers, unification and interconnection of project work methods that facilitate the rapid exchange of information in electronic form between designers and the enterprise.

The most important and urgent problem of manufacturing technologies is technological preparation, which is associated with significant time costs, which makes machine-building enterprises not an attractive industry for investment. Modern approaches to technological preparation of manufacturing are associated with the subjective nature of making design decisions in the development of technological processes and the inability to take into account the real state and capabilities of specific manufacturing systems. A fundamentally new methodology is laid down in the system of planning multi-nomenclature technological processes [3], based on the full formalization of all stages of development and implementation of technological processes, ensuring due to operational planning of manufacturing technologies for products that take into account the capabilities of a real manufacturing system and the current manufacturing situation.

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ASSESSMENT SAFETY DURING THE METALLIZATION OF PARTS OF MINING MACHINES OF CVD-METHOD WITH OF APPLYING THE RISK THEORY

The application of wear-resistant coating for hardening for parts working in abrasive and corrosive-mechanical wear conditions is one of the important directions of research into increasing the service life of mining machines. The preparation of a metal coating on the surface of a substrate can be carried out by various methods, such as galvanic deposition, diffusion metallization, gas-flame and plasma spraying, laser and gas-powder surfacing [1 - 3]. Recently, the CVD-method has been of great interest, the use of which allows one to obtain high-quality coatings and films on substrates of various chemical compositions and configurations.

The essence of this method is as follows: the initial compound (various groups of metal-organic compounds), converted by evaporation or sublimation into a gaseous state, enters the reaction chamber, where it is deposited on the surface of a substrate heated to the decomposition temperature of the reagent. In the practice of modern plants, when choosing initial metal-organic compounds, preference is given to carbonyl compounds of transition metals, which is determined by their high volatility and ease of thermal dissociation at relatively low temperatures. Many carbonyl compounds are classified as highly toxic compounds, which imposes serious requirements on ensuring the safety of the technological processes in which they are used [1, 3].

The main safety problems in the implementation of the CVD-method in the production environment are associated with the potential risk of contamination of the air of the working area with toxic chemicals used as auxiliary and starting compounds, as well as those formed as products of chemical gas-phase deposition of organometallic compounds.

The release of harmful substances into the atmosphere can occur in several cases:

1. Hazardous to the environment and human health substances are formed in the form of products of incomplete combustion of metal-organic compounds when non-compliance (violation) of the technological conditions of the process (temperature and pressure in the reaction chamber, pumping speed of reagent vapors, concentration of metal-organic compounds vapors, volumetric gas velocity, the presence of additives to vapors metal-organic compounds and others and can enter the atmosphere when using installations that are not equipped with an afterburner.

2. Toxic compounds can enter the air of the working zone during depressurization of the reaction chamber during operation of faulty equipment.

This case can be attributed to the category of emergency situations at the facility, which determines the need for an accident risk analysis procedure, which includes identifying the conditions for the occurrence and development of a dangerous situation and assessing the risk of accidents at the metallization site of the enterprise [2, 4].

For the CVD-method it is rational to apply the hazard and operability analysis method. Presents the results of application of the method of hazard analysis and operability of the installation for the application of functional coatings (wear-resistant chrome coating onto precision parts of hydraulic systems of mining machines) the CVD-method of chromium hexacarbonyl to assess the effect of deviations of metallization technological parameters from regulatory regimes and the possibility of occurrence of a hazard [4].

Thus, when developing technological processes and introducing them into enterprises, it is necessary to justify the safety of all elements of the production system (feedstock, auxiliary materials, hardware design, marketable product) for human health and the environment.

At the stage of experimental research, when the search for optimal temperature and speed conditions of metallization is carried out and the process is carried out unidirectionally, the

installation for applying metal coatings should be equipped with a afterburner in which, under the influence of high temperatures, unreacted compounds are completely decomposed to safe products. This will reduce the risk of returning to the reaction chamber of non-volatile compounds (products of incomplete thermal decomposition of the starting reagents) and eliminate the likelihood of their release into the environment.

In other cases, metallization is carried out in optimal technological conditions in a closed circuit: unreacted compounds (not more than 5 %) are returned to the reaction chamber, where re-decomposition of the vapor-gas mixture occurs in subsequent intervals of the working cycle.

The increase of the industrial safety of metallization is achieved due to automation of the process, equipping the plant for the application of metal coatings with locking and alarm systems.

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TESTING THE TECHNICAL CONDITION OF PUMPS IN WELLS

It is known that the pressure characteristic of the pump decreases during operation. During operation, the pumping equipment wears out. As a result, the pressure and flow characteristics of the pump no longer correspond to the passport characteristics. The experience of operation of borehole pumps from various manufacturers indicates that about 80% of all failures are associated with failure of electric motors. Therefore, increasing the reliability of pumps significantly depends on the reliability of the electric motor. In addition, the operation of the pump beyond the operating range leads to a decrease of its resource.

The characteristics of submersible pumps are removed at the factory on special stands. Pressure measurement is performed by a pressure gauge installed at the outlet of the water-lifting pipe, with simultaneous measurement of the dynamic level in the column and measurement of the supply by a water meter on the pressure pipeline. It is also possible to conduct acceptance tests of the pump at the workplace in order to confirm the design characteristics of the pump. In this case, the pump is provided with all the necessary water lifting pipes, lowered into the well and tested.

The actual pressure characteristic of the pump H=f(Q) can be plotted directly on the well with sufficient accuracy to determine the wear rate of the pump. To assess the degree of reduction in the pressure characteristics of the pump as a result of wear, the General coordinate grid is applied to the characteristics of the pump, taken at the manufacturer's factory, or taken at the stand of the repair shops of the operating organization before installing it on the well.

Characteristics are compared if the pump characteristic $N_{obsl}^{n}=f(Q)$, taken at the workplace, falls below the characteristics, this indicates some wear of the pump.

Finally, an analytical dependence was obtained for determining the head of a submersible pump installed in a water intake well, and a method was developed for removing the energy characteristics of the pump at its workplace. An analysis of the decrease in pressure characteristics of pumps from a number of manufacturers at the wells of the existing underground water intake was given. And it is confirmed that the intensity of pressure reduction depends on the duration of operation of the pump at this well, the material of the pump impellers and the sand content in the pumped water. As well as the purpose of predicting a decrease in well productivity over time, a method was developed to account for wear of submersible pumps during operation. For this purpose, an expression is proposed to describe the characteristics of the pump at any time t, calculated from the moment it is installed in the well.

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DEVELOPMENT OF THE EXPERIMENTAL DEVICE FOR SURFACE ALLOYING FROM THE MEDIUM OF FUSIBLE METAL MELTS

Modern world industry, in particular mechanical engineering, chemical, petrochemical and nuclear industries are developing at a high rate due to the growing needs of mankind for energy sources, new devices and machines. There is a significant increase in requirements to operational characteristics of used metal products: wear resistance, cavitation resistance, corrosion resistance in various aggressive environments, etc. That is why the main task of material science in mechanical engineering is the development of new methods and modifying of existing to increase the resource and characteristics of metal details.

There are two main ways to solve this problem: manufacturing of parts and elements of machines and mechanisms as full-metal, from steels and alloys with the necessary set of characteristics, or manufacturing of similar items from structural steels with subsequent modification of the surface in accordance with the specified requirements.

As the overwhelming majority of processes destroying metal details occurs on a surface, it is fair to notice that achievement of the maximum economic efficiency is possible by processing of surface layers by methods of chemical and thermal processing, capable to provide high operational indicators in the conditions of a combination or separate influence of destroying factors.

The most perspective method of chemical and thermal processing is a method of surface alloying from the medium of fusible metal melts, based on processes of diffusion saturation of surface layers of items with alloying elements or their complexes. Application of the given

method allows to raise operational properties of details with insignificant expenses of alloying elements.[1]

The existing technology of diffusion metallization from the medium of fusible metal melts assumes implementation of technological process with application of vacuum equipment and protective atmosphere on the basis of inert gases. [2, 3] The depth of the resulting diffusion layer is directly proportional to the temperature and exposure time, so the application of the existing technology, especially in the conditions of industrial scale and obtaining layers of significant thickness, capable of providing proper resistance to external influences, puts into question its economic efficiency.

The main purpose of this work was the implementation of the technological transition to an "open method" in order to unify, simplify and reduce the cost of the technology.

As a result of the work the experimental device for surface alloying from the medium of fusible metal melts was developed on the basis of laboratory resistance furnace type SSHOL-10/11 with a device for vertical loading of processed products.

The coating process is carried out in the following way. Tank with lead-based transport melt saturated with an alloying element - diffusant is installed in the chamber of the furnace. When the temperature level reaches the required value for the technological process, the processed item is immersed into the transport melt by the use of rod. The exposure is performed isothermally, where the time is determined in accordance with the required thickness of the diffusion layer. In most cases, the products do not require additional machining.[4, 5]

Based on the results of this work, tests and approbation of the developed experimental device were carried out in order to demonstrate the operability of the "open method" and the experimental device. The device is protected by patent [5].

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STUDY OF THE EFFECT OF STIFFNESS ON THE ACCURACY AND PART QUALITY IN WATERJET CUTTING

Currently, it is necessary to constantly update product ranges in order to increase the competitiveness of domestic engineering products. Improving the competitiveness of do-mestic engineering products primarily depends on the accuracy and productivity of mate-rial processing. Improving the accuracy and productivity of processing on Metalworking equipment is a complex problem, the solution of which is associated with improving the quality of manufacturing of metal-cutting equipment, fixtures and tools, maintaining their accuracy

characteristics during operation, as well as automation, complex mechanization and robotization of production [2]. Improving the quality of equipment at the design and manufacturing stages is achieved by improving methods for calculating structures, using modern materials, and advanced technology for processing and assembling parts and as-semblies. Therefore, precision management in the application of advanced technologies is an urgent task.

Huge impact of water flow at high pressure with an admixture of abrasive through a very thin nozzle, cutting stainless steel and its alloys. Waterjet processing allows you to perform various manipulations: cutting sheet metal; cutting and perforating profiles; perfo-rating sheet metal of various thicknesses; cutting blanks of various thicknesses and con-figurations [4].

The basis of the method of waterjet cutting is the impact on the material with a mixture of water and abrasive sand. Due to the impact of the jet, the material is destroyed, and the part does not heat, deform, or form scale as in laser cutting [3].

In this paper, we consider ensuring the specified accuracy and quality of processing of parts of different shapes by scientifically-based selection of the processing zone, cutting modes and conducting corrections of control systems for the technological system of waterjet cutting.

Waterjet cutting technology is based on the principle of erosive effect of a mixture of high-speed water jet and hard abrasive particles on the material being processed. With this type of processing, the cutting tool does not require sharpening. The product will reduce the impact load and the effect of the reverse force on the cutting tool, since there is no direct contact between the workpiece and the cutting tool. The low tangential force on the part allows you to do without clamping this part in some cases. On a waterjet machine, it is possible to perform various operations (for example, drilling and cutting) with the same tool. This allows you to concentrate several operations in one.

The waterjet processing process is a multi-factorial technological process. Many factors affect the accuracy and quality of the resulting product at GAR: the rigidity of the technological system, namely, the rigidity of the cutting head movement system, the rigidity of the portal system, the rigidity of the platform (grid); cutting modes: jet feed pressure, feed speed; cutting tool conditions: the quality of the abrasive and water.

Therefore, it is necessary to optimize parameters that affect the quality and accuracy of processing. The influence of the rigidity of the positioning system of the waterjet cutting tool on the accuracy and quality of the surfaces of the resulting product was considered. The rigidity of the system directly affects the accuracy and quality of the resulting product. During a number of experiments, it was found that the resulting errors in GAR have a systematic character, that is, in zones that have a more rigid displacement device, minor deviations, and in zones that are no longer rigid displacement devices, significant deviations. The nature of errors corresponds to the nature of deformations of the displacement device. Therefore, one of the ways to improve the accuracy and quality of the product in GAR is to ensure uniform rigidity of the system.

To increase the accuracy and improve the quality of processing in waterjet cutting, it is necessary to ensure uniform system stiffness or change the cutting modes depending on the system stiffness.

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STUDY DESIGN PARAMETER ELEMENTS OF CONVEYOR ROLLERS FOR ENERGY EFFICIENCY CRITERIA

Of all the existing types of conveyors, despite the restrictions on the size, abrasiveness and poor resistance to shock loads, the belt industry is becoming more widespread in the mining industry. They account for more than 12% of the total bulk cargo movement, which is explained by the high productivity and the possibility of full automation of the transport and handling process. Its use instead of railway and road industrial transport allows to solve the general plans of the enterprises more effectively and to ensure the delivery of bulk cargo (coal, ore, sand, etc.) over long distances (up to 100 km and more).

However, a significant disadvantage limiting the use of belt conveyors is their high energy consumption, which is explained by the saturation of the structure, regardless of the type of roller supports (rigid GOST 22645-77 and garland roller support (with hinged rollers) GOST 25722-83 13 ST-SE 13) the same type of assembly units, conveyor rollers, in which components there is friction. Under normal operating conditions, the capacity of the conveyor can reach more than 500 kW (for the conveyor 2L120B) [1], which is a significant component of energy consumption when transporting materials. The increased drive power of belt conveyors is explained by the large inertia of the rotating masses of the conveyor rollers, which consume most of the energy at start-up and is the main cause of failure, both the rollers themselves and the conveyors as a whole.

Purpose of the work is to substantiate the parameters of the dimensions of the design elements of the conveyor rollers by the criteria of energy efficiency.

From the analysis of the obtained dependence follows the conclusion about the direct dependence of the reduction of energy consumed at start-up on the reduction of the mass of the rotating parts of the rollers. This property of the components of the conveyor equipment is used by world manufacturers and consumers of transport equipment, which allows to eliminate problems with balancing, noise, reduce loading at start-up, and provide a more gentle mode of operation of the belt. The use of conveyor rollers with smaller mass dimensions will also increase their life, as well as the life of the conveyor as a whole by reducing the dynamic loads at start-up caused by the inertia of the rotating parts of the roller.

Analysis of dimensions of rollers of European manufacturers of transport equipment TRANSROLL, RULMECA, SANDVIK, ULMA. When comparing the weight of the rotating parts of the rollers, a significant difference (up to 30%) of the weight towards the reduction of the structure for foreign components of the conveyors was noted, which should be used in the production of domestic equipment.

The Ukrainian Enterprise (NVKP Press) is developing by increasing the resource of manufactured equipment and improving energy performance. Thus, practically most of them switched to the construction of a solid body with a sheet thickness of less than 3 mm.

In the manufacture of thin-walled elements of rollers, the attention was paid to the modeling of the processes of drawing, which allowed to reduce the number of technological transitions.

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DEVELOPMENT OF MULTI-STAGE NOSE REDUCTION-MULTI-BLADE HYDRAULIC DRIVE

Pump hydraulic drive is used in two variants: pump-without- accumulator (easy-pump) and pump-and-accumulator [1]. Advantages simple pump drive are higher efficiency, simplicity of design and control – key essential. Disadvantages is a large installation and incomplete utilization of the capacity of the pumps and their drive motors [2].

The main way to improve a simple pump drive is the reduction of installed power of the pumps [3]. Known methods of solving this problem is aimed at the approximation of the mode of loading pumps to the characterization of the so-called ideal pump for which $P_p \cdot Q_p = const$ hence the main directions of solving this problem are:

- Stepped or continuous adjustment of the flow of the pumps subject to the load change (pressure pumps);
- Speed regulation operating pressure of the pumps while maintaining a constant pitch;
- Reduction of installed power of the drives while maintaining the maximum generating capacity of the pumps.

Ways of the second direction use of simple pump having a constant supply and the most valuable of them is the option to include in the composition of the intermediate drive hydraulic multiplier, operating in areas of high load (mode multiplier) that allows the use of low pressure pumps [4].

It is proposed to expand the area of regulation of pressure and in areas with low-load mode opposite to the mode multiplication mode (reduction). The mode of reduction achieved using hydraulic reducer, which structurally repeats the design of the multiplier.

The introduction of the simple pump drive two modes of pressure control (mode and animation mode reduction) makes it a gear-multiplier. The mode of multiplier provides at sections of high load, reduced working speed and pump pressure, and in the mode of reduction, on a plot of low load, improve the working speed and pump pressure [5]. The alignment of the pressure pump at a much lower maximum level in the power cylinder ($P_p < P_c^{max}$) at a constant flow ($Q_p = const$) provide the lower space of the pump power.

Increase speed at the site of reduction compensates for the reduced speed on the part of the animation that allow you to keep cycle times [6].

A variant of the multi-stage geared-drive multiplier, which use block reducer-multiplier.

For example, consider the hydraulic press with four pressure stages of speed.

Hydraulic press (figure 1) includes a power cylinder 1 pumping station 2, a hydraulic reducer-multiplier 3, the input piston cylinder 4 and two output piston cylinders 5 and 6. The piston of the input cylinder of diameter D and the output plungers of the cylinders with a diameter of d1 and d2 rods are combined in a common movable block 7. So $D > d_1 > d_2$ and $D^2 < d_1^2 + d_2^2$. The system includes a three position four-way reversing valve 8, the inlets of which are separately connected to the pressure and drain lines pump stations, and one output

pipeline 9 with the return cavity of the power cylinder. A second output of the reversing valve is connected to the input of the two-position three-way valve 10. A closed outlet of the valve pipe 11 is connected to the working cavity of the power cylinder, and an output – with the input cylinder 4. All output cylinders reducer-multiplier connected two-position three-way valves 12 and 13. Closed the outputs of these spools is connected with a drain, and open outputs connected with a pipeline 14 with the piston cavity of the power cylinder and the conduit 15 connected with the return cavity of the power cylinder. In this case, the conduit 14 is installed normally open two-way two-position shut-off valve 16 and the pipeline 15 – normally closed two-way two-position shut-off valve 17.

Hydraulic press operates as follows. The working cycle of the press occurs with the running of the pump station and includes periods of idle, working and reverse. Period of idle starts from the position at which the piston of the power cylinder occupies the extreme left position and the power plug reducer-multiplier – the lowest position (on the diagram). The reversing spool occupies a position in which the input cylinder 4, through which in the initial position the valve 10, is connected with pressure line of pumping station. Conduit 9 and the return cavity of the power cylinder connects with drain. Fluid coming from the pumping station into the cylinder 4 moves the unit of the plungers 7 upwards (on the diagram). Fluid displaces from the output cylinder 5 and 6 thought spools 12 and 13 through the pipeline 14 through a shut-off valve 16 into the working cavity of the power cylinder 1. The power cylinder piston moves to the right (on the diagram), displacing fluid from the cavity via the return conduit 9 for draining. With the adopted ratio of the size of the plungers of the cylinders of the multiplier ($D^2 < d_1^2 + d_2^2$) the multiplier in this case functions as a reducer. This is to enhance the speed of the piston of the power cylinder with simultaneous increase of pressure in the pressure line (pressure developed by the pumps) against the pressure in the working cavity of the power cylinder, which is determined by the force on the cylinder rod. So:

$$V_r = \frac{Q_p}{S_p \cdot K_r}; P_{pr} = \frac{P_c}{K_g} = \frac{\mathrm{R}}{\mathrm{S_p \cdot K_r}},$$

where $\mathrm{V_r}$ – speed piston; $\mathrm{Q_p}$ – flow pumps; $\mathrm{S_p}$ – piston area; $\mathrm{P_{pr}}$ – pressure pumps; $\mathrm{P_c}$ – pressure in the working cavity of the power cylinder; $\mathrm{K_r} = \mathrm{D^2}/(\mathrm{d_1^2 + d_2^2})$ – coefficient of reduction on the first stage of reduction.

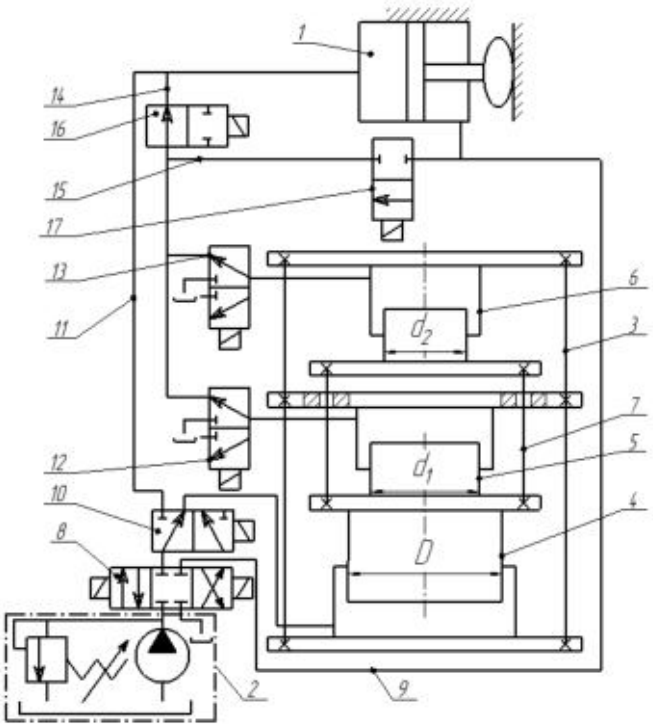

Figure 1 - Scheme of hydraulic press with four pressure stages in speed

With help of the action of technological effort at the beginning of the working stroke when the pressure in the working cavity of the power cylinder (P_c) less than the nominal pressure (P_{nom}) spool 10 takes up a position in which fluid from the pumps through the pipeline 11 into the working cavity of the power cylinder (pumping level pressure K_r=1).

In comparison with the mode of reduction there is a decrease in speed of the piston in case of equal pressure in the working cavity of the power cylinder and the pressure developed by the pumps. So:

$$V = \frac{Q_H}{S_п}; P_H = P_ц = \frac{R}{S_п}$$

During increase in processing load and thus the pressure in the power cylinder to a value higher than the nominal pressure of pump ($P_c > P_{nom}$). The valve 10 switches to the starting position and the input cylinder reducer-multiplier again connects to the pressure line. As, in accordance with condition:

$$d_1^2 < d_2^2 < D^2$$

reducer-multiplier in this case, the multiplier operates the mode switching steps of the multiplier, which is provided by disabling one of the output cylinder from the conduit 14. Thus there is a further reduction of the piston speed and reduction of pressure developed by the pump against the pressure in the working cavity of the power cylinder. So:

$$V_м = \frac{Q_H}{S_п \cdot K_м}; P_н = P_{нм} = \frac{P_ц}{K_м} = \frac{R}{S_п}$$

Where $K_m > 1$ – coefficient multiplier.

The first lower tier of animation, with the assumed conditions, $K_{m1} = D^2 / d_2^2$ (turn off a 6 cylinder). The second bigger step –$K_{м2} = D^2 / d_1^2$ (turn off cylinder 5).

Disabling the output of the cylinders performs by switching the spool 13 and 12, respectively.

During the return stroke of the press simultaneously with the return of the power cylinder piston to its starting position is also returned to the starting position of the block plungers reducer-multiplier. For it used, the fluid displaced from the working cavity of the power cylinder, which fills the cavity of the output cylinder 5 and 6. Starts reverse switching of the reversing valve 8 in the position in which the pressure pipeline of the pumping station is connected with the conduit 9 and further with the return cavity of the power cylinder and the power cylinder 4 reducer-multiplier through the open valve 10 and reversing valve – with drain. The power cylinder piston moves to the left (on the diagram), block plungers 7 – down (on the diagram) displacing liquid from the input of cylinder 4 for draining. The volume of fluid in the working cavity of the power cylinder before the return stroke may exceed the volume of output cylinders, high pressure multiplier, or may be less than this amount. In the first case in the lowest position (on the diagram) enters the block of the plunger 7. The valve 10 occupies the position in which the pipe 11 connects with the reversing valve. The power cylinder piston, continuing movement to the left (on the diagram), displacing the remaining fluid from the working chamber to the drain via the conduit 11 through the valve 10 and 8. In the second case to the left (on the diagram) enters the power cylinder piston. This deactivates the spools 17 and 16. The spool 16 closes the conduit 14; the valve 17 opens the conduit 15. After the fluid in the output cylinders reducer-multiplier fed from the pumping station through pipelines 9 and 15 through a shut-off valve 17 and the spools 12 and 13. Output block plungers 7 of the gearbox-the multiplier to its lowest position and the power cylinder piston to the left (on the diagram) ends the working cycle of the press.

Signals required switching of the electromagnets spools can be obtained from the limit switches controlling the position of the moving elements of the press and reducer-multiplier, and pressure switch.

The total number (n) of pressure is provided by a gear-animator (stage of reduction and level of the multiplier) is determined by the number of output of cylinder (m) as: $n = 2^m - 1$. The scheme of the press also provides an additional level of pressure at which the fluid in the power cylinder supplies from the pumps directly. In the end, the press has 2^m levels of pressure and speed.

The operation of the press with several stages of pressure and speed (in this case 4 stages) expands technological capabilities, brings the pump load closer to the pressure of an ideal pump that allows reducing the installed capacity and increasing the efficiency of the press.

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SURFACE HARDENING AS A MEAN TO INCREASE IMPACT AND ABRASIVE WEAR RESISTANCE OF MINING EQUIPMENT ELEMENTS

One of the main reasons for loss of mining equipment performance is the wear of its working elements, which occurs in the process of mining and processing of rocks. The most highly wearing-out parts of equipment are elements that work with direct contact with rock such as teeth of bucket excavators, liners, deflector plates of crushers, hammers of grinding mills and etc., as evidenced by a significant share of the expenses of mining and processing plants on their repair and replacement. A significant amount of work has been devoted to the development of methods for increasing wear resistance [1-4], but such method as surface pre-hardening have not been sufficiently studied. In this regard, it is relevant to investigate this method as a possible effective mean to increase the wear resistance of mining elements.

The research is devoted to the experimental evaluation of pre-hardening treatment as a way to increase the wear resistance of mining equipment elements exposed to high wear. In previous works of the authors, using the example of relatively soft and low-abrasive apatite-nepheline ore, it was established that under the conditions of impact-abrasive impact of the rock, surface hardening of element can significantly (up to 1.6 times) increase its wear resistance. In this work, this conclusion is confirmed by experiments on the effect samples made of Hadfield steel of harder and more abrasive rock-magnetic ironstone.

Samples made of Hadfield steel was quenched with obtaining hardness of 200 HB, other part of samples were additionally pre-hardened, then they were weighed on analytical scales, after which they were set in experimental installation, and a container with a water-abrasive mass of crushed magnetic ironstone was installed at a fixed distance. Using the experimental

installation, a series of impacts were made by the end of the sample on the abrasive mass, then this samples were cleaned and weighed on a scale to fixe mass loss. An extrapolation line was drawn through the experimental points of the dependence Δm - t, the tangent of the angle of inclination of which was taken as the wear rate of the material. Similar experiments were carried out on similar steel samples, the end part of which was previously pre-hardened until the surface acquired the necessary hardness (Figure 1).

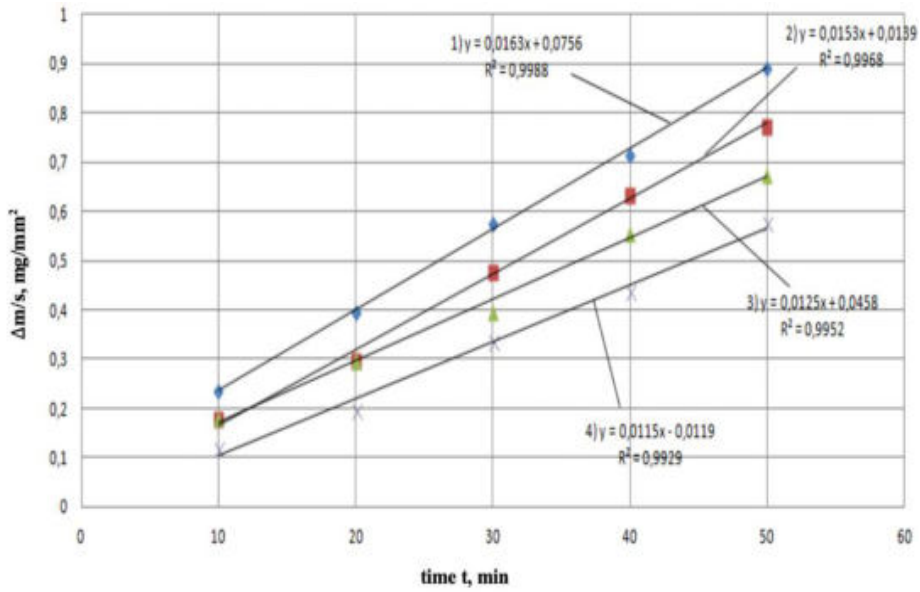

Figure 1 - Time dependence of the total mass loss of samples made of steel 110G13L at their impact-abrasive wear on magnetic ironstone: samples of initial hardness (1), hardened to 300 HB (2), 337 HB (3) и 368 HB (4)

From the comparison of the type of dependences on the figure, it can be seen that the velocity of impact-abrasive wear of pre-hardened samples ($V_{2,3,4}$ = 0,0153, 0,0125, 0,0115 mg/(mm^{2}min)) less than in the case of the initial sample (V_1 = 0.0163 mg/(mm^{2}min)). At the same time, with an increase in the intensity of surface hardening, the wear resistance of the sample increases (up to 1.4 times).

Therefore, pre-hardening treatment of mining equipment elements made of Hadfield steel can significantly increase their resistance to impact and abrasive impact of rocks of certain hardness and abrasiveness.

This circumstance is advisable to use in the development of ways to extend the life of equipment elements that are worn out in the conditions of impact interaction with the abrasive without noticeable movement of solid abrasive particles in relation to the wear surface.

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COMPARATIVE ANALYSIS OF LATHE BODIES WITH A MONOLITHIC AND FOLDING STRUCTURE BASED ON THE RESULTS OF FEA ANALYSES

Manufacturers wanting to win more customers must constantly improve the quality and attractiveness of their products. In the case of machine tool manufacturers, it usually comes down to providing the desired static stiffness, which directly affects the machining accuracy and productivity of the machine [1]. The greater the static stiffness, the greater the dimensional and shape accuracy that can be achieved, the greater the machining parameters that can be used to increase machining performance. Dynamic stiffness and vibration damping capacity are also no less important [2]. Therefore, the question arises as to how the supporting structure of the machine tool should look like. Whether it should be a steel structure welded and bolted from the modules, or whether a cast iron structure and bolted from the modules would be better, or maybe a monolithic cast iron structure. Some manufacturers also opt for a polymer concrete casting or a hybrid construction, i.e. a steel structure filled with polymer concrete [3]. The choice depends largely on the type of machine tool and its purpose and size. It also depends on the manufacturing technology available to the manufacturer.

The subject of the research was Underfloor Wheel Lathes designed to regenerate the profiles of the running wheels and brake discs of heavy rail vehicles without removing the wheelsets. These machines can also be used to regenerate wheel sets in trolleys dismantled from vehicles or the wheel sets themselves. The machine tools operate in a pass-through system [4]. Two machine tools differing in the structure of the supporting system were tested: monolithic and folding.

The CAD models of the analyzed machine tools, developed by the constructors, have been modified in order to simplify them to a form allowing for FEA analyses. To this end, small holes, chamfers and roundnesses, which were irrelevant to the stated purpose of the analysis, were removed. The model was discredited using finite elements such as HEXA and TETRA.

In order to show the effects of bolted connections on the static stiffness of lathes, simulations were carried out, taking into account non-linear contact in the connection between the support beam and the columns and preload in the bolts connecting these elements. A previously developed geometrical model of the lathe was used for the calculations. However, due to the simulation of non-linear phenomena, the model was limited using symmetry.

Conclusions are based on the results of the FEA simulation. They concerned the influence of the type of supporting structure and connection between the bodies on the static stiffness, forms of vibrations and dynamic stiffness of machine tools. The most important of these are the following:

1. The comparison of the results of the analysis of the monolithic and folding structure with the rigid contact showed that the monolithic supporting structure is characterized by greater static stiffness in all directions. This stiffness is higher in relation to a supporting structure that is bolted in the X direction by approx. 28%, in the Y direction by approx. 15% and in the Z direction by approx. 7%. Conclusions were formulated for a single slide load. The static stiffness for a bolted structure is likely to be slightly overestimated as a result of the assumptions made at this stage of the test, which relate to a perfectly rigid connection between bodies.
2. The comparison of the results of the analysis of the monolithic and folded structure with non-linear contact shows a higher stiffness of the monolithic structure by 12% in the X direction, by about 63% in the Y direction and by about 33% in the Z direction respectively.

3. A straightforward comparison of the natural frequencies shows higher frequency values from about 20% to 49% for a monolithic construction. However, to compare the frequencies, the form of vibration must also be considered. This comparison shows an increase in frequency from about 8.5% to 32% for similar forms of vibration.

4. The results presented show that the use of a monolithic supporting structure gives in most cases significantly greater dynamic rigidity in relation to the folding supporting structure.

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STUDY OF COMPLETE ENERGY REDISTRIBUTION IN AN INTEGRAL-ADIABATIC GAS FLOW WITH DISSIPATION TO ESTABLISH THE SCOPE OF APPLICATION IN THE MINING INDUSTRY

Conventional air conditioning methods do not always meet energy conservation and energy efficiency requirements. Problems such as ease of manufacture, reduced material consumption and overall dimensions, faster operation and ease of use are often ineffective.

Despite a large number of studies, there is currently no well-founded theory of vortex effect allowing for a clear definition of the physical essence of the latter.

The available experimental results do not give a clear answer to the question about the selection of optimal values of the main design parameters of the vortex tube - the shape and length of the energy separation chamber. Data on the effect of the internal surface of the chamber on the efficiency of the separation process are also contradictory.

In known vortex individual air conditioners, the possibility of cleaning air directly in the air conditioner is not provided, which limits the field of their use. Air conditioning systems have not been developed, with low pressure vortex tubes most promising in terms of energy consumption reduction. The control of vortex tubes used in air conditioning systems has not been sufficiently developed.

The above-mentioned objects can be achieved to a large extent by using as generators the cold and heat of vortex tubes (VT), which are very compact, cheap to manufacture and easy to operate devices. The main advantage of such systems is the possibility of air conditioning in the immediate vicinity of the place of use. This advantage significantly reduces the losses associated with the transport of air during its centralized treatment.

One of the directions of this topic is personal means of protection for a person working in extreme conditions with high ambient temperature. Individual air conditioners made on the basis of VT can provide ventilation and cooling of protective suits, can be used as anti-plant equipment of individual protection of miners. Despite the fact that the energy efficiency of the process of temperature separation of air in BT is low, taking into account mass exchange in the space under clothing, where cooled air is supplied, efficiency when using vortex pipes for

individual conditioning purposes is quite high. Each kilogram of used compressed air with a pressure of 0.3... 0.6 MPa allows to remove from the person 12.8 18.6 W of heat, respectively. [1]

Currently, individual air conditioner operating from pneumatic network is developed at Kuibichev Aviation Institute. Air conditioner and corresponding protective suit are intended for welders operating inside pipes of main gas pipelines. [2]

For mine transport, with the necessary adaptation, a device for cooling the air entering the car cabin can be used. Vortex tube nozzle inlet is connected with engine air filter. Cold air from the vortex tube enters the heat exchanger, where it cools the atmospheric air supplied by the fan to the cabin. Then cold flow, as heated, is directed to engine carburetor.

The results of the performed studies can become the basis for a promising direction to solve the problem of ventilation of quarry vehicles. Comprehensive research and development of air conditioning systems with vortex pipes and clarification of conditions of their effective use are one of the current and most important directions of improvement of principle technical solutions in the field of technology.

One of the objects of the study was individual vortex air conditioners, which provide air purification immediately before it is supplied to the consumer, as well as air conditioning systems with a low-pressure vortex tube to service small premises.

Based on the solution of the problem, it is possible to control temperatures and air flow rates in vortex conditioners by acting only on the throttling or inlet valve of the pipe or by changing the length of the core of the separation chamber.

The possibility of practical realization of energy redistribution effect in vortex tubes with different geometry for further use of cooled and heated air flows was checked. [3]

As a result of the calculations, the main conclusions were drawn on the influence of the cone installation or cross-pieces on the thermogasodynamics of the flow and energy separation in the vortex tubes.

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WATER INJECTION – A PROMISSING WAY TO IMPROVE PERFORMANCE AND EMISSIONS OF GASOLINE DIRECT INJECTION ENGINES

The internal combustion engines (ICEs) are the primary driving force of our society since its discovery. It converts heat energy generated by the combustion of fuel into mechanical energy used for power generation or propulsion. Although it was invented in the 17th century, it still seems impossible to replace the ICEs for decades to come [1]. Today, they are used in different power applications ranging from over 100 MW to under 100 W, including massive marine systems, automobiles, earthmovers, mining, trains, aircraft, power generators, agricultural pumps,

hand-held tools, and so on. In the mining industry, ICEs are used in heavy-duty vehicles for material transportation, which demands higher and reliable performance under stringent emission norms. However, their dependence on fossil fuels and higher emissions of CO_2, NO_X, and particulate matter are a major concern. Currently, the automotive sector uses boosting methods, after-treatment devices, or conventional strategies (such as EGR, lean combustion, retarded ignition, low compression ratio, etc.) to meet the efficiency and emission requirements of ICEs. However, these techniques are individually limited to either improving efficiency or emission characteristics; or achieving both within a short operating range [2]. Although turbocharging is helpful in engine downsizing, it comes with another challenge of knocking. Therefore, a promising technology needs to be developed/employed that can simultaneously improve engine performance and emission characteristics while mitigating the knock. Under such a scenario, water injection is a potential strategy that not only reduces NO_X and soot emissions but also effective in engine downsizing and improving fuel efficiency.

In the water injection system, a certain amount of water is injected directly into the combustion chamber. Water act as a heat sink, which absorbs the heat of vaporization from the air-fuel mixture and reduces the peak temperatures during the combustion. Furthermore, it also cools local hot spots, which might be the source of NO_X formation and premature ignition. Due to the charge cooling and antiknock ability of water injection, it is possible to reduce NOx emissions while improving the engine efficiency through knock mitigation [3]. Furthermore, water gets dissociated into OH and O ions during the combustion that reduces soot emissions. However, water injection can also affect engine combustion and emission characteristics if water injection and injector parameters are not correctly set. The majority of the previous studies on water injection are done through experiments. Therefore, subtle aspects of water injection, such as in-cylinder interaction of water sprays, the spatial distribution of water vapor, the effect on flame propagation, etc., are not clearly understood and rarely reported in the literature due to experimental limitations. Thus, in the present study, a CFD (computational fluid dynamics) investigation is carried out to analyze the effects of water injection amount and its distribution inside the combustion chamber on water evaporation, combustion, performance and emission characteristics of a gasoline direct injection (GDI) engine.

Nowadays, GDI engines are highly preferred by the automotive industry because of their higher specific power output compared to conventional gasoline engines [4]. However, higher NO_X and soot emissions are the main threat to GDI engines. Therefore, the strategy of direct water injection is used in the GDI engine to improve their emission and performance characteristics.

In the present research work, the term W/F ratio is used to denote the water injection quantity, which is defined as the ratio of the mass of water injected to the mass of fuel injected in a cycle. For the present investigation, the W/F is varied from 0 (no_water) to 1 in the step of 0.2. Additionally, various in-cylinder distributions of water vapor are analyzed, and the criteria for the proper distribution is defined. The water is injected at the optimized water injection timing, pressure, and temperature of 120° CA before TDC (top dead center), 50 bar, and 320 K, respectively. The engine has a compression ratio of 13.5, which is operated under full load and naturally aspirated condition at 2000 rev/min. All the CFD models used in the study are properly validated from the literature.

The results show that the amount of water evaporation decreases as the W/F increase. About 9%, 13%, 15.5%, and 19.5% of the total injected water was still in liquid form in the case having W/F ratio of 0.4, 0.6, 0.8, and 1, respectively. This is due to the lack of time available for the complete evaporation. The flame propagation was highly dependent on the spatial distribution (or concentration) of water vapor inside the combustion chamber. It was slower in the presence of water vapor owning to the thermal and dilution effects of water. For the better engine performance, the concentration of water vapor should be high and uniform near the walls of the combustion chamber and nil at the spark plug location.

The optimum combustion phasing is advanced with an increase in W/F ratio due to spark advancements. This is because water vapors reduce chemical reactivity and ignitability of the mixture. To compensate for the adverse effects of water injection, the spark timing needs to be advanced, which shifts the combustion phasing towards TDC. Thus, a large part of the combustion occurs near the TDC that also increases the peak in-cylinder pressure. The water injection played a significant role in the reduction of peak combustion and exhaust gas temperature, which is the aim of every engine investigator. The peak in-cylinder temperatures, for the cases of W/F ratios of 0.2, 0.4, 0.6, 0.8 and 1 are lesser by about 100 K, 142 K, 201 K, 329 K, and 406 K respectively, whereas exhaust temperatures are lesser by about 12 K, 35 K, 66 K, 109 and 156 K respectively than that of the no_water case.

Among all the considered W/F ratios, the W/F ratio of 0.6 is found to be the optimum one, with the IMEP of about 9.29 bar, which is higher by about 8.4%, 3.2%, 1.3%, 4.6%, and 6.4% compared to those of the W/F ratios of 0, 0.2, 0.4, 0.8 and 1 respectively. The NO_X, soot, and CO emissions in all the water injection cases found to be lesser compared to that of the no_water case. At the W/F ratio of 0.6, NO_X, soot, and CO emissions are about 42.7 %, 30.2 %, and 16.6% lower than those of the no_water case, respectively.

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AN EARLY FAULT DETECTION IN PREDICTIVE MAINTENANCE STRATEGY OF ROTARY MACHINES WITH AN OPTIMIZING INPUT SELECTION METHOD AND USING MACHINE LEARNING APPROACH

Due to the increasing demands on system performance, modern technical processes become more complicated and the automation degrees of such systems are significantly growing. On the other hand, the complete reliance on human operators to deal with abnormal events has become increasingly difficult as shown by the following fact that it is claimed that about 70% of the industrial accidents are caused by human errors [1].

The malfunction of electric machines can be generally attributed to various faults of different categories. Several surveys regarding the likelihood of induction machine failures conducted by the IEEE Indus-try Application Society (IEEE-IAS) [4]–[6] and the Japan Electrical Manufacturers' Association (JEMA) [7] reveal that fault is the most common fault type and is responsible for 30% to 40% of all the machine failures.

This research permits examining a novel method of Feature extraction and Input selection as data preprocessing method and their combination with a deep neural network to analyze the

resulting vibration signal. Prediction of the fault situation in the Rolling Element component is our main goal. Subsequently, the design and realization of a NASA Bearing Dataset, which produces the data from healthy to faulty for analysis and test the designed algorithm. By means of these data, the concept of predictive maintenance is evaluated. The algorithm is based on methods, which apply historical data of the component's degradation process for the estimation of the current and future damage state.

In this study four important steps of Data preprocessing have been used. Because of the big data problem, complexity, high frequency, and noisy components of the vibration signals, analysis and signal processing is essential. At first step, HAAR Wavelet transformation based de-noising is used as a strong method for de-noising the data and it helps us to omit the noisy data from our dataset. After that, we use Wavelet Transformation base feature extraction again as a Feature Extractor. By means of Wavelet transformation are our data decomposed to three levels, it means we have three high-frequency data vector components and three low-frequency data vector components. After de-noising and Feature Extraction and by considering suitable delay for the data, our problem defines as a time series problem for fault prediction. Selecting the delay times and the number of delays is based entirely on trial and error. In this problem for every feature, we consider 3 delay So we have totally 18 data vectors for Inputs of neural network. For better performance of the Neural network and have more appropriate inputs, Particle swarm optimization has been used as an optimization algorithm to select the best Inputs from these 18 extracted inputs. now the data is ready to use as the inputs of deep neural network to predict the fault situation of this rotary component. the LSTM deep neural network is a great predictor for the time series problem that is used in this research study.

However, accurately identifying the presence of a bearing fault can be challenging in practice, especially when the fault is still at its incipient stage and the signal-to-noise ratio of the monitored signal is small. But with this optimum data preprocessing method, we could have an accurate model of LSTM neural network as the predictor of Fault situation in Bearing after 120 Seconds. Regarding future research directions, we could suggest new sensors with low or any noise to have data with more high quality.

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INVESTIGATION OF EFFICIENCY OF PULSATING METHOD OF METAL BLOWING WITH INERT GAS IN STEEL TEEMING LADLE

In modern steel production technologies carrying out a number of secondary refining technological operations in steel-teeming ladle is necessary condition for obtaining high-quality

metal. The most common heat finishing operation in a steel teeming ladle is to purge it with an inert gas to homogenize in chemical composition and temperature as well as to refine it against non-metallic inclusions. As a rule such secondary refining processing involves inert gas blowing into liquid alloy through porous plugs located in the bottom of the ladle or submersible tuyeres.

One of the problems with the secondary refining processing of steel is disclosure of liquid metal surface when purged with inert gases. As a result, the liquid steel reacts with the oxygen of the atmosphere, which leads to formation of ferric oxides, contamination with non-metallic inclusions, and consequently steel quality losses [1]. The research of metal and slag behavior directly in the "ladle – furnace" unit in production conditions is a complex process, so it is more convenient to carry out its study with the help of the physical model of a steel-teeming ladle [2].

The test subject was a steel-teeming ladle with a nominal volume of 300 tons. The ladle model is made of transparent organic glass with necessary similarity criteria. Design flow rate of blowdown gas can vary from 2 to 28 l/min, which corresponds to argon flow in the range of 100 to 1400 l/min. at site. 18-25^{o}C temperature water was used as working liquid simulating melted steel, and motor oil was used as liquid slag. The choice of water as a model liquid is explained by the fact that the viscosity values of water and steel in the out-of-furnace temperature range are quite close to each other.

The model, was subjected to research to study the behavior of modeling liquids (water and oil) during the stationary and pulsating mode of blowdown gas (air) supply through two blowdown plugs, the structures and parameters of which are as close as possible to those used at the site. Electric solenoid valves were used to carry pulsating feed of the purge gas into effect.

The gas flow rate during blowing through the model at the above mentioned modes was 4 l/min. The electric solenoid valves were controlled during pulsating feed by the computer via a sound board using Cubase 5 program. The most effective purge gas feed frequency was determined experimentally and accounted for 6 Hz. During simulation of stationary mode of blowdown through two bottom plugs it has been established that blowdown gas supplied with flow rate of 4 l/min forms two rotating gas-liquid jets which emerge at the outlet of model liquid and disclose its surface [3].

The water surface disclosure area for stationary blowdown mode was 10.48% of the total area of the liquid metal surface area, indicating intensive secondary oxidation of the melt at the site. It has been noted that the water between the gas-liquid jets is practically not homogenized and forms a stagnant zone. Non-metallic inclusions in this stagnant zone will be virtually unaffected by the formed streams on site. Thus, it can be stated that at this 4 L/min purge gas flow rate, the stationary purge process is ineffective for homogenizing liquid alloy and refining it against non-metallic inclusions.

At the pulsating mode of blowdown gas supply water surface disclosure area was 7.0% of the total model surface area. This is because a pulsating gas feed, compared to a stationary one, produces streams in the stagnant part of the water volume to facilitate non-metallic inclusions removal. Pulsating gas supply has a positive effect on the reduction not only of water surface area, but also of its contact time with atmosphere. Alternate impulses lead to periodic opening and closing of the water surface above each of the blowdown plugs, while in a stationary blowdown process, contact of the water with the atmosphere is observed throughout the treatment.

Thus, the research has made it possible to establish the advantages of the pulsating method of blowing the melt in terms of reducing the intensity of secondary oxidation of metal, reducing the volume of stagnant zones in a steel-teeming ladle, as well as the efficiency of non-metallic inclusions removal.

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STUDY AND DEVELOPMENT OF MEASURES TO MAINTAIN THE PERFORMANCE OF THE PNEUMATIC SYSTEM OF BUSES

Road transport is the most extensive and most dangerous kind of transportation in the Russian Federation. More than 170 thousand road traffic accidents annually occur in the Russian Federation, as a result of which over 18 thousand people die and over 200 thousand people get injured. Most road traffic accidents occur either during the process of vehicle braking, or associate with a sharp change in driving speed. The number of traffic accidents and the severity of their consequences depend greatly on the technical state and performance of the brake system of vehicles [1]. To determine the need to maintain the pneumatic system of buses in a good operating condition, an analysis of failures arising during the operation of the rolling stock of Bus fleet No. 6 of St. Petersburg State Unitary Enterprise “Passazhiravtotrans” throughout a year, was conducted and the most frequently occurring failures were identified. Most failures fall on the pneumatic system and makes 37% [2]. To determine the most significant element of the pneumatic system of buses and to ensure further development of measures to maintain the system’s performance, a priori ranking of factors was implemented. Based on the results obtained it follows that first of all the performance of the pneumatic brake system is affected by the following factors: compressor malfunction, air leak from the system and brake release problems, since the sum of their ranks is the smallest, and other factors affect to a lesser extent.

Based on operating experience and taking into account the fault analysis results, there is a need to improve the system for purification of air being supplied to the pneumatic compressor and install protective heat shields on PVC tubes. To complete these measures and improve the technique for the restoration of pneumatic compressors, it is necessary to upgrade the pneumatic section of the said bus fleet. For the purpose of the pneumatic section modernization, the basic equipment, required to further maintaining the performance of the pneumatic system of buses, was selected. Having conducted the pneumatic section modernization feasibility study, it was revealed that its cost and payback period are as follows: 1011142 Russian rubles and 0.87 year, respectively [3].

According to the results of trial operation, installation of a separate air filter on a pneumatic compressor, resulted in the reduced ingress of dust particles into the cylinder compared to the operation of the compressor with a standard engine air filter. The wear rate of the cylinder wall and piston rings of the pneumatic compressor is reduced. Installation of an additional heat shield to protect the tubes and hoses of the pneumatic system, passing in close proximity to the exhaust system, resulted in the reduced total number of failures on the VOLGABUS and LiAZ buses. The measures, discussed in the present article, to maintain the effective performance of the pneumatic system of buses will result to the reduced number of failures associated with the pneumatic system malfunction.

Thus, having conducted the experimental studies, and based on the analysis of failures arising during the operation of the rolling stock of the bus fleet, it was revealed that most failures associate with the pneumatic system and its elements, including: pneumatic compressor, poor

tightness of tubes of the system, etc. According to the results of the pneumatic section modernization feasibility study, it was revealed that its cost and payback period are as follows: 1011142 Russian rubles and 0.87 year, respectively. Modernization of the section includes the development of measures to maintain the performance of the pneumatic system of buses, as a result of installing a separate filter for purification of air being supplied to the compressor and using a heat shield to prevent the destruction of pneumatic hoses from high temperatures. These measures will improve the efficiency of maintenance and repair work and reduce idle time.

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MODERNIZATION OF THE MECHANISM FOR REGULATING THE SUPPLY OF AN OIL PUMP FOR CARRYING OUT LUBRICATING AND REFUELING OPERATIONS ON MINING MACHINES

KEYWORDS: pump, motion conversion, reciprocating motion, eccentricity, MRO, mining machine.

Existing piston pumps on the domestic market, used for lubrication and welding operations on mining machines have a built-in worm gear. It is known that the coefficient of efficiency of worm gear does not exceed 60%, and this gear wears out quickly and requires constant care and frequent repair.

In this connection it is offered to use the gear-type eccentric mechanism of transformation of reciprocating movement of the high-pressure piston pump with the optimized geometry of gear gearing of a drive of the piston and variable value of its stroke in a pump design. This simplifies the mechanical design of the pump, eliminates the need for worm gear and increases the reliability of the pump.

The specifics of the conditions for the use of mining machines in the mining industry (a significant distance from oil depots and repair and maintenance facilities) require mobile maintenance tools, which can reduce the workload of workshops during intense mining.

Among other things, a guaranteed normal mode of functioning of technological production processes of mining is impossible without special-purpose pumps designed to work with fuels and lubricants [1].

During the operation of pumping equipment, problems arise associated with low generated pressures and low productivity [2]. An increase in these parameters (pressure and productivity) leads to intensive wear of the drive of the worm-crank assembly with the formation of travel, increases the dynamics of wear and reduces its durability.

This leads to a pump out of operation, which can cause the preparation and collection of lubricants to stop, which in turn will lead to failures of mining equipment.

In this regard, it is proposed to use the deterministic reciprocating motion of the pump piston by means of a gear-eccentric gearbox with a complex movement of the drive and driven gears for supplying a lubricant with a high pressure piston pump to the lubrication system when carrying out lubricating and refueling operations for its maintenance in the quarry and reduce labor intensity of these works [2].

To deduce the law of motion of the output shaft of a planar mechanism with a kinematic pair of 4th class, it is necessary to consider plane-parallel motion of a solid body on Figure 1.

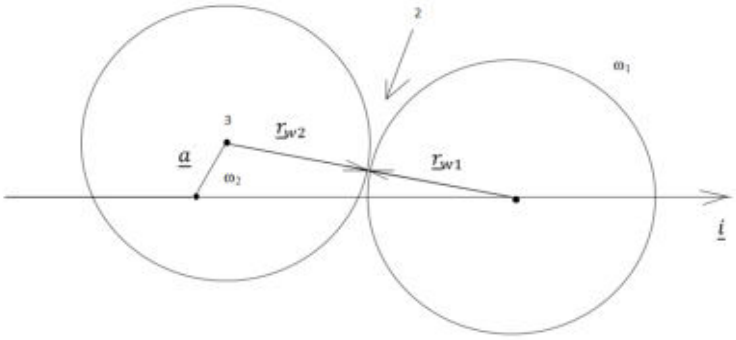

Figure 1 - The planar mechanism with a kinematic pair of 4th class

The complete equation of the law of motion of the piston for the pattern shown in Figure 1 is written as:

$$S = r_{w1} + r_{w2} + e - [(r_{w1} + r_{w2})^2 + e - 2(r_{w1} + r_{w2}) \cdot e \cdot cos\ (\pi - \varphi)]^{0.5} \quad (1)$$

where φ - angle of rotation of the drive gear, the angle of rotation of the gear; r_{w1} – initial radius of the first gear r_{w2} – initial radius of the second gear; e - eccentricity of the driven gear; S – piston stroke.

Thus, we can conclude that the piston stroke at a given distance of the axle distance depends on the eccentricity, as well as the swing angle ⊓ of the driven gear.

To prove this conclusion, we will build graphs of the dependences of the piston stroke on the eccentricity, expressing the value of the eccentricity as the ratio of the eccentricity to the axle distance which shows on Figure 2.

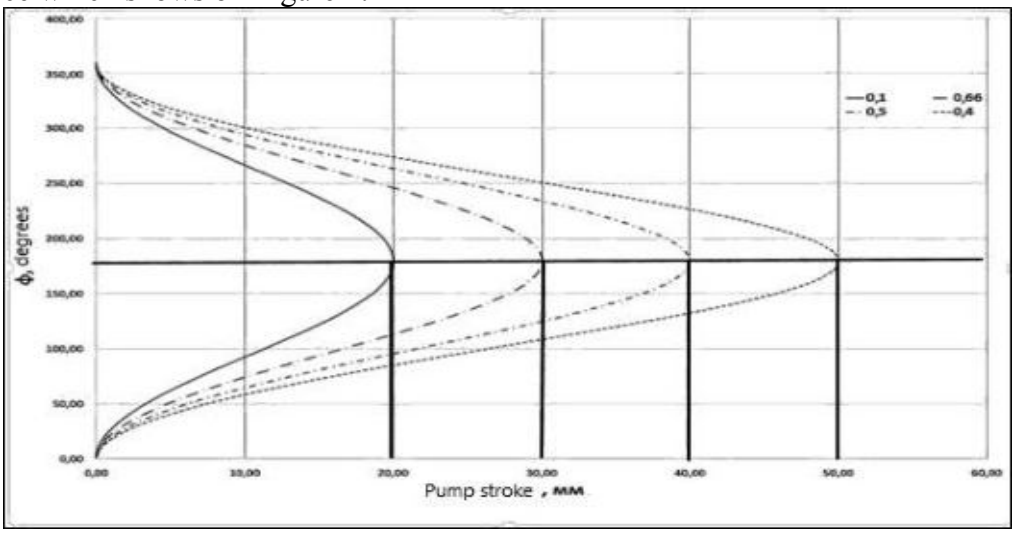

Figure 2 - The dependence of the piston stroke on the angle of rotation of the crank.

Thus, it is proposed to use a feed control mechanism with a gear-eccentric motion converter as the actuators of the pump, during the operation of which the conversion of rotational motion to reciprocating is necessary. Such a mechanism is more compact, and the transmission

efficiency, according to preliminary estimates, will be at least 90%. Among other things, this mechanism will allow to solve problems with leaks and significantly reduce maintenance time, as well as achieve savings in reagents by ensuring the accuracy of the injection of lubricants and increase the service life of the pumps by reliability.

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OPTIMIZATION OF FLYWHEEL PARAMETERS FOR INDUSTRIAL VIHICLES

One of the current trends in the electrical equipment of average power carrier vehicle (tractors, trucks, etc.) is mass-dimensional indicator improvement. To start an internal combustion engine (ICE), most carrier vehicles need a starter. The characteristics of electric starter machines used in diesel average power carrier vehicle are given. Also is drawn attention to the fact that the electric motor of the starter must have a high torque (80-500 N·m) at a relatively low speed (100-150 rpm). The generator is the main source of electricity in the power supply system of wheeled transport. Serial tractor generators have a low torque (1-3 N·m) at a significantly high speed (950-2300 rpm). [1-3]

As a rule, the source of energy for a starter electric car is a rechargeable battery. However, at low temperatures, it is not able to provide a reliable start of the ICE. Both electric machines (starter and generator) have approximately the same power, but their mechanical characteristics are very different from each other. As a result, the desire to combine a starter and a generator in one electric machine encounters very great difficulties.

For the calculation was used the tractor engine D-240, the engine operates in several operation modes, one of them is the mode of accumulation of energy necessary for cranking the engine at start. In the proposed solution, it is possible to implement the kinetic energy storage function, the functional diagram of which is shown in Figure 1. In the accumulation mode, the brake T and the coupling Mf are disconnected. In this case, the carrier shaft S is motionless, which is achieved due to the relatively large moment of scrolling of the ICE. The energy is taken from the feed source of on-board electric system (BAT) and sequentially through the electric

machine, sun gear S, satellites ST rotating in the considered mode around their motionless axes of carrier C, enter the epicyclic shaft E and the connected flywheel masses.

We optimize the flywheel mass-dimensional parameters, which acts as an epicycle in the starter-generator system based on a differential drive with a planetary gearbox.

The initial calculation of the flywheel parameters was to select the external and internal radii of the flywheel. The calculation of the moment of rolling resistance is carried out in accordance with a change in the viscosity of the oil due to a change in temperature. the dependences of the viscosity of winter motor oils on air temperature, taken from the directory of oils and additives of tractor engines of Arabyan S.G.[4], the above dependences correlate with what other authors weigh in. The graph shows that with decreasing temperature, the viscosity of the oil increases, and therefore increases the moment of rolling resistance (Mc).

During this research were selected the optimal parameters of the external and internal parameters of the flywheel, which acts as an epicycle in the differential electric drive system of the starter generator. The obtained dependences make it possible to select the optimal parameters of the flywheel with the changing of initial conditions.

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INFINITELY VARIABLE HOLD AND ADJUSTABLE SYSTEM

The task was to innovate an Infinitely variable hold and adjustable System. The System should be able to lock all kinds of moving systems independent of their actual position. It could be used for example in Car-doors (or similar). In that case the door should be able to get opened but shall be able to be stationary in case of sensor detected collision.

The Solution is a hydraulic based system with two chambers. The Moving object can be set stationary by blocking the fluid of running between the chambers. The system is able to hold against the force that act on the object till reaching the vapor pressure. It is possible to use this system in every mounting position. We reduced the solution to a System with just six parts, that means less weight and a simple assembly. The chambers can be built in different sizes and materials. You also have the ability to change the fluid inside the chambers to adjust it to the given conditions (e.g. ambient Temperatures).

It is to connect the system with many modern control systems and nearly every kind of artificial intelligence [AI] (e.g. on-board systems). The Connection to a Gyroscopic sensor can stop, increase or decrease the velocity of closing doors, when detecting a tendency. This can be realised by reducing the fluid of running through the chambers.

To trigger the systems its possible to decide- mechanical, hydraulic, pneumatic or even electrical connections are possible. That depends on the whole construction where the system is integrated.

As a conclusion its possible to turn out, that the solution is a new standard for comfort, security against damages and connectivity to modern computer systems.

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TECHNOLOGICAL QUALITY IMPROVEMENT OF HIGH- LOADED THREADED SURFACES OF DRILLING RODS FOR ROTARY-PERCUSSIVE DRILLING

At the present stage of market economy formation, underground mining is the basis of efficient functioning and development of mining industry of the country. Among the many existing mining methods, the rotary-percussive drilling method is the most effective, in which the drilling tool, under a heavy axial load in constant contact with the bottom of the well, breaks rock as a result of rotation and periodic impacts on the tool.

For the rotary-percussive drilling method realizing, drilling rigs are widely used. There are drilling rods in the construction of drilling rigs, in which one of the most important elements is threaded connections [4]. Threaded connections of drilling rods often operate under difficult dynamic conditions in which they break due to a variety of factors, such as fatigue failure and wear.

Fatigue failure and wear resistance increasing of threaded connections can be implemented by means of constructive or technological methods. Constructive solutions are necessary but insufficient; besides, constructive changes in threaded connections lead to complication of structure, as well as cost, dimensions and weight of item increasing. As a result, special attention should be paid to technological ways of solving problem that allow improving the quality of threaded surfaces and, as a consequence, increasing the fatigue failure and wear resistance of threaded connections.

It is known from the theory and practice of mechanical engineering that the performance characteristics of items, such as fatigue failure, wear resistance, etc., depend on the surface quality (roughness, microhardness, etc.) formed at the manufacturing step of items. The final surface quality of item is formed with finishing operations, one of the most effective which is magnetic-abrasive finishing. Magnetic-abrasive finishing is carried out when the powder ferromagnetic abrasive mass having been thickened by magnetic-field energy has an abrasive influence on a workpiece; herewith, the workpiece is subjected to specific motions required for the processing: rotational, oscillatory and to-and-fro (if possible) motions.

The possibility of being successful in using magnetic-abrasive finishing for structural steels, which are mainly used for making threaded surfaces of drilling rods, are confirmed by numerous experimental studies carried out by different scientific teams [1, 2, 3]. It is established in their research that in a fairly short time (60- 210 sec) magnetic-abrasive finishing decreases roughness from Ra = 0.4... 0.44 to Ra = 0.03... 0.035 μm and waviness in 8...10 times (from 2...3 to 0.2...0.3 μm), increases (compared to circle, bar, tape) local strength and wear resistance of item in 2...3 times, as well as improves curve of the profile bearing length up to 75... 85% [3].

As a consequence of the above, at the Department of Mechanical Engineering of St. Petersburg Mining University it was decided to carry out the research of external and internal threaded surfaces magnetic-abrasive finishing at the final step of drilling rods threaded connections manufacturing. The research has to be fulfilled in order to reduce roughness and

increase the contact area fillet of the threaded connection, remove the preceding defective layer formed in the preceding operation and form a new - strengthened layer, increase fatigue failure and wear resistance of the threaded connections.

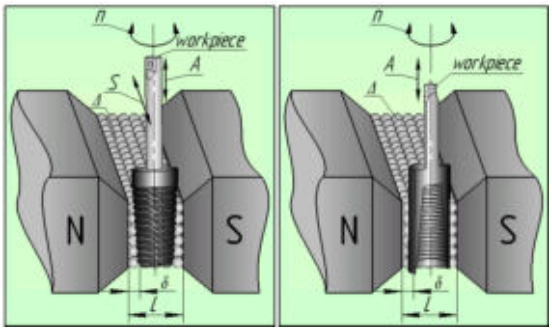

Figure 1 – Magnetic-abrasive finishing of external and internal threaded surfaces

Magnetic-abrasive finishing of the external and internal threaded surfaces should be carried out according to two schemes (figure 1). External threaded surfaces have to be processed with simultaneous rotational, oscillatory and to-and-fro motions of workpiece in magnetic-abrasive mass in interpolar space of magnetic-abrasive device. Internal threaded surfaces have to be processed with simultaneous rotational and oscillatory motions of workpiece in the magnetic-abrasive mass in the interpolar space of the magnetic-abrasive device. To-and-fro motion in the second scheme is excluded due to the inability to get magnetic abrasive material into the inner zone of the workpiece.

Figure 2 – Magnetic-abrasive device

Currently, experimental research has been planned for external and internal threaded surfaces magnetic-abrasive finishing. Experimental researchs are planned to be carried out on a specifically developed device (figure 2) for magnetic abrasive finishing, which is located in the laboratory of CNC machines of Department of Mechanic Engineering, St. Petersburg Mining University. The device for magnetic abrasive finishing is based on a CNC mill, which enables one to provide the finishing process by all required working motions.

Workpieces of structural alloyed steel 40X with external and internal threaded surfaces were prepared for the experiment (figure 1). A magnetic abrasive material based on titanium and iron carbide (TiC+Fe) will be used to form the magnetic abrasive brush in the electromagnetic system operating space. Varying parameters of magnetic-abrasive finishing will be changed in following ranges: powder grain Δ = 160... 315 μm; magnetic density B = 0.6... 1.0 T; finishing time length t = 60... 210 sec. The testing parameters to be controlled will be the roughness Ra and microhardness Hv of the threaded surfaces, as well as the amount of material to be removed.

The Department of Mechanic Engineering of St. Petersburg Mining University has experience in solving similar problems, in particular magnetic abrasive finishing of complex profile surfaces. In works [1, 2, 3] it was found that the use of magnetic abrasive finishing in the preparation of cutting tools for internal thread surfaces manufacturing in difficult materials can increase the wear resistance of the cutting tool in 2-3 times and reduce the roughness of the internal thread surfaces in 2,1-4,0 times (depending on the conditions of preparation of the tool).

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FUTURE DEVELOPMENT TREND OF SHEARER

KEYWORDS: drum shearer; automation and intelligent control technology; development; application.

This paper introduces in detail the technical problems faced in the development of intelligent and automatic control of drum shearer, and discusses the development status of remote communication and monitoring, fault diagnosis, early warning, structure height and walking control technology associated with it, and compares the gap between the intelligent control technology of drum shearer automation at home and abroad. After that, it explores the future development direction of this technology, so as to provide reference for relevant personnel.

Key Technologies for Automatic and Intelligent. Control of Shearer (1) Airborne Control Computer Technology, as the core technology with high modernization and intelligent coal mining, control and protection used in today's coal mining industry, can realize the automatic operation of the whole shearer and ensure the reliability and safety in the operation process by using airborne control computer technology. The airborne control computer technology mainly monitors and protects the temperature, pressure, load, flow and other factors associated with the whole shearer equipment from the aspects of logic and feedback control. At the same time, it can directly transfer the graphical human-computer interaction interface to the operator to facilitate the operator to make statistics and analysis of relevant data, and display these data in the form of audio, video and radar data to ensure the safety and reliability of the basic control part. However, when airborne control computer technology is used to control and protect the core part of the integral shearer, the main centralized control structure is mainly single board machine and machine as the core, and gradually changes to have the highest reliability and expansion capability today. Force, at the same time convenient maintenance and maintenance in the process of operation after the module under the network distributed structure. By combining the centralized control structure combining the single board computer and the industrial personal computer with the network distribution structure, the whole airborne computer system can continuously work in the underground harsh environment with more dust and humidity, and can be connected to a part of safety sensors and actuators, thus obtaining good effects and improving the adaptability and reliability of the whole shearer equipment.

Cutting height and walking control technology. One of the most important technologies to control the running speed and direction of shearers is cutting height and walking control technology. Through the application of this technology, it can solve a big difficulty in realizing

automatic operation of shearers like today. The core problem of several height and walking control technologies lies in the automatic recognition of the shearer's door-edge interface. Nowadays, countries around the world have made in-depth research on the automatic recognition technology of coal seams and tried a variety of different recognition directions, but now there is no reliable development of an automatic recognition technology with more reliability. Today, when coal mining machines need to automatically adjust their running speed and direction, the main method used is memory cutting technology. However, due to the fact that this technology cannot correctly identify the change of coal seam bedding, this technology has not been widely popularized and applied. Another difficulty in realizing the automatic operation of the shearer lies in precisely controlling the attitude, speed and position of the shearer. At this time, the scraper conveyor can be accurately positioned by installing the multi-turn absolute encoder on the low-speed shaft or the incremental encoder on the high-speed shaft of the traction drive system, and the mining height can be accurately controlled on the working face with complicated and changeable coal seams. And can adapt to the actual terrain conditions of the working face, dynamically correct the structural posture and height of the industrial crisis, and realize the butt joint between the hydraulic support and the scraper conveyor by calculating the three-dimensional space running track of the coal mining machine, so as to smoothly advance the working face.

Remote communication and monitoring technology must be applied to ensure that coal miners are in a good working environment in the process of coal mining, to separate the workers from the work with higher risks, and to replace manual work with machines. Through the remote control of tunnel console and ground dispatching center, and through the application of this equipment, real-time communication of data can achieve this goal. Through the application of the data, the wireless LAN technology with higher broadband optical fiber communication can be applied to the monitoring and communication process. However, due to certain installation requirements and inconvenience for subsequent maintenance when installing optical fiber communication on the working face, if the wireless LAN technology is applied to the working face, the experimental and reliability of monitoring and control will be affected, and a large number of access points and other problems need to be arranged. Therefore, in order to better apply the communication and monitoring technology in the control process of the drum shearer, various problems need to be continuously improved and solved.

The development direction of shearer control technology in the future. Nowadays, with the continuous breakthrough of the above technologies and their application in all walks of life, shearer has been developing rapidly in the direction of intelligence, automation, informatization and mechanical integration under the blessing of various technologies, making the basic characteristics of overall coal mining gradually develop towards the characteristics of industrial robots. And through this development, it can realize its own automatic control and programming work. At the same time, by installing equipment with various degrees of freedom in the coal mining machine, instead of manual operation, it can complete various dangerous tasks, making the common functions possessed by the coal mining machine gradually develop into the direction of a coal mining robot which integrates automation and intelligence. The application of artificial intelligence technology in the transformation and upgrading process of shearer can make the acoustic sensing control and execution system of shearer have high reliability, safety and maintainability, and through continuous research and exploration in these technical fields, drum shearer is gradually moving towards a more intelligent direction to realize technological leap.

In the operation process of drum shearer, the driver has greater labor intensity and does not have higher production efficiency. In addition, during the emergency driving process of the shearer, the operators and their own equipment have higher safety risks. Through making the shearer gradually develop towards the direction of automation and intelligent control technology, the intelligent level of the product itself can be improved, thus improving the mining efficiency

of the working face. At the same time, machines are used to replace manual labor, so as to realize safe production in the process of coal mining as much as possible.

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STUDY OF PARTIAL FACE MACHINES: MODELLING EXCAVATOR PERFORMANCE USING FULL SCALE CUTTING SIMULATION

Underground mining is projected to be future due to the dearth of surface accessible mineral deposits and the growing environmental demand to leave lesser footprint in mine sites[1]. To achieve production similar to surface mines, automation of the mining activities is the path forward. Conventional drill and blast operations consists of discrete unit operations which makes automation difficult to implement. Automation is achievable through continuous mining operations, which is possible by mechanical excavation technologies. Further in drill and blast, the use of explosives leads to damaged roof and walls, causing dangerous seismic outbursts in deep mines other than ventilation issues.

Mechanical excavation leads to smooth walls, integrated support systems and higher production in competent ground. It also offers better advantage to automation and selectivity. The cutting tools employed in mechanical excavation undergo different cutting action in partial face machine (road header) and full face machines (like TBM). Full scale cutting tests have been developed and used to model full face machines in the past. Simulating the cutting actions of partial face machines has not been very successful, thus not common in the past due to a variable penetration of the cutting tool along the path within the contact area.

To cut hardrock full face machines (like TBM's) are used, which offer less flexibility and makes it difficult to use in dynamic mining operations. Existing partial face machines (like road header) offer the flexibility but fail to deliver the production in rocks greater than 100MPa (15000psi) compressive strength. An attempt has been made recently to develop equipment to cut rocks greater than100MPa, i.e. the Mobile Miner.

The development of mobile miner prompted to develop a variable penetration method of testing in typical laboratory full scale cutting tests to simulate the cutting action of partial face machines. A modified method to simulate partial face machine in full scale cutting tests is developed and compared for different rock cutting tools - Conical Pick Cutter, Disc Cutter and Button Roller cutter. This method has been used to test on different rocks to understand the difference between the cutting action of partial face machine and full face machines. Further, its implications on comprehensive cutter head models to estimate accurate performance (production) and cutter head stability will be carried out.

The aim of the model is to predict the cutter head performance for a partial face excavator using variable penetration method of testing and study the impact of key parameters, i.e., cutting forces, eccentric forces and cutter head vibration. The data is used to model partial face cutter heads, including mobile miner and compare with existing models using full scale tests. The developed cutter head model with modified testing method is studied for impacts on excavator operation and design in terms of eccentric forces and vibrations. This model is verified with field

results and adjusted to make accurate performance prediction and optimal cutter head design. The outcome of the study and model will identify reasons for difference in various cutting parameters in the two types of cutting actions among mechanical excavators.

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AUTOMATICALLY REENGAGING TORQUE LIMITING CLUTCH BY REVERSAL OF THE DIRECTION OF ROTATION

The present publication is the result of a cooperation between the Maschinenfabrik Mönninghoff GmbH & Co. KG [1] and the Technische Hochschule Georg Agricola zu Bochum [2]. The research was done in the context of a master thesis. The aim of this thesis was to develop a concept for a rotational dependent reactivating safety clutch. With their increasing complexity and necessary availability, machines are representing a substantial asset. Safety clutches can sustain this value by preventing machine damage and reducing downtimes which would occur in the event of a crash. Previously, these couplings had to be made ready again by hand or with a lever after every overload event. With the presented automatic reactivation, the economic efficiency can increase significantly. Time and cost intensive machine downtimes, arising to the manual reconnection or by complex installation work in hard to reach places, can be avoided.

Basically in this use case, the drive torque is transmitted to the hollow shaft (1) of the clutch via a key or clamping hub connection (Figure 1). Via a screw connection (10) of the axial moveable membrane (11) to the hollow shaft (1) and switching ring (9), the torque is transmitted about the plane-toothed components (8/9) to the flange connection (8) on the output side. In normal operations the clutch transmits the torque from the drive side to the output side. If there is an overload, the toothing slides apart, so the clutch will disconnect the torque transmission completely. This is made possible by the special disc springs (19), which change the direction of force as soon as a critical torque is exceeded. At this point normally the safety clutch has to be made ready again by hand or with a lever. The new concept eliminates this step. By reversing the direction of rotation, the clutch switches automatically and only with mechanical power in a ready-to-operate state again. This new function is made possible by added components such as a freewheel and further functional units that preload the compression springs (18) for reengagement. By the force of the compression springs, the disc springs moves back through its zero point and returns to its original starting position. The safety clutch is ready for operation again.

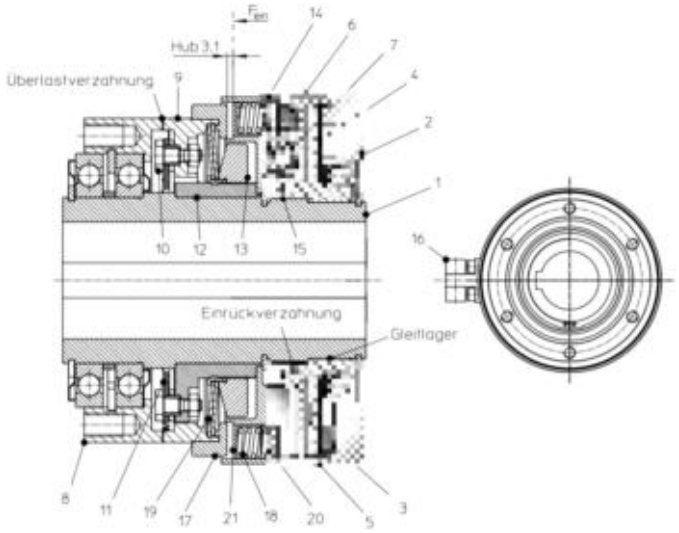

Figure 1: SecMatic-Plus-W [1]

The functionality of the presented development concept was confirmed with a first prototype. Further the presented concept is new and does not infringe existing patent rights. This was checked by first recent patent researches. The next step is to develop this product ready for series production.

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IMPROVING THE EFFICIENCY OF OPERATION OF REDUCTION UNIT OF MOTOR-WHEEL OF QUARRY DUMP TRACKS

Modern BelAZ dump trucks with a lifting capacity of over 90 tons are equipped with an electromechanical transmission. The main modules of electromechanical transmissions are individual motor-wheel reducers on all driving wheels (RMK), that are built into their hubs and driven by traction motors. RMK is a closed differential, consisting of planetary and cylindrical gears.

During the operation of the machines, the RMKs are subject to irreversible wear processes of gear teeth and splines. This leads to a change in their geometric dimensions. At present, the operating and maintenance conditions of the machines do not include measures to control the general condition of the mechanical part of these gearboxes.

The results of the analysis of various diagnostic options for gearboxes of machine transmissions show that the following parameters can be used as the main parameters for diagnostics: temperature (oils, housings), noise, vibration, quality of the working fluid in the

crankcase, monitoring the condition of the working surfaces of the main gearbox elements during disassembly. In this case, the following diagnostic methods can be effective: a thermal imager, bench tests of the units, monitoring of the parameters of the working oil, diagnostics of the parameters of the total angular play and splined joints, the spectral-acoustic method for monitoring the hub housings, monitoring of bearing wear during maintenance.

The difficult working conditions of mining dump trucks impose increased requirements on the fuels and lubricants used in the operation. Oil is the most effective, flexible, variable and controlled element and accumulator of information signs of the state of technology and its systems. The condition of the oil, the level of its parameters change much faster than the failure of the equipment. This is justified by the fact that in the conditions of the development of the pre-failure condition, the content of wear products increases sharply and, as a result, the temperature rises. In this regard, we consider it appropriate to use temperature as an indicator of the state of the system. The oil heating temperature is of great importance when operating the gearbox, because at elevated temperatures, gear oil loses its lubricating properties. As a result of this, there is increased wear of the gears and bearings of the gearbox.

To maintain the operating temperature of the oil in the operating range in the gearbox, we propose to equip the mechanism with an active cooling system of the housing, which is a fixed support hub. For this, a spiral channel (tube) is made along the cylindrical surface of the housing. As a result of the circulation of the coolant from the active feed system of the machine, controlled heat exchange will occur through the fixed housing (hub) with an active effect on the oil in the gearbox.

Based on the information mentioned above, in order to increase the operational efficiency of RMK we offer the following measures:

1. to equip RMK with an autonomous “climate control” system with simultaneous diagnosis of changes in the intensity of oil heating;

2. to equip the gears of the motor-wheels with a hydraulic system for periodic cleaning of oil from the RMK crankcases with a static position of the machine, that is, by suctioning it from the crankcase, cleaning the parts from wear products in a centrifuge and returning the purified oil to the crankcase. (It should be noted that if this is carried out when the machine is moving, cavitation of the oil in the system may occur, which is unacceptable).

3. To prevent intensive wear of the working surfaces of gear elements, bearings, as well as the bearing surfaces of the hubs and shafts of the shafts, which, in our opinion, arise also from additional loads in case of misalignment of the mating elements, we suggest changing the type of the main wheel bearings, i.e., instead of two angular contact bearings, use a system that consists of a pair of double-row spherical (self-aligning) roller bearings and one double-sided thrust bearing.

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THE INFLUENCE OF CHANGING THE TRANSPORT SYSTEM ON COSTS AT OPEN PIT „DOBRNJA“ NEAR BANJA LUKA

KEY WORDS: open pit, haulage system, production costs, truck haulage, combined haulage.

Engineering monitoring of the results of equipment operation in surface exploitation processes and their technical - technological and techno - economic analysis are the task for every technical manager or production manager on surface mines. On the open pit "Dobrnja" was analyzed the possibility of using a belt conveyor system, where is the truck transport system currently active, and the aim was reducing the limestone production costs.

In order to demonstrate the justification of the haulage system change, it is necessary to determine the current working conditions, ie the current structure of the haulage equipment with defining of the operational costs directly related to the specific working conditions, configuration of the haulage routes, production capacity etc. Then there are determined the basic technical and technological parameters of the equipment proposed as a more favorable variant or in this case a conveyor belt system. Based on these parameters, the possible operational costs of such equipment are defined and then compared with the current actual operating costs of the available equipment.

Cost differences observed through the techno-economic analysis indicate feasibility of introducing a new transport technology, especially in terms of the necessary additional investment in new/replacement equipment. A detailed calculation and analysis of the possibility of replacing the transport system on the open pit Dobrnja were performed, and the results are presented in this research.

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THE SELECTIVE LASER MELTING METHODS IN THE MINING EQUIPMENT

The Additive Manufacturing (AM) methods are one of the most intensively developed technologies, whose are representing a realistic alternative to many conventional manufacturing techniques. The properties of the final AM elements are comparable or superior to elements obtained by traditional processing method. Additionally the AM elements are characterized by very good dimensional accuracy. The Powder Bed Fusion (PBF) is a group of manufacturing method that use one or more thermal source to induce melting or sintering powder material. One of the most popular PBF methods, which enable freeform manufacturing parts from metal power is Selective Laser Sintering/Selective Laser Melting (SLS/SLM) method. The SLS/SLM process are capable of manufacturing metallic elements directly from many engineering alloy powder – stainless steel, maraging steel, cobalt based alloy, titanium and their alloy, nickel based alloy and more [1-4].

Many devices used in mining are built of many complicated elements. Damage to one component often leads to the shutdown of the entire device. Therefore, it is necessary to replace the element with an identical one. Laser scanning, along with 3D printing facilitates replication of standard spare parts and mining tools, as required [6,7]. Currently, the 3D printing methods are a mainstream tool across industry for producing machine parts quickly and cheaply with the minimal waste. Using the 3D printing methods provide to significant reductions in cost – it is possible up to a 50%, and in some cases a 90% reduction of cost of parts. Furthermore, the 3D printing allow for a rapid redesign of components. Additionally, 3D models of mining fields

allows to obtained construct topographic outlines of mining state. The surface quality of the final elements and accuracy is the key as minesare made up of variable geometric patterns.

Though 3D printing technology does not appear to exhibit limitations from a design point of view, this is not the case from a technological perspective. In the most cases, the surface quality and the properties of the final elements. The surface quality and is associated with process parameter (particularly laser power P, scan speed SP and layer thickness t) and balling effects, which depend on wettability of metal by melted metal. Additionaly, the mechanical properties of the final parts are too strongly related to the process parameters. The aim of the research was to characterize metal components – such as stainless steel or titanium and its alloy, manufactured by SLS/SLM for obtained full density and defects free parts with good surface quality – without impurities at the surface and spattering particles.

The tested samples were manufactured by Selective Laser Melting (SLM) using SLM/SLS machine type AM 125 (Renishaw). As a part of this experiment an attempt was made to determine the influence of values of energy density (E) used in the SLM process on the properties of manufactured samples. The SLM process was carried out with an energy density calculated according to the formula $E = P/(t \times PD \times SP)$. The result of performed experimental prove that selection of the right SLM parameters is very important in determining the final properties, which enable safe use of created elements and their reliability.

Based on the obtained results it can be concluded, that the laser power P and scanning speed SP have significant effect on the properties of the SLS/SLM parts, due effect on the stability and uniformity of the melt pool and single track. Generally, the lower value of the scanning speed lead to roughness, bigger that the set layer thickness.

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ENSURING CONTROL OF FUEL CONSUMPTION OF ROAD –BUILDING MACHINES

In exploitation road-building machines, cost of fuel and lubricants is the highest and can exceed 50% of the cost of a machine hour.

In the process of using road-building machines, it is important to comprehensively approach the reduction of fuel and lubricant consumption, which will improve their efficiency. In the road industry, GLONASS / GPS systems are currently being installed, which allow real-time monitoring of machine operation. An integrated approach to assessing the technical condition and operating mode of the machine, as well as the consumption of fuel and lubricants, allows you to answer many questions that arise when implementing a navigation satellite system.

In conditions of limited funding, the implementation of the planned volumes of work is possible when each organization implements internal reserves to reduce the cost of a unit of work performed. In the road industry, the largest costs are associated with consumed energy, materials and mechanization of production processes. That's why, the saving of building materials and energy used, as well as the reduction in the cost of mechanized work, is of particular importance in modern conditions.

The rational consumption of fuel and lubricants during the operation of road-building machines is one of the urgent problems of saving resources.

There are 5 main areas of saving fuel and lubricants:

– improvement of machine designs;

– optimal engine operation and reduced idle time;

– maintaining machines in good condition in accordance with the technical conditions for operation;

– improving the quality of machines and fuel;

– improvement of fuel and lubricant consumption rates taking into account operating conditions.

One of the main ways to save fuel during the operation of road-building machines is to reduce the engine idle time and optimize its load and thermal conditions (up to 90% of the rated power and 85-95 ° C in the cooling system). Researches have shown that of road-building machine's engines, launched without a starter, 30-40% of the working time idle, while consuming up to 25% of the fuel, without performing useful work. At the same time, the easy start of the main engine by the starter ensures its shutdown during technological, lunch and other breaks during the shift.

A negative impact on fuel and lubricant consumption is exerted by violations of the requirements of the chemotological map developed by the manufacturer of the operating machine.

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WELL TO WHEEL ANALYSIS OF NATURAL GAS FOR HYBRID TRUCK APPLICATION

Natural gas as an alternative primary energy source has great development potential in transportation. Hekkert M P etc. summarized that natural gas-based hydrogen applied in fuel cell vehicles can lead to the largest CO2 emission reductions, up to 40%. Khan M I etc. found that dedicated natural gas vehicles equipped with direct injection technology may result in 20% less GHG emissions compared to gasoline. But the methane leakage from feedstock to end-use may eliminate the benefits of natural gas as an alternative energy source. The aim of this research is to provide a Well-to-Wheel assessment of GHG emissions especially the methane leakage for a heavy hybrid electric truck with a special focus on the compressed natural gas pathways. Although several life cycle studies available in literatures are comprehensive in relation to natural gas production, it is problematic to apply the results to hybrid-electric trucks.

The well to wheel analysis is divided by upstream and downstream energy, form a gas well till the combustion emissions from a truck to produce wheel power. The well-to-pump part captures the natural gas production, including recovery, processing, transmission and storage, and distribution pathways. The tank-to-wheels part of the analysis considers the heavy truck use energy and emissions when running in a high way for 300 km. Meanwhile, the gas emissions from a

variety of supporting primary energy (diesel, gasoline, etc.) used in the well to tank process will also be considered.

In different processes, efficiency plays a leading role. According to the simulation, the compression process efficiency has the greatest impact on the entire well to tank process. For the total gas emissions in the well to tank process, CO2 is the largest emission part accounting for 96%, and methane accounts for 3%, other gases like CO, NOx, etc. only for 1%. The emission of CO2 in the transmission and distribution process is lower than that of recovery and processing when the greenhouse effect caused by methane emissions is not considered, but the equivalent CO2 increase sharply with the largest methane leakage occurs in the pipeline, almost 60%. Besides, 13% of methane leakage occurs in the recovery phase, which was due to the well equipment process. Improving these processes and improving the performance of equipment and pipelines can help reduce the amount of methane leaks throughout the whole life cycle.

In order to better optimize the performance of the truck and reduce energy consumption, the minimum battery power is determined by testing the truck's performance when running in the city. When considering that the truck is driving in a high way, the main energy comes from the combustion of natural gas. The compressed natural gas consumed for trucks will increase with the load weight. It shows small growth at low level weight but when the load increases to a certain level, the CO2 emissions will change more significantly than before, this is due to the large mass trucks need more fuel to provide power, and CH4 emissions will add greater weight to the total equivalent CO2 emissions.

This research describes the analytical and methodological bases for the studies of the CO2 equivalent emissions and CH4 leakage from the production of natural gas to the final application to truck combustion. The results indicate that leakage of methane occurs in many processes, 1.05% of methane directly emit into the atmosphere (equal to 9.05kg CO2 equivalent), the total CO2 emissions from well to wheel are 95.60kg, the methane leakage improve 8.65% CO2 equivalent emissions, and transmission and distribution is the largest contributor. Improve the tightness and efficiency of pipeline transportation or capture and use the vented methane during gas production and processing may be a good way to reduce methane emission. This well to wheel analysis provides insight into the critical stages in the natural gas industry where emissions occur and where opportunities exist to reduce the greenhouse gas emissions of natural gas. It can also be used a strategic decision-making process for future transport energy transformation.

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A MODIFIED PI CONTROLLER OF CONVERTER SEPIC FOR IMPROVEMENT OF ITS DYNAMIC PERFORMANCE

The concept of standalone power sources in the form of elements of a backup energy storage system is becoming an increasingly important part of distributed generation (DG) and will become a key element in the formation of future intelligent networks. Distributed power supply systems based on renewable energy sources make extensive use of energy storage systems in the form of rechargeable batteries or supercapacitor modules. Thus, we can notice the following actual tasks:

1. Improving the characteristics of DC/DC converters to ensure the required voltage level of the DC link (DC bus), taking into account the continuous changes in their input voltage level (output of energy storage system ESS modules).
2. As well as the necessity to regulate and stabilize the output voltage of the converter.

The Scientific novelty consists in improving the means of controlling the output voltage level of DC/DC converters used in distributed generation.

The control mode of the DC/DC power conversion system can be implemented by various circuit topologies. Among them are the basic and most commonly used converters: buck converters, boost converters as well as converters like Cuk, Zeta and SEPIC. Most of the various types of bridgeless converter topologies are based on boost converter configurations. Their main advantage is low cost. However, they have the following disadvantages: 1- lack of isolation of the input - output; 2- high ripple current. The main feature of converters such as Cuk, Zeta and SEPIC is that they can operate both in boost and in buck modes. However, the polarity of the output voltage does not change in the SEPIC converter, which is an important advantage over its analogs. Another advantage of SEPIC is its ability to provide input / output isolation. A conclusion can be drawn that SEPIC converter can be considered as the best option for DG applications [1-3].

To achieve the desired results, the converter must be modernized to provide a bi-directional flow of energy [4].

When creating a model, it must be taken into account that the SEPIC converter model is described by a fourth-order transfer function that is hard to be controlled from the control theory perspectives. However, for correct control operation this transfer function must be taken into account. At the beginning, since the transfer function of the converter is obtained from small signal models, the ordinary PI controller is improved by means of adding a dynamically calculated stationary duty cycle signal “D” at the input of the PWM block to accelerate the response to the signals. Thus, the transient response speed of the signal increases and the control signal of the converter’s transistors reach faster its required time span.

The proposed controller is based on the concept of a PI controller, but using the theory of "Internal Model Control" (IMC). It is also proposed to reduce the transfer function of the converter using the PADE approximation. Two models of this transfer function were obtained: 1st and 2nd order. The K_p and K_i parameters of the PI regulator were derived for various cases. Since the IMC method requires the use of a low-pass filter in its structure, the time constants of these filters were experimentally obtained.

The proposed controllers have shown their effectiveness in various types of interference and disturbances:

- By changing the amplitude of the input voltage:

- Step Change.
- Gradual linear change.

- Electromagnetic interference (EMI) in the form of:
  - Random white noise generated signal (10 kHz – 10 GHz).
  - Multi-frequency sinusoidal noise (50Hz – 350 Hz).

Further upgrade of the converter was proposed when using anti-windup in the PI controller. It was experimentally established that when using the appropriate low-pass filter, this update does not show further improvement when the input voltage drop is up to 20% of the nominal voltage. Below -20% voltage drop, Anti-Windup can be useful if the integrator part of the controller does not reach its saturation limits. In fact, as the voltage continues to fall, the required signal “D” must increase in order to provide a higher voltage conversion. Depending on the state of the integral part of the PI controller and the ability of the converter to increase the low voltage level with the assistance of the controller, the success of the operation will be determined. Saturation points should be selected carefully to ensure that the voltage drops or rises are in such a way as to keep the small signal "d" within certain limits. The simulation results showed variable saturation limits in accordance with various cases of voltage changes. This problem should be further studied in order to achieve a confirmed end result.

The personal contribution of the author is to study the dynamic characteristics of the SEPIC DC/DC converter in electromagnetic interference. The possibility of using a reduced transfer function order (Model Order Reduction technique) to simulate the SEPIC converter model by implementing the IMC method is substantiated. The results of the study show that even with a decrease in the transfer function to the first order, the IMC controller is still able to withstand all experimented types of EMI and showed better resistance to changes in the input voltage of the converter than a conventional PI controller as well as a faster response time due to the addition of the dynamically computed “D” signal.

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DESIGN AND SIMULATION OF THE INTERCOOLED REHEATED REGENERATIVE GAS TURBINE FOR THE EXTENDED RANGE ELECTRIC VEHICLE

Transport represents almost a quarter of Europe's greenhouse gas emissions and is the main cause of air pollution in cities. The importance of reducing fuel consumption in the automotive industry pushed the engineers to work on a new energy converter. A recent study by GROUPE PSA researchers [1]. [2]. [3]. highlights the surpass of the intercooled reheated regenerated gas turbine (IRReGT) on the internal combustion engine (ICE) in a series hybrid electric vehicle with obvious excellence in terms of high efficiency, high specific work thus reduced weight and size, the reduced number of components and rotating parts, the reduced vibration, and the multi-fuel capability. This work is about designing, modelization, and simulation of the IRReGT to compare its performance with the ICE.

The IRReGT system consists of two-stage intercooled centrifugal compressors, a regenerator, a two-stage reheat centrifugal turbines, and two combustion chambers. The work started with thermodynamics studies of the IRReGT cycle using Refprop, then optimize the cycle efficiency in term of compression ratios of the radial compressors and the expansion ratios of the turbines, temperatures, and mass flow rate. This work gave all the necessary data for designing the components of the system. The turbomachines of the model were designed with high efficiencies on Ansys, the losses of these machines were minimized by CFD simulations. Using the Amesim software, the IRReGT was modeled, the input of the operating conditions was taken from the thermodynamic study. The turbomachines maps of the components were taken from Ansys. The recuperator data was chosen directly in Amesim to give the desired performance.

The IRReGT efficiency attained 39% at 950ºC, significantly higher than the ICE which operates at an optimum of 36%. The IRReGT made a 6% fuel consumption reduction compared to the ICE. A lag of the IRReGT, 25 seconds, at the startup was found due to the inertia of the components, mainly caused by the recuperator. To sum up, the intercooled regenerative gas turbine is a potential candidate for replacing the ICE in the extended range electric vehicle.

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SUSTAINABILITY STRATEGIES IN MINING

Mining poses critical sustainability challenges and threats, especially in terms of environmental sustainability and sustainable social development. Mineral resources, at least in human or biological timescales, are limited and non-renewable. Environmental and social problems and risks, including environmental pollution, negative impacts on ecosystems and

biodiversity, the displacement of people and the loss of natural resources that serve as livelihoods for poor and vulnerable populations, are increasingly creating conflicts between mining companies and local communities.

Sustainability principles play an important role for the challenges and risks created by mining. When taking into account of the cost benefit analysis evaluation we have to consider the Energy efficiency techniques, Water scarcity techniques such as the use of sea water and high-pressure grinding roll., Climate change limitation such as the use of renewable energy to power the operations, As well as future sustainable growth mining strategy for specific metals given the evolution of electric vehicles and renewable energy.

This research is aimed at bringing out the sustainability strategies in Mining in other to enhance the Economy, Efficiency, Safety, Community and the Environment using digitalization technologies such as Energy efficient Equipment's, High Pressure grinding roll technology and new technologies like the sensor-based ore sorting.

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ADVANTAGES OF A COMBINED CYCLE GAS TURBINE SYSTEM IN AUTOMOTIVE APPLICATIONS

In order to meet the European Union's target of 80.8 gCO_2/km fleet-average emission for passenger cars in 2025, vehicle manufacturers are investigating different alternative energy converters to replace the Internal Combustion Engine (ICE). Among these energy converters are fuel cell technologies, that offer higher efficiency compared to the ICE, but present drawbacks regarding hydrogen storage and distribution infrastructure [1]. This study explores the integration of a Combined Cycle Gas Turbine (CCGT) system in Extended Range Electric Vehicles (EREV) with a series hybrid powertrain. The system uses a Gas Turbine (GT) machine coupled to a Steam Rankine Cycle (SRC) for heat recovery, making up a combined cycle that presents higher efficiency and power density than the conventional ICE. This system is suitable for a series hybrid architecture where the vehicle acceleration lag of the CCGT is eliminated, as the energy converter operates as an Auxiliary Power Unit (APU) used to recharge the battery. A review of the literature shows that studies that focused on the CCGT system present limitations regarding thermodynamic optimization and vehicle applications. On one hand, different studies evaluated the performance of the simple CCGT system [2-3], but none proposed an optimization methodology of the system's architecture by adding reheat systems and multi stage compressions and expansions. On the other hand, no study assessed the performance of the CCGT system in

vehicle applications, and particularly in series hybrid vehicles. In fact, studies investigating CCGT systems are mostly based on stationary power plants [4].

This study proposes an optimization methodology of a CCGT system in EREV with a series hybrid powertrain. REFPROP is first used to conduct an exergo-technological analysis of the simple CCGT configuration in order to determine the overall efficiency and net specific work. As for the exergy analysis, the exergy destruction is calculated for the system's component, and based on the major exergy destruction sources, different CCGT topologies are generated using modifications such as compression intercooling, expansion reheat, and internal regeneration.

Subsequently, a thermodynamic assessment is conducted on all configurations, taking into consideration state-of-the-art components' specifications and technological constraints. Then, a multi-objective Genetic Optimization Algorithm (NSGA) is used to determine the optimal expansion and compression ratios, and the maximum pressure in the Rankine cycle, while optimizing for the efficiency and net specific work. Pareto curves are then drawn to detect the optimal operating point for each configuration.

Overall, the Reheat Gas Turbine combined to a Turbine Reheat Steam Rankine Cycle system (ReGT-TReSRC) is chosen. Compared to the ICE, a 5% to 26% improvement in efficiency is obtained by varying the turbine inlet temperature from 950°C to 1250°C, reflecting on the materials used for the gas turbine. The study offers promising results for the implementation of a CCGT system in EREV with series-hybrid powertrain. However, the APU cost is not taken into consideration in the study. Future studies will conduct a techno-economic analysis for the system, along with a further investigation of the system integration on different vehicle applications from different vehicle segments where parameters and power requirements vary.

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SOLVING THE NOISE PROBLEMS OF GAS TURBINE POWER PLANTS FOR THE MINING INDUSTRY

In recent years, the gas turbine power industry has become more widespread. Gas-turbine power plants are characterized by fast commissioning, low water demand, high degree of automation, and cost-effectiveness. At the same time, the noise of gas turbine engines as a part of power plants is one of the most acute problems in the field of labor protection.

The reasons for the occurrence of aerodynamic noise created by the blade machines of a gas turbine engine (compressors and turbines) are pulsations of speed and pressure in the air flow flowing through the gas-air path. There are three components of aerodynamic noise:

a) vortex noise resulting from the formation of vortices and their periodic failure when the elements of the blade machine flow around the air flow;

b) noise from local flow inhomogeneities at the inlet and outlet of the impeller;

c) the noise of rotation of each rotating blade of the impeller is the source of the disturbance of the air flow.

Thus, the level of aerodynamic noise depends on the aerodynamic and design features of a particular blade machine, the number of rotations of the rotor and the operating mode estimated by the efficiency coefficient.

The noise of the exhaust channel directly depends on the operation of the turbine. A high degree of turbulence and heterogeneity, a very high speed, and sometimes a twist of the flow behind the turbine are the reasons for the appearance of noise in the output channel.

It is important to note the fact that the propagation of turbine noise upstream is difficult due to the cluttering of the flow section of the flow part (air-gas tract) by the combustion chamber and compressor stages and the convection of sound by the flow. The propagation of turbine noise down the stream is significantly affected by pulsations of speed and temperature in the stream, and speed gradients.

As for the turbine stage, noise generation in stage is complicated by the presence of a field of pulsations of the flow temperature. In this case, the most important source of noise is the pressure pulsations on the surface of the working blades (rotor blades) and nozzle apparatus (stator blades), when they interact with the turbulent traces behind the blades located upstream [1].

At present, it is advisable to implement effective sound attenuation systems at the design and manufacturing stage of gas turbine engine prototypes. This makes it possible to make an optimal choice and position the sound attenuation equipment in accordance with the acoustic and structural features, in contrast to the case of implementing additional noise reduction measures at existing stations equipped with low-efficiency noise attenuation equipment.

The design of existing gas turbine engine turbines does not take into account the significant influence of parameters such as the profile installation angle, the width of the grid, the maximum curvature of the profile and the value of the axial gap on the trace unevenness, which is the main source of noise in the grid [2]. Without taking these parameters into account, you can not only not get the effect of reducing aerodynamic noise, but on the contrary, to strengthen it by placing the blades of subsequent blades rows in the areas of the greatest trace irregularities, which will cause an increase of the aerodynamic noise.

Analysis of the gas-dynamic and acoustic experimental studies of flat models of turbine stage at different orientations (i.e. angles of profile installation) of the blades (in the authors experiment used nozzles grid) allows you to make a recommendation on placement of nozzle blades of the second stage of turbine. It should be located with a displacement along the output edge at a distance equal to the ratio of the axial clearance $\Delta 0$ to the tangent of the installation angle of the previous profile γ.

It has been experimentally proved that the practical application of this recommendation can allow to reduce the aerodynamic noise of the turbine by 10% [3].

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OVERALL EFFICIENCY OPTIMIZATION FOR WASTE HEAT RECOVERY SYSTEMS FOR RANGE-EXTENDED ELECTRIC VEHICLE

Waste heat recovery (WHR) systems constitute a promising solution for reducing vehicle fuel consumption in order to meet the CO2 regulation targets by 2025. An overall efficiency optimization of a combined cycle machine consisting of a reciprocating internal combustion engine (ICE) and a bottoming WHR system for a range extended electric vehicle (REEV) is studied in this paper [1].

A methodology is firstly proposed to improve the overall operation efficiency for such a combined cycle machine. Four WHR systems, namely Simple Brayton Cycle (SBC), the Intercooled Brayton Cycle (IBC), the Steam Rankine Cycle (SRC) and the Stirling Machine (STR) are investigated separately |2]. By calibrating the ICE at some specific points in the engine map, an overall optimal efficiency is achieved when combining the ICE and the WHR system. An EREV model is developed and energy consumption simulations are performed on the worldwide-harmonized light vehicles test cycle (WLTC). Fuel consumption simulation results are compared to a reference EREV using a conventional internal combustion engine auxiliary-power-unit [3].

The simulated fuel consumption results show the interest by delaying the ignition to enable higher engine exhaust gas temperature and mass flow rate, which are more favorable for WHR systems. The proposed method is also beneficial to avoid knocking problems and can enable the design of higher compression ratio engines in the REEV applications in the future.

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QUALITY ASSURANCE OF PRODUCTION OF FUNCTIONAL UNITS OF ELECTRONIC SYSTEMS OF POWER ELECTRONIC DEVICES

Printed circuit boards are the supporting structure of most electronic systems and modules. The use of modern materials [1], technologies [2], production equipment and control methods make it possible to ensure high reliability indicators of electronic devices throughout the entire life cycle. The process of forming defect-free soldered joints is important for applying surface mount technology. The quality of the soldered joints depends on the choice of a suitable solder paste and the perfection of the process and also requires additional adjustment of the thermal profile.

For high-quality soldering of mixed components, it was decided to use the MP218 solder paste of company “Multicore” based on Sn62/Pb36/Ag2 [3]. The advantage of this paste is high flux activity, which allows preserving the quality at high melting temperatures necessary for soldering Pb-free components. Also, this solder paste has a wide technological reflow window. This facilitates the choice of mode for working with various coatings of pins and pads.

The thermal profile of soldering can be divided into four main zones: the preheating stage, the stabilization stage, the reflow stage and the cooling stage. Before the start of thermal profiling, the speed of the conveyor and the temperature in the zones of the furnace are determined. The duration of the thermal profile zones, the activation temperature of the paste, the melting point of the alloy and the recommended maximum melting temperature are used as the input information for the construction of the thermal profile. The thermal profile for soldering lead-containing components according to this information.

However, the construction of the thermal profile for soldering mixed components requires to carry out the following adjustment. The board contains Pb-free components; therefore, the time is 330 seconds deficiently for high-quality reflow. So, it is necessary to reduce the conveyor speed to 230 mm/min. The temperature in the stabilization stage was increased by 10-15°C to alignment the curve and prevention of spraying solder. It is necessary to increase the temperature by 32°C in the reflow stage for high-quality reflow of Pb-free components.

As a result of the researching, the graph of the thermal profile of the convection furnace was obtained. It allows efficiently soldering the mixed components by lead-containing solder pasteMP218. Correction of the thermal profile was necessary due to Pb-free components, that require higher soldering temperatures. This feature leads to the need to increase the heating temperature at the remaining stages, as well as to increase the time of both reflow and subsequent cooling of the printed circuit board. The increase in the duration of the soldering stages is achieved by reducing the speed of the conveyor.

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STIRLING SYSTEM OPTIMIZATION FOR SELF-SUSTAINING HYBRID ELECTRIC VEHICLES

There have been many studies conducted to replace the conventional internal combustion engine (ICE) with a more efficient engine type in electrified powertrains [1, 2]. Over the years, several external combustion engines were considered as alternatives to these traditional ICEs for their intrinsic benefits, mainly their multi-fuel capability and low emissions. One of these engines considered are Stirling-machines, which showed some apparent benefits such as multi-fuel ability which allows it to operate using natural gas, low vibrations, silent operations, better fuel consumption, and lower emissions; therefore, attracting automotive manufacturers to consider them in their models as energy converter. Several Stirling engines were formerly developed in conventional powertrains; however, they presented some drawbacks, such as working fluid leakage problems and high investment costs. These problems got resolved with today's technological enhancements, allowing the manufacturers to reconsider these engines in series hybrid configurations (SHEV). In these configurations, the Stirling engine is allowed to operate at a quasi-stable efficiency, since it is decoupled from the vehicle load, offering far less fuel consumption, which is a major advantage compared to the ICE. Moreover, the Auxiliary Power Unit (APU) of this series configuration combines an energy converter consisting of the Stirling-engine, responsible for recharging the battery once depleted, and an electric generator driving the wheels, using the energy stored in the battery.

The purpose of this study is to investigate the possibility of implementing a Stirling-engine in a self-sustaining series hybrid model to substitute the ICE.

A three-step methodology is applied to select the best Stirling configuration. First, a mathematical model was established, based on a real simple Stirling model. An energy and exergy analyses were conducted on the retrieved model, to pinpoint the room for improvements; and then, based on these results, other configurations were developed using heat recovery, cogeneration, and other techniques, to reduce the losses. Henceforth, through an exergo-technological explicit selection, the best configuration was found to be the RRe-n2-Stirling, offering the best efficiency and power combination.

Hereafter, a self-sustaining series hybrid electric vehicle was modeled using the different Stirling-configurations as APUs, while sizing the properties of the other components such as the battery and the electric engine. Then the identified Stirling-configurations were compared with the real simple Stirling in terms of fuel consumption, in a self-sustaining model on the WLTC driving cycle, by setting the initial and final battery's state of charge (SOC) to be 60%. This was performed using an Energy Management Strategy (EMS) consisting of a bi-level optimization technique, combining the Non-dominated Sorting Genetic Algorithm (NSGA) to the Dynamic Programming (DP) [3]. This arrangement is used to diminish the fuel consumption, while considering the reduction of the APU's ON/OFF switching times, avoiding technical issues.

Results showed that the real Stirling presented the highest fuel consumption among the other investigated Stirling configurations. In fact, the RRe-n2-Stirling showed 42% fuel consumption savings compared to the real Stirling.

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IMPROVING THE EFFICIENCY OF A DOWNHOLE ELECTRIC STEAM GENERATOR AS PART OF AN ELECTROMECHANICAL COMPLEX FOR HIGH-VISCOSITY OIL PRODUCTION

At present, further development of oil industry is directly related to the extraction of high-viscosity extra-heavy crude oil due to the depletion of high-gravity oil reserves and as a result of the technological progress in crude production field. According to a report by Ministry of Energy of the Russian Federation, a share of oil resources whose production is problematic exceeds 65% of the total proved oil reserves. Thermal methods of high-gravity oil reservoir engineering are the most widespread. Heat carrier injection is one of the thermal methods that are the most developed. The electrotechnical complex based on downhole electric heat generators for thermal treatment of reservoirs has been developed at Saint-Petersburg Mining University.[1]

The main function of downhole electric heat generators is the production of steam with the highest quality of wet vapor to treat bottom-hole zone of a well more efficiently, increase heat treatment coverage of a reservoir, reduce oil viscosity, the result of which is oil recovery growth.[2]

The design electric steam generator, which is part of the electrical complex for heat treatment of wells in the bottom-hole zone, has been developed. The electric steam generator is fixed at the end of the flow column. It consists of a metal body, at the top of which the central current distributor is fixed throughout the bushing insulator. Inside the steam generator housing, perforated disc electrodes which are enclosed in heat-resistant ceramic cups with windows for electrical contact between the phase electrodes and the steam generator housing attached to the current distributor in the insulation layer. The interelectrode distance is determined by the power of the device, the power voltage, the surface current density, and the resistivity of the conductive liquid (water). At the top of the body is free from disc electrodes and serves as the steam zone of the heater, in this part of the housing there are outlet openings for the steam.

A simulation of the reservoir temperature field was performed by setting the heat flow in the ANSYS software package to understand the thermal processes in the steam generator and to more accurately determine the necessary heating parameters for a given water flow rate. Based on the simulation results, the optimal value of the thermal power was obtained which amounted to 2 MW for generating steam with a calculated quality of wet vapor was 0.8.

The temperature field of the reservoir simulation after the heat treatment of the bottom-hole zone was conducted in the software package Femlab 3.5. It is proposed to enter a horizontal heating well with a downhole steam generator to the existing complex of bottom-hole zone treatment of the extractive horizontal well with steam to increase the crude production by reducing oil viscosity. Based on the results of reservoir modeling, the optimal distance between

wells was determined, which is less than 10 meters. This distance accounts for half of the reservoir depression (the pressure at which the fluid moves from the reservoir to the wellbore).

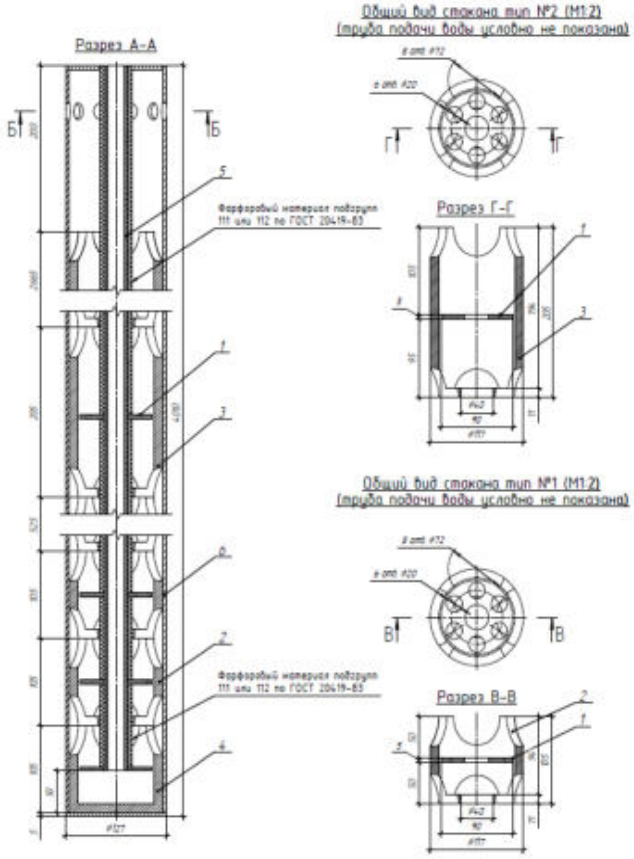

Figure 1 - Design of the downhole electric steam generator

The proposed design of the electric steam generator allows to increase the oil recovery of the reservoir, and also provides an additional positive effect after thermal treatments. The electric steam generator has some other advantages, such as: mobility, working with minimum water conditioning and oil pool development located in nature-protected areas that are difficult to access.[3] The proposed simulation models can help in the development of the physical model and further research.

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QUALITY CONTROL OF HARDENING TECHNOLOGIES USING THE ACOUSTIC EMISSION METHOD

Due to the increasing requirements for the reliability of technical devices, the need to improve technologies aimed to improve their operational properties becomes more and more urgent. In particular, there is a large number of various hardening technologies applying in practice [1], which can affect the entire volume of a product or its separate parts. Each of the existing methods of hardening has advantages and disadvantages, which are characterized by specific technical and economic indicators that determine the effective areas of application of hardening technologies. Both traditional, well-known technologies are being improved, and fundamentally new technologies are being developed, which makes it possible to affect the entire volume of a product or to obtain thin coatings (or layers) on a variety of materials. The effectiveness of applying one or another hardening technology on a particular product depends on many factors and has to be ensured by methods of quality control, which is a significant task.

Existing methods of estimating the quality of hardening technologies can be classified in terms of the type of signal being monitored and its connection with processes that determine the strength of the material. The signals recorded by the methods of transmission and reflection of waves introduced from outside are indeterminately related to the strength and the process of damage growth, since nano-scale factors are missed due to the wave bending round the strength anomalies. Unfortunately, the traditional physical methods of non-destructive testing (for instance, the ultrasonic method) do not allow to detect defects less than a quarter of the length of the ultrasonic wave in the controlled material, i.e. less than 2-5 mm [2]. The methods of radiation are promising, as they emit waves that are associated with the process of damage of the material. This is electromagnetic and acoustic emission (AE).

One of the solutions of the problem of the strength AE control is the use of the information and kinetic approach based on a multi-level model of the acoustic emission parameters that combines statistical and physical approaches to diagnosis, as well as additionally "scooping" information on macro-, micro-, and nano-levels of strength researches to justify the selection of the valuable diagnostic AE indicators. A more detailed approach is described in [3,4]. Each object consists of structural elements, the state of which determines the state of the whole object. It is known [5] that most of the elements do not carry overloads, while a smaller part of them are overloaded with varying degrees. At a certain point of time $t=\tau^*$, the concentration of overloaded structural elements C reaches a critical value C*, at which the destruction of each structural element has already significantly affected the stress state around the neighbouring, previously destroyed.

An experimental assessment of the proposed approach was made. Testing was carried out on metal samples with weld in the middle, which were processed by 3 types of hardening technologies. The first group included untreated samples, the heat treatment (high tempering) with heating to 600° C, with constant temperature during an hour and then cooling with the stove, was applied to the second group. Ultrasonic impact processing [6] was applied to the third and fourth groups for the welded joint and the heat-affected zone. The impact associated with welding technology and the presence of a chamfer on both sides of the metal was applied to the last group.

Samples of welded joints were stretched to rupture on a universal testing machine. The tests were carried out until the complete destruction of the material and during these tests the acoustic emission was recorded. Processing of the registration results was carried out at the stage

of elastic loading, which corresponds to operating stresses. The results are shown in Table 1. Hardening occurs where the values of concentration-kinetic strength indicators are reduced.

Table 1 - The obtained results

Type of HT / parameter (dimension)	Untreated	Heat treatment	With chamfer	UST of weld	UST of heat-affected area
X_{AE} (s^{-1})	0,066	0,025	0,036	0,044	0,072
Y_{AE} (MPa^{-1})	0,0042	0,0012	0,0028	0,0034	0,0058
The difference between the coefficients of variation of Y_{AE} and X_{AE} (%)	6	3	1	3	1

As a result of the work which has been done, an analysis of the quality control methods of hardening technologies is made using the example of weld and an information and kinetic approach to assess the quality of hardening technologies was considered. This approach has shown high efficiency for quality control of treated welds with various types of hardening technologies.

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CALCULATION OF THE OPTIMAL ANGLE TILT OF THE STATIONARY SOLAR GENERATOR

Today, the use of alternative energies, such as solar energy, has become extremely important for the development of energy in the world. This is because the Sun is the most powerful source of renewable energy and radiates about 1 kW / m2 to the Earth's surface on a clear day. However, for the successful use of this type of energy, it is necessary to solve a number of problems - increasing the efficiency of converting solar energy, increasing the efficiency of collecting solar energy by a plant, reducing the cost of generating 1 kWh and others [1]. This paper presents a solution to increase the electrical energy generated by a photovoltaic power plant (FES).

Two ways to maximize the energy received from a photovoltaic installation are widespread: improving the structure of the photovoltaic panel, aimed at increasing its productivity; increase in the amount of solar radiation captured by the panel. To achieve the best results when applying the second method, the area of the photovoltaic panel should remain perpendicular to the radiation of the light source. For this, solar tracking systems are used in photovoltaic systems [2]. Today, photovoltaic panels have a typical efficiency between 12% and 25% and approximate performance in the range of 120-250 W / m² depending on the efficiency of the photovoltaic panel.

As part of the study, a model was developed in Matlab software for modeling a generator of a photovoltaic solar system with a power of 5 kW (Fig. 1). The model allows you to study the main electrical variables that make up the system of connection to the solar network, taking into account specific weather conditions in the region [3].

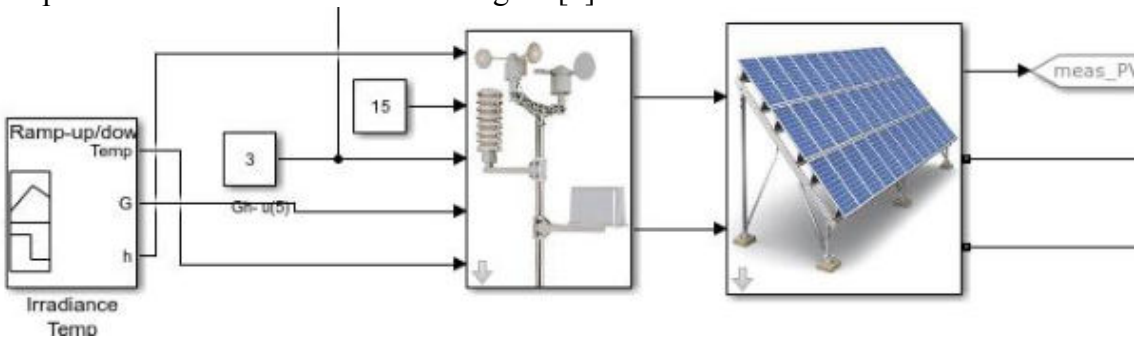

Figure 1 - Simulation of a 5 kW photovoltaic solar system generator in the MATLAB / SIMULINK software environment

In the course of the study, the angles of solar height and the angle of inclination of the photovoltaic panel were calculated using the example of climatic and geographical conditions of the Republic of Cuba.

Based on the mathematical model (Fig. 1), the optimal tilt angle of the solar module was calculated, as well as the electrical energy produced by the solar generator for different tilt angles (Table 1). The energy calculation obtained using the Matlab / Simulink simulation was performed for every 15th day of every month of the year.

Table 1 - Calculation of energy (kWh) received in the solar generator for different angles of the static solar generator

β_{opt}	1	2	3	4	5	6	7	8	9	10	11	12
10	20.5	21.4	21	21.6	18.3	16.8	18	18.5	16.6	18.7	20	19.5
20	21.7	22.3	21.3	21.4	17.9	16.4	17.6	18.2	16.7	19.1	21	20.7
30	22.4	22.6	21.2	20.8	17.1	15.8	16.8	17.7	16.5	19.4	21.6	21.5
40	22.7	22.5	20.7	19.6	16	14.9	15.6	16.7	15.9	19.1	21.8	21.8
50	22.5	22	19.9	18.6	14.6	13.6	14.4	15.4	15.1	18.6	21.6	21.8
ΔЭ	1	0.3	0	0.2	0.4	0.4	0.4	0.3	0.1	0.3	0.8	1.1

Where ΔЭ - electric energy (kWh / day), which is lost every month as a result of the inadequate tilt of the solar generator.

This difference was calculated between the maximum energy obtained at the optimum angle of inclination of the panel and the energy obtained between the current angle of the solar generator 5 kW, which is 20 degrees. Many authors recommend that the slope of static solar generators be equal to the latitude of the place where the solar generators are installed [4].

Based on the results of the work, the following conclusions were made:

1. The maximum values of the energy transmitted by the solar generator, regardless of the angle of inclination, are reached in January, since in January the distance from the Sun to the planet Earth is minimal.

2. It is observed that the greatest energy losses due to the tilt of the solar generator occur in January, November and December, since the height of the Sun in these months is small, and this angle does not approach the perpendicular position relative to the surface of the solar generator.

3. It is observed that the current tilt angle (20 degrees) of the solar generator is optimal for a latitude of 20 degrees. A decrease in the energy delivered by the solar system of 7% with an inclination angle of 50 degrees, by 3% with an inclination angle of 40 degrees, by 0.38% with an inclination angle of 30 degrees, and 1.5% at an inclination angle of 10 degrees.

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ANALYSIS OF ENERGY SAVING AT THE MINE OF A MINING AND METALLURGICAL COMPANY

One of the most promising sources of alternative renewable energy is the geothermal potential. The geothermal potential is use of the Earth's internal thermal reserves, for which geothermal facilities are being built stations. The principle of operation of geothermal stations is based on the use of energy of steam coming from underground tanks containing hot water. Geothermal power generation by installed capacity is significant part of renewable energy is developing at a moderate rate of 3-5% per year and it is one of the most cost-effective technologies [1].

In Russia significant reserves of geothermal energy are concentrated, currently explored about 50 geothermal deposits with significant reserves of thermal water. On Geothermal deposits with temperatures in the North Caucasus are well studied. tank from 70 to 180°C, located at a depth of 300 to 5000 m. Here for many years geothermal water is used for heating and hot water supply. In Dagestan produces more than 6 million m3 of geothermal water per year. in northern Caucasus about 500 thousand people use geothermal water supply [2].

In RSO-Alania, one of the main geothermal sources is Biragzang thermal mineral water Deposit, which is 45 km away from the city of Vladikavkaz, 2.5 km Southeast of Alagir, on the right Bank of the Ardon river, on the southern edge of the village of Biragzang, within the foothills of the Forest and Pasture ranges [3].

In 1990-1993, as part of the program to expand the medical profile of the sanatorium "Tamisk", at the stage of detailed search for medicinal-drinking and thermal waters was drilled well No. 1BT at a depth of 2370 m. To characterize physical properties and drilling materials were used for parameters of complexes and rock differences wells for various purposes within the area, including Korinskoe mineral water Deposit. In well No. 3T, drilled in the Northern zone At a depth of 2700 m, the bottom-hole temperature was 65 °C, and in the well No. 1BT at a depth of 2370 m-64 °C after completion of drilling. It is obvious that when a longer exposure time of well No. 1BT would have resulted in a higher temperature value (about 70 °C), but even at this temperature, the geothermal gradient for cut the lower Cretaceous deposits well # 1БТ is 4.62°C/100 m more than 3 times above the average geothermal gradient for the breakdown lower Cretaceous sediments in well No. 3T, equal to 1.5°C/100 m and 8 times above average values of geothermal gradient for the well No. 1T, equivalent to 0.58°C/100 m [3].

The formation of mineral thermal waters of the Biragzang section is associated with climate, geomorphological, geological-structural and lithological-facies conditions of the region as a whole, as well as features of the site structure. In particular, being confined to the Northern (Montenegrin) monocline, thermal the mineral waters of the Biragzang section are characterized by a number of features, which are common to a number of different deposits and sites manifestations of fresh and mineral waters, a chain stretching throughout this structural zone. Based on the results of the pilot release conducted from 20.05.08 to 10.06.08, the coefficient of water permeability of the tested rocks was determined water-bearing zone (2064-2160 m). The value of the water supply coefficient, defined as at the stage of pilot production, as well as when restoring the pressure, it was 4 m2 / day. The power of the tested zone is 96 m. Pressure above the surface land – 121 m, well flow rate-3.57 l/s. At the debit corresponding to the license fee to the limit, 1.74 l / s the pressure response was 45 m. The pressure was 76 m. Water temperature during the period of geological study of the subsurface (2007-2008) it fluctuated in the range of 50-51 o C [3]. Thickness of early Cretaceous deposits in the interval the perforation (2064-2160 m) was quite water-rich. When released, based on this interval at the end of the well drilling, water was obtained with mineralization of 2.1 g / dm3 of sodium bicarbonate-chloride composition with a pH of 8.8. The water flow rate was 5.5 dm3 / s with a decrease of 268 m. The temperature at the mouth was 53 °C.

During long-term releases, water salinity decreased to 1.5-1.9 g / dm3 , the temperature increased to 54-55 o C, the flow rate increased to 5.6 DM 3 /s. It should be noted that the composition of water obtained from early Cretaceous deposits in well No. 1 BT is somewhat differs from the water obtained in well No. 3T, where sulfides are present in the water, and from water in the wells of the Korinskoye field, where water mineralization from sediments the Barre is slightly higher. In the course of the geological study of the subsurface area for well No. 1BT were conducted observations of well No. 3T with the mutual influence between these wells, as and in the course of earlier work, it was not established. Obviously, the location wells in different structural blocks cause a difference in hydrodynamic parameters: piezometric levels of the goitre sediment aquifer complex- of the Barremian tiers registered during the observation period for well No. 1BT, they were 121 m, and 82 m for well No. 3T. The results of the research allowed describe the current state of output to the surface using wells No. 1BT of underground water, to confirm the stability of their hydrodynamic and quality characteristics [3].

Regarding the use of geothermal power stations for energy supply consumers can draw the following conclusions: Almost the entire territory Russia has unique reserves of geothermal heat with temperatures of heat carrier from 30 to 200 ° C. In recent years in Russia, and in particular in the North The Caucasus, based on major fundamental research, has been created geothermal technologies that can quickly ensure efficient use of heat land at geothermal stations [1].

To attract investment and loans in renewable energy should be implemented effectively and guaranteed timely repayment of borrowed funds, which is possible only with full and timely payment of electricity and heat released to consumers. Recommendations [1].

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ELECTROMAGNETIC FIELD EXPOSURE ASSESSMENT AT 1800 MHZ IN WINHOEK, NAMIBIA

Abstract — In this paper, the exposure levels of radio frequency (RF) electromagnetic field (EMF) from three mobile operators at 1800 MHz were measured at chosen points inside Paratus head office located in Windhoek, Namibia. The measurement system consisted of an Anritsu 2724B (MS2724B) spectrum analyzer, a Yagi antenna and a laptop to record the measurement data. EMF exposure measurements were performed every day for 66 consecutive days. After subjecting the measurement data to statistical test, the visual values of the electric field strength of the spectrum analyzer were corrected by accounting for cable losses as well as antenna factor. The composite electric field level was determined and the highest value was then compared with exposure limits set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) for the general public. The highest composite field strength was 200.23 μV/m, which is several orders of magnitude below 58 V/m at 1800 MHz exposure limit set by ICNIRP.

Increasing demand in the mobile communication industry has seen an increase in the installation of mobile base transceiver stations (BTS) in and around residential areas, hospitals and schools. The public is exposed to an ever-increasing number of sources of electromagnetic fields (EMF). Exposure measurements around mobile communications base stations have been proven to be an effective measure in risk communication regarding the public acceptance of these stations. Moreover, exposure assessment is a necessary precondition for the approval of the base station site, which is mandatory in many countries. In Namibia, however, there are limited data available related to the exposure of the general public. In this paper, we conducted measurements to assess the EMF exposure level inside an office located in Paratus Telecom building at 1800 MHz from the deep catch tower comprise three antennae belonging to the mobile operators Mobile Telecommunications (MTC), Paratus Telecom (PT) and Telecom Namibia Mobile (TNM).

This research focused on electromagnetic radiation due to a deep catch tower comprising three mobile operators: MTC, PT and TNM operating in the 1800 MHz and located 590 meter east of Paratus Telecom head office, Windhoek. Measurements were conducted in four pre-selected points A. B. C and D. The antenna height relative to ground was maintained. In this study, the measurement system consisted of an Anritsu 2724B (MS2724B) spectrum analyzer with frequency range of 1805 – 1880 MHz with zero attenuation connected to a 50 Ohms impedance Yagi antenna with gain of 9.2 dBi for a frequency of 1710 – 1880 MHz and secured on a portable pole, with vertical polarization facing towards the deep catch tower as well as a laptop with an i5 Processor for recoding the measurement samples as data logger. The Anritsu MS2724B spectrum analyzer was configured to receive the 75 MHz bandwidth for three operators

at 1800 MHz. To consider the effect of time variation and user traffic [1], at each of the pre-selected points, exposure measurements of electromagnetic field from the deep catch tower for each of the three mobile operators E_{MTC}, E_{PT}, E_{TNM} were conducted each day consecutively from the 18 August 2017 to 18 September 2017. The visual values of the electric field strength of the spectrum analyzer E were corrected for the cable loss ($L_{cabble} = 3dB$) and antenna factor ($A_{f\,dB}$) as follows:

$$E_c = E - L_{cable} - A_{f\,dB}$$

The logged measurements in all the points were then statistically analyzed. Due to the fluctuation observed in the measurement at each point, the data at each measurement point was subjected to an Augmented Dickey Fuller (ADF) statistical test [3] in order to determine the stability of the measured time series. The p values of the statistics showed that the time series data for all 4 measurement points were un-stationary. However, the duration of the measurement was not increased. For each point, the composite electric field strength E_{Σ} from all the three operators was obtained by the formula:

$$E_{\Sigma} = \sqrt{E_{MTC}^2 + E_{PT}^2 + E_{TNM}^2}$$

where, E_X is the electric field strength due to operator x at a given point.

The measurement indicated a highest composite corrected electric field strength of 200.23 μV/m recorded at point A with the highest contribution of 149.99 μV/m from the MTC mobile operator with a transmit power of 40 W (46 dBm). This highest composite corrected value was then compared to the standard [4].

The highest exposure level was detected with a composite electric field strength value of 200.23 μV/m which is several orders of magnitude below the 58 V/m at 1800 MHz exposure limit set by the ICNIRP for the general public [4]. However, for future study, the following recommendations are made:

1. More test points within Paratus Telecom head office should be considered.
2. A computer interfaced measuring tool for each test point to permit the continuous recording of data.
3. Extend the measurement duration to beyond a month as this may incorporate variation of EMF caused by seasonal factors.

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DIAGNOSTICS OF THE STATE OF CRYOGENIC GASIFIERS BY THE ACOUSTIC EMISSION METHOD

Cryogenic gasifiers have a great practical interest as they are used for transporting natural gas, which is the most environmentally friendly and cost-effective energy resource. The monitoring for the condition of these pressure vessels, their qualitative diagnostics and reliable resource assessment are needed for the ensuring the safe transportation of natural gas. Cryogenic gasifiers consist of external and internal vessels. The internal vessel is the main subject for control which is vacuum-insulated by the external one. Because of the completely tightness construction installing the sensor on the internal vessel without destroying the external one is impossible. This fact makes cryogenic gasifier difficult to control. The preference for using the acoustic emission method (AE) is explained by the possibility of registering the signal by installing AE converters to the pipes that come out from the inner vessel and serve as acoustic waveguides. As the pipes are located at different points of the vessel, they have different lengths, that cause a problem of decoding the data obtained under the conditions of significant influence of destabilizing factors. In this case the traditional AE hazard criteria based on the registration of the number of impulses or the amplitude of AE signals are not reliable diagnostic parameters [1]. In this regard, the problem of developing a method of acoustic emission diagnostics that is resistant to the influence of destabilizing factors and provides an estimate of the residual resource of the cryogenic gasifier is relevant. The main sources that reveal the theoretical foundations of this problem are the works of V. V. Nosov and V. I. Ivanov.

As a solution the information-kinetic approach to acoustic emission diagnosis is proposed, according to which the AE control should be carried out in the metrological and structural homogeneity, and long-term resource loaded material is determined by the accumulation of critical concentration of micro-cracks elastic processes of destruction. The separation of the stage of fine-dispersed destruction into heterogeneous and homogeneous stages on a kinetic basis makes it possible to distinguish an informative time interval from the General flow of AE signals. Structural elements selected by kinetic and temporal similarity criteria represent the strength properties of the material. This approach has a number of advantages over traditional AE methods, which are expressed in the principles of diagnostics optimization.

The information-kinetic approach is based on a multi-level micromechanical model of time dependencies of AE parameters, which implies the analysis of both the destruction process and the conditions for recording signals with associated destabilizing factors. By changing recording channels, a specific parameter of the model is variable. This parameter is the acoustic emission coefficient (AEC), which depends on the amplitude distribution function and contains information about additive interference. Short-term stabilization within a single channel during the loading and registration period allows to be freed from the influence of the AEC with appropriate mathematical processing of the registration results. Thus, acoustic-emission strength indicators follow from the time dependence of the number of pulses. Such indicators are free from AEC and, therefore, resistant to interference. This situation creates favorable conditions for diagnostics, removes the uncertainty of the model and ensures its effective using [2-3].

That is how the using of the information-kinetic approach of AE allows reducing the influence of factors of various scale levels on the registration of signals from material, that stabilizes and optimizes the control and diagnostics of cryogenic gasifiers.

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ENERGY DEMAND SIDE MANAGEMENT IN STAND-ALONE POWER SUPPLY SYSTEM WITH RENEWABLE ENERGY SOURCES

Currently, the electricity production for the needs of remote facilities in decentralized zones of power supply in Russia is carried out, as a rule, with the help of diesel power plants (DPP). The high cost of diesel fuel at shipment stations, as well as the transport component, sometimes reaching 70% of the fuel cost at the consumption location, explains the cost of generated electricity, which in some cases exceeds 100 rubles per kWh [1]. An economically attractive solution that can also solve ecological problems is the construction of hybrid power plants, combining traditional diesel generators and renewable energy sources (RES). For the optimal integration of unstable RES into distributed power supply systems, reduction of RES excess energy in systems with a high diesel fuel substitution degree, it is necessary to develop algorithms to ensure the maximum possible concurrence of electricity consumption and generation schedules. An actual research area in this direction is the demand side management (DSM) development [2].

In this paper, the DSM functioning principles in conditions of an electrical complex consisting of households and industrial electricity consumers and a hybrid power station consisting of wind generators, diesel generators and energy storage are proposed. For household consumers, a classification of electrical appliances is proposed, which are divided into 4 groups – shiftable periodic load, shiftable non-periodic load of low priority, shiftable non-periodic load of high priority, non- shiftable load. In contrast to the classification in the study [3], where 3 groups of household appliances are proposed, in the proposed version, shiftable electrical appliances list for which a separate high-priority group is created is expanded.

Within the system's functioning principles formation, it is proposed to use 2 types of notifications by the user of the system about the intention to change the device's operating mode – advance notice and "in 10 minutes" format notification. The last type of notifications is used for a shiftable non-periodic high-priority load group, devices of which are often referred to as non-shiftable. These appliances include, mainly, powerful kitchen appliances. On the one hand, a short notice time minimizes the changes in the user's plans probability for the use of appliance. On the other hand, the system is warned of a future significant load increase. In addition, the system has a small-time reserve in order to determine the preferred operation mode and either send proposals to some users to change plans for the devices use, or correct the shiftable periodic load operation mode, which is partially under its control. To encourage or punish consumers, a system of rewards and fines have been developed as part of DSM.

Methods for constructing a consumers' electrical load predicted graph and RES generation schedule have also been developed. In this paper, it is proposed to use artificial neural networks (ANNs). So, to construct the consumers load graph, it is proposed to use the ANN, the output of which is the non-shiftable load forecast. The ordinal day number in the year, the ordinal day number in the week, the previous values of the load, the value of the load 1 day ago and 1 week ago, ambient temperature and ambient light are predictors. Then, to the obtained forecast graph profile, the algorithm adds the capacity at the consumers request. To construct a schedule for RES generating it is proposed to use meteorological information from external sources, for example, the Hydrometeorological Center. However, the available RES generation capacity for an hour ahead, being a critically important parameter for the system, should be refined based on information about previous influencing meteorological parameter values (in the case of wind generators, wind speed). For these purposes, the ANN is also used in the work, with an absolute error MAPE of not more than 3% based on 4 previous values that determines the wind speed and, accordingly, the electricity generation by a wind generator, an hour ahead.

In conclusion, it should be observed that DSM, according to the results of modeling the small system operation over several typical days, can significantly improve the main technical, economic and environmental system parameters. As part of further work, it is necessary to simulate the DSM work over a long period of time to establish a possible economic effect and assess the reduction of negative environmental impact. In addition, an important stage of research will be the development of user interfaces for interaction with a smart control system and the information transmitted amount assessment.

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GETTING ADDITIONAL POWER ON 800 MW BLOCKS BURNING NATURAL GAS

Currently, there is a sharp increase in the consumption of natural gas in the energy sector of many countries of the world. In Russia, in 2018, natural gas production amounted to 733 billion m^3, and by 2050 it should increase by 40%. To achieve the goal of stable, uninterrupted and cost-effective satisfaction of the ever-increasing demand for natural gas, it is necessary to provide for the reduction of losses during its transportation, as well as to provide resource and energy supply.

In Russia, significant consumers of gas are thermal power plants (TPPs), to which it comes from gas distribution stations (GDS) with a pressure of 0.7⊓1.3 MPa. In front of boiler units of TPPs, this pressure decreases to a value of 0.13⊓0.2MPa due to gas throttling in a gas control unit (HF). From the point of view of the useful utilization of excess gas pressure entering the hydraulic fracturing and obtaining additional power of thermal power plants in hydraulic

fracturing, it is advisable to install turbo-expansion units, which we will call the generator expansion unit (GEU). In GEU, natural gas expands to the required value p = 0.13÷0.2 MPa.

Figure 1 shows our proposed project for the use of GEU for the Perm TPP on which three power units with a capacity of 800 MW each are installed. Based on the gas flow rate for each 800 MW unit, we suggest installing three GEUs on hydraulic fracturing. Note that hydraulic fracturing can work both according to the usual scheme, and with the inclusion of GEU to generate additional power.

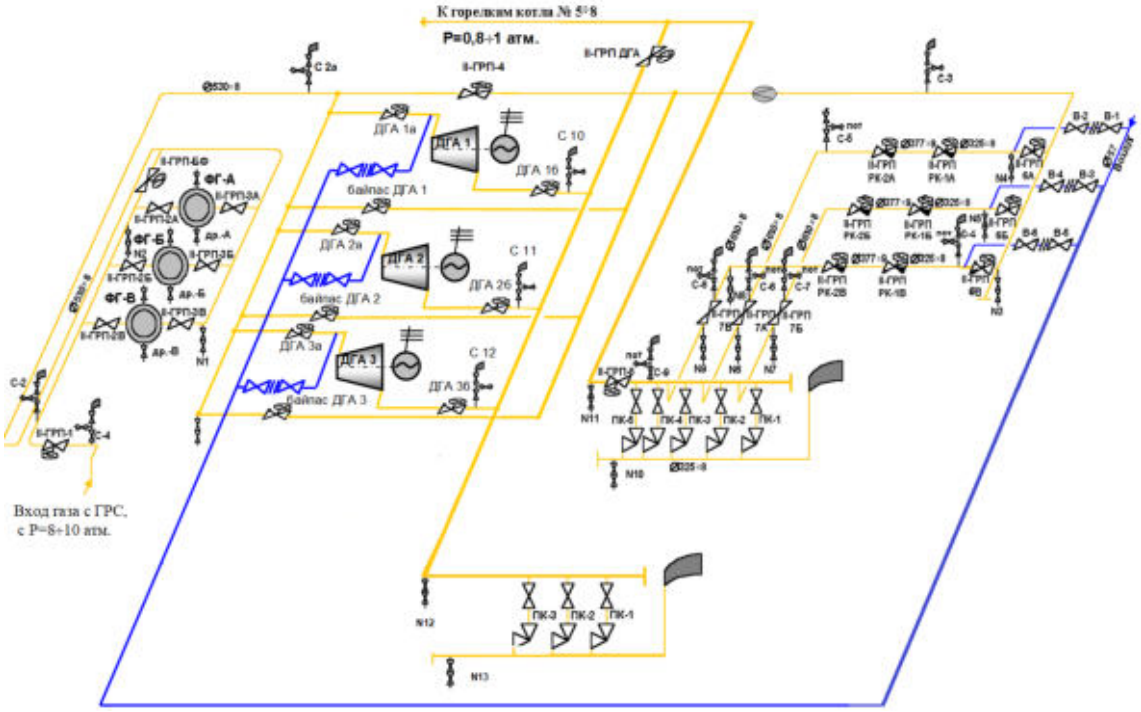

Figure 1 - The proposed scheme for the inclusion of GEU in the pipeline system of hydraulic fracturing of Perm State District Power Station

However, with the expansion of gas in a turboexpander, its temperature decreases significantly and can reach significant negative values. We show this in more detail. The gas parameters at the inlet to the GEU are usually: pressure P_o = 0.8 ÷ 1 MPa; temperature T_o = 273 K. Gas pressure at the outlet of the GEU P_k = 0.12 ÷ 0.18 MPa. Using the adiabatic equation $TP^{1-к/к}$ = const, we calculate the final gas temperature after GEU, taking the adiabatic exponent for natural gas k = 1.35:

$$\frac{T_к}{T_0} = \left(\frac{P_0}{P_к}\right)^{\frac{1-к}{к}}; \qquad T_к = T_0\left(\frac{P_0}{P_к}\right)^{\frac{1-к}{к}} = 273\left[\frac{(0{,}8 \div 1{,}0)}{(0{,}12 \div 0{,}18)}\right]^{\frac{1-1{,}35}{1{,}35}} = (167 \div 175)K, \qquad (1)$$

or

$$t_k = T_k - 273 = (167 \div 175) - 273 = -(106 \div 98)^{0}\,C$$

When supplying such gas to the boiler unit, it will be necessary to spend additional fuel on its heating. To eliminate this drawback, it is possible to heat the gas in the heat exchanger by installing it at the inlet or outlet of the gas from the turboexpander. We examined the heating schemes of natural gas at the outlet of the turboexpander in the heat exchanger with steam from the turbine's take-offs, as well as the heating circuit of this gas with water in the heat exchanger included in the bypass of the low-pressure heaters (HDPE) of the regenerative circuit of the unit (Figure 2), which turned out to be more effective.

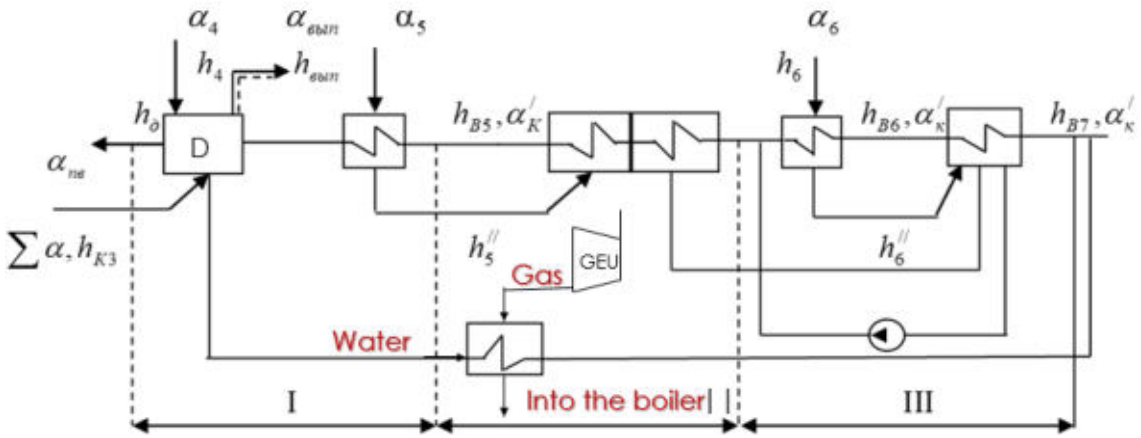

Figure 2 - Scheme for heating the gas leaving the turbo-expander before feeding it for combustion in the boiler unit.

Water for heating the gas circulates along the circuit: a cycle deaerator, a gas heater, HDPE and again a deaerator. Installing a heat exchanger on the HDPE bypass will require a slight increase in the flow rate of water passing through the HDPE by about 5.5%. Due to the selection of steam in the HDPE to heat the water of the proposed circuit, the steam consumption in the turbine condenser will decrease, which will increase the energy production at regenerative sampling and reduce heat loss to the environment with circulating water from the condenser. In addition, the magnitude of the output losses from the last stage of the turbine is reduced. Based on the 800 MW block with the K-800-240 turbine, the effect of installing a turbo expander was determined, which amounted to 8.8 MW of additional power, which can significantly reduce the specific fuel consumption for generating kWh of electricity.

Gas heating in a gas-water heat exchanger provides savings in fuel consumption for the generation of 1 kWh by a 800 MW unit at about 0.55 g. t. With the number of hours of using the installed capacity of the unit τ_{year} = 6500 h / g, this savings will be about 2860 t.o.e./g. Considering that three such units are installed at TPPs, the total annual savings in fuel consumption will amount to 8580 tons of equivalent fuel / year, plus additional electricity generation of the order of E year = 57.2 GWh. A study showed that power plants consuming gas from gas pipelines can, using turbo-expanders, significantly increase their efficiency.

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METHODOLOGY OF COMPLEX ANALYSIS OF HEATING SYSTEMS PROJECTS IN THE REPUBLIC OF BELARUS

At present, the world community is faced with the problems of energy resources shortage. In this regard, there is an urgent need to take serious measures to reduce energy consumption in industry. Traditional heating systems are the most popular in the existing modern market of Belarus, which does not fully meet the indicators of environmental friendliness and economic feasibility.

A methodology has been developed to assess the efficiency of various heating systems, taking into account the environmental compatibility of projects. At the first stage, existing traditional and potential innovative heating technologies have been identified and technical,

organizational, legal, financial, economic, environmental and social groups of factors have been taken into account. In the work the most widespread at present heating systems on different types of fuel are considered [1]: on the basis of electric energy (WESPEHEIZUNG); on the basis of natural gas (ARISTON); on the basis of solid fuel (hard coal, anthracite, peat, firewood (Cosmos-10); with the use of city heating network; on the basis of heat pump (NIBEBO/W45).

At the second stage, qualitative and quantitative assessment of factors was made. The expert method was used to qualitatively assess the impact of each group of factors. Quantitative assessment was determined as a sum of total savings at all stages of the project as well as the environmental effect [2]. When determining the effect of introducing an innovative heating system, a planning period of 10 years was chosen and all revenues and costs were assessed. At the same time, cash flows were discounted. At the third stage, the minimum present costs were estimated.

At the fourth stage the estimation of risks of application of systems of heating of dwelling houses corresponding to all stages of life cycle of the project is made and the list of antirisky actions is developed [3]. The developed methodology allows minimizing economic costs during the project life cycle, reducing the environmental impact and risks.

At the fifth stage the assessment of heating project performance using the area method was performed. In this method, based on the data obtained, a radar chart with a given division scale has been constructed, which shows the correlation of characteristics for each heating project. The characteristics of the projects have been distributed on a scale based on their desirability for an ideal project. By calculating the area of figures for each project, we have the possibility to make a comparative analysis on the basis of all the mentioned above factors. Comparable area indicators for each heating project are shown in table 1.

Table 1 - Comparable area figures for the heating projects of residential buildings

Heat generator type (brand)	**Area indicator**
WESPE HEIZUNG (electric boiler)	10,1623
Ariston (gas boiler)	114,9283
Cosmos-10 (solid fuel boiler on coal)	51,8025
Cosmos-10 (solid fuel boiler on anthracite)	56,1746
Cosmos-10 (solid fuel boiler on a torophobriquette)	143,5888
Cosmos-10 (solid fuel boiler on firewood)	145,6246
Municipal heating system	126,3858
NIBE BO/W45 (Groundwater heat pump)	111,6456
Perfect heat generator	200

Proceeding from the received results it is clear, that the most effective is use of solid fuel boilers on fire wood and peat briquette while use of solid fuel boilers is not expedient. Quite competitive are heat generators in the form of gas boilers and heat pumps, as well as the city heating system. The developed technique allows to estimate and choose the heating project taking into account total expenses and incomes throughout the project life cycle, to reduce loading on environment and to lower risks.

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CONTROL SYSTEM FOR ELECTRIC DRIVE OF A BALL MILL ROTATION MECHANISM

Ore grinding is a high-tech and energy-intensive process, which is characterized by the complexity of the mathematical description, control and optimization, in order to increase technological efficiency and reduce energy consumption. [1]. The physics of the process is caused by the probabilistic nature of the interaction of the crushed particles and grinding media in the mill drum, and it is impossible to observe particles in the mill. The physicomechanical properties of the crushed ore, which are variable in the process of the developed deposits, and the size of the initial ore entering the mill, are difficult to maintain at the same level, since careful classification under industrial conditions is impossible. The paper [2] presents a study of the strength properties of copper ore. For ore samples taken from one deposit, the difference in energy required for grinding it reached 5 kWh / t. Deviation from ore settings may affect the whole redistribution as a whole. Therefore, a method is needed that will limit the influence of changes in the properties of the ore and will help maintain the performance of the grinding process at a nominal level. The paper proposes to consider the possibility of regulating the rotational speed of the mill drum using an automated electric drive as a corrective operating parameter of the grinding process.

It is proposed to consider an algorithm for calculating the optimal rotational speed, which takes into account the physicomechanical properties of the ore based on data on the consumption of the initial ore and the finished product, as a setpoint for the frequency of rotation of the electric drive. For the criterion of optimality, the minimum grinding time is taken - 25 minutes, necessary to obtain the finished product yield of 0.074 mm at the level of 70%. Based on the Bond theory, the energy consumption for ore grinding is estimated with a change in its strength properties [3]. It is shown that due to changes in the speed mode of the mill, it is possible to optimize the energy for ore destruction. Therefore, stabilization of grinding time is achieved at the optimum value of 25 minutes. Thus, the proposed algorithm will allow to obtain an energy-technological effect from the use of an automated electric drive.

To implement the developed algorithm, it is proposed to use an automated twin-motor electric drive. The choice of electric drive is justified by a gradual increase in production capacity and, as a consequence, the possibility of reducing the power of the drive motor in the electric drive. However, twin-motor drives have some features to use. Such an electric drive requires consistent, precise control due to the possible uneven distribution of the load between the motors. The uneven distribution is connected with the difference in the winding parameters of the drive machines, which leads to a change in the rigidity of the mechanical characteristics. For load balancing, a developed algorithm for correcting moments in the motor control system is proposed. Correction is carried out due to additional values of the moments. The alignment of the moments is achieved by changing the task to the moment-forming current. Therefore, the

amplitude values of the currents will not be the same, one of the motors will be magnetized. The energy consumed will be spent irrationally, motor resources will be used unevenly. To balancing the amplitude values, it is also proposed to add an algorithm for adjusting the task for flux linkage. Due to the imbalance of the flows, the amplitude values of the motor currents are balanced. The currents are equal and correspond to the minimum value. It is worth noting that the developed algorithms as part of the propulsion control system do not affect the quality of the controlled signal of the rotation frequency. The economic effect is presented, which (for the selected motor) is 3.2 million rubles in year.

To implement the algorithm for calculating the optimal speed and a modified motor control system, it is proposed to use a modular multi-level frequency converter (MMC). Medium and high voltage MMC can be performed without transformers, without DC and AC filters. They distort currents and voltages relatively little, and have high efficiency. Using this converter allows you to implement a multi-inverter structure. In this work, at this stage, studies of a modular autonomous inverter for different PWM are presented: a sinusoidal PWM with shifted reference signals in amplitude and a sinusoidal PWM with shifted reference signals in phase. The results of the study showed the advantages of using a sinusoidal PWM with shifted phase reference signals as a modulation control system.

The process of grinding and crushing ore are the most energy-intensive processes in the enrichment. Due to the fact that the content of useful components in the composition of ores decreases, new approaches and technologies are required to maintain both production capacities and leading positions in the mining industry. A new approach to the grinding process control is proposed. Estimated energy-technological and economic effects are obtained, according to which it can be concluded about the advisability of automating the main rotation mechanism using an automated electric drive.

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IMPLEMENTATION OF THE COMPRESSION ALGORITHM AND TRANSMISSION OF SEISMIC DATA

Seismic data acquisition complexes used in geological exploration provide simultaneous transmission of signals from several thousand measuring channels with typical sampling rate of 500–1000 Hz of 24-bit samples. Customary, such streams of data (12000-24000 bps per channel) are transmitted using cable technologies. Now is actively developed wireless data transmission technologies, which should reduce the total area of deforestation during cable laying. Of greatest interest are real-time systems that allow immediately receiving and evaluating the quality of seismic data, as well as monitoring the operation of all equipment. The main problem of designing such systems is providing radio communication over long distances in conditions of

significant attenuation (the worst case is an unbroken deciduous forest) in the UHF range acceptable for a broadband radio organization [1].

One of the ways to get around the mentioned problem is to use a retransmitting ("message forwarding") method of data transfer, where each seismic acquisition point transmits not only its data, but also retransmits the data of the neighboring point "in a daisy chain" towards the central collection point. Such a solution has been presented by Wireless Seismic (USA) in its RT2 complexes based on a broadband radio channel in the 2.4 GHz ISM band [2]. One of the disadvantages of RT2 is that the information stream for each collection point is irregular and increases as oncoming to the data collection center (maximum for the point nearest to the center). This requires the use of a broadband radio channel for all field units due to their intersubstitutability. For the field units nearest to the center, energy consumption from the battery increases and battery life decreases, for the reason, the batteries themselves are unevenly discharged. The task of developing a real-time wireless seismic complex is becoming an urgent problem.

For implementation of this complex, a multi-level telemetry system is proposed using radio channels of different frequency ranges and types [3]. At the first level, data is transmitted from the field units communicated with a seismic receiver – seismic acquisition units (SAU) to intermediate repeaters – domain coordinator modules (DCM) via the radio channel (RCh1). One repeater forms one domain and serves up to NS SAU. At the second level, a radio network is formed to transmit data from all SAU via the radio channel 2 (RCh2) to the base station (BS). One BS forms a cluster and serves up to ND DCM. At the third level, data from all clusters are collected via the radio channel 3 (RCh3) or cable technologies to the network central station (NCS), which also manages the operation of the entire complex.

To study the possibility of using a transceiver to build RCh1, a radio module based on the Si4468 transceiver was developed. In this work, we consider the example of radio channel implementation with a nominal transmission rate of 256 kbit/s using a transceiver. To use the frequency resource more effectively, it is proposed to use 4GFSK modulation. The use of 4GFSK modulation allows the use of six radio channels in the selected frequency band for the transmission rate, since the use of a Gaussian filter reduces the side lobes of the spectrum and also significantly increases the rate of decrease of the spectrum of the GFSK signal in comparison to FSK signals.

As stated above it is reasonable to design the RCh1 network as completely synchronous network within the domain. For the practical implementation of a synchronous system, it is necessary to determine the dimension of the node address, the optimal format and length of frames. It should be noted that the implementation of any method of competitive access to the channel is not required. The proposed frame structure includes the preamble (a 1010... bit sequence), the length of which is selected on the basis of the modulation type. For a 4GFSK signal, the recommended preamble length is 10 bytes. The length of the sync word is chosen to be two bytes from the maximum four possible. The transceiver has an ability to set up to four fields with checking the CRC of each field separately, or the CRC of the entire frame. In our case, two fields are used to check the integrity of the frame completely. The maximum length of all fields is determined by the size of 64-byte transmit and receive FIFO buffers, into which the transmitted and received data are load-ed. It is possible to combine both buffers into one buffer with a length of 129 bytes, which al-lows to increase the frame length.

The minimum transfer rate for a domain on 16 channels is 192000 bps. So it is the urgent task of reducing the amount of data transmitted via the radio channel in order to optimize the load on the radio network and reduce power consumption. The ARM Cortex-M4 microcontroller solves this problem, receiving seismic data and compressing them. To implement compression we used the Miniz library that was modified for using with a microcontroller. This library contains implementation of the LZ77 algorithm and Huffman coding. It was possible to achieve the values of the compression ratio of 1.5-1.8 for the seismic signal. Data is accumulated in the ring buffer of the microcontroller as soon as the first half of the buffer is filled, the compression

subroutine is started and accumulation continues, the same is done with the second half of the buffer.

The considered single-chip programmable transceiver Si446x allows creating a network for RCh1. In dependence to the problem to be solved within the dedicated radio-frequency range, the developer needs to select the main parameters of the radio channel: bit rate, modulation index and type, radiated power level. The used algorithm of the seismic data compressing allows to optimize the load on the radio network.

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COMPRESSED AIR ENERGY STORAGE SYSTEM FOR SERIES HYBRID ELECTRIC VEHICLES

The transport sector is the main source of greenhouse gas emissions due to the exhaust gases that cause the global warming. With the depletion of fuels, many researches are being provided to find a substitute to the internal combustion engine. Thus, a thesis realized in Mines-ParisTech demonstrates that gas turbines are potential energy converters for series hybrid electric vehicles [1]. They offer intrinsic advantages to the automobile sectors as their multi-fuel capability, the reduced number of rotating parts, the reduced noise and vibration and the reduced NOx emissions. This work focuses on studying a compressed air energy storage system that can be used as a source of clean energy to recharge the battery of the electric vehicle. This work is about choosing the convenient configuration of the compressed air energy storage system by optimizing the needed pressurized mass of air, because higher it will be, higher will be the weight of the system and the fuel consumption.

The system consists of a high pressure gas at 400 bar stored in high pressurized tanks, followed by a series of expansion turbines. These tanks are recharged either directly at the compressed air stations (duration of 4 minutes), or electrically (duration of 4 hours) [2] [3]. The heat recovery at the outlet of the last turbine can be achieved either by adding a recuperator or by using a Rankine cycle. The work started with thermodynamics studies of the two configurations using Refprop in order to choose the suitable configuration in terms of a lower needed pressurized air and a higher power density to achieve a power of 25 kWh. Then a technological study is conducted in order to predict the weight of the chosen system.

The combined cycle is considered as the suitable configuration. The pressurized mass flow needed to achieve a 25 kWh is 76 kg/h (163 L), almost the half of the needed mass flow rate in the recuperated cycle 135 kg/h (290 L), resulting in a higher power density of 154.19 kWh/m^3. The weight of the system does not exceed 170 kg. To sum up, the compressed air energy storage system coupled to a gas turbine combined cycle can be a potential range extender for series hybrid electric vehicles.

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IMPROVING THE HEAT TRANSFER EFFICIENCY OF DIRECT-FLOW RECYCLING BOILER USING AN ORGANIC FLUID

Implemented in recent years, the policy of introducing energy-saving technologies determines the need for maximum use of waste heat from various enterprises, power plants and boiler houses [1]. Such sources are very common in the oil, metallurgical chemical and other industries [2]. Available low-grade heat can be used to generate electrical energy in small power plants based on the principle of the organic Rankine cycle (ORC) [3].

In one of the main elements of the ORC unit - evaporator, there is a problem of high vapor content in the final sections. The supply of steam with an insufficient degree of dryness leads to the entry of wet steam into the turbogenerator with droplets of liquid. This leads to the destruction of the turbine blades. Thus, to solve this problem, it is necessary to study the heat transfer in the evaporator.

The study of heat transfer in the evaporator was carried out using numerical simulation in the ANSYS software package. The geometry of the studied model is an evaporator pipe of the ORC unit with an internal diameter of 32 mm. The length of the straight pipe section and the bending radius of the pipe are equal to 0,5 m and 0,052 m, respectively. The number of pipe turns is 7.

In the resulting boiling picture of model, 2 areas can be distinguished: 1 — area of intense vaporization; 2 - area of the same steam void. Area of intense vaporization ends after the first turn of the pipe. The area of equal steam void occupies most of the evaporator pipe. Thus, heat transfer on most of the surface of the evaporator is not effective.

To increase the heat transfer efficiency, it is necessary to determine in which area a sharp drop in the heat transfer coefficient occurs. For this, was conducted a study of the change in the heat transfer coefficient along the length of the pipe. A sharp drop in the heat transfer coefficient occurs in the area of 0.5 - 1 m. In the following sections of the evaporator pipe, the value of the heat transfer coefficient doesn't change significantly.

Further research was carried out for a straight pipe section 0.9 m. The aim of this study is to obtain a criteria equation for calculating the Nusselt number during the boiling process.

As a result of the study, the dependences of the heat transfer coefficient on the pipe diameter, fluid velocity, pipe length and type of fluid were obtained. After studying all the obtained dependencies, an equation for calculating the heat transfer coefficient was obtained. This equation takes into account the nonlinear dependence of the heat transfer coefficient on the diameter and its change along the length of the evaporator.

Thus, in this work, it was determined that in the evaporator tube during boiling 2 areas stand out: area of intensive vaporization and area of the same steam void. An equation for calculating the heat transfer coefficient during the boiling process, that taking into account the change in the heat transfer coefficient along the length of the evaporator was also obtained.

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EVALUATION OF THE CONSUMERS CONTRIBUTION TO THE ELECTRIC POWER QUALITY INDICATORS IN RELATED SYSTEMS OF INDUSTRIAL ENTERPRISES

Features of non-sinusoidal processes in the electrical networks of industrial enterprises has not been studied thoroughly. At the same time, nonlinear elements are increasingly used in industry. Since Russian and international electricity quality standards regulate the indicators of electric power quality, such as total harmonic distortion of voltage and current, so it becomes relevant to assess the impact of the nonlinear load of the enterprise on the electric power quality of both the power supply system (PSS) and other enterprises connected to the same PSS.

Nowadays, there are a number of methods that allow us to identify a non-linear load with dominant contribution to power distortion, for instance, the active power method [3], the reactive power method [4], the non-active power method [1], the distortion power method [2]. Despite this, none of the methods provides accurate information in percentage correlation. In addition, there is no method that is officially defined by the power quality standards.

This study is devoted to the development of a method to determine the quantitative contribution of distortion sources to the power quality indicators of the enterprises' power supply systems with a common network at the point of common coupling (PCC).

Within the mathematical modeling, the equivalent circuit of two enterprises powered by a common network was drawn up. Based on the obtained dependences, the possibility of assessing the contribution of distortion sources to the total voltage distortion at the PCC by the higher harmonics current vectors of consumers was confirmed.

Also, formulas were derived for determining the enterprise's higher harmonics currents which will ensure minimal voltage distortion in the PCC with constant parameters of the PSS and regardless of the relative position of the current vectors. In the other words, the higher harmonics compensation measures are mathematically sound.

To evaluate the error of the method resulting from the influence of the higher harmonics of the enterprise on the consumption of a non-sinusoidal current by another enterprise, a more detailed scheme was analyzed that included two industrial enterprises with a common PSS providing for such an impact. The error values for PSSs with relatively large and small voltage losses were estimated.

Based on these studies the method was formulated that determines the contribution of higher harmonics of consumer current to voltage distortion in PCC. The point of the method is to calculate the projections of consumer currents on the total current vector.

The novelty of the method is that it is necessary to measure only the modules of currents in the PCC to implement the method. It simplifies the collection of data that is one of the main advantages of the method.

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GENERALIZED EFFICIENCY INDEX OF UTILIZATION OF ELECTRICAL ENERGY IN PRODUCTION

At present, the main efficiency index of utilization of electrical energy at enterprise is the specific energy consumption per unit of production. However, this indicator cannot fully characterize the efficiency of energy consumption (for example, economic efficiency) of the enterprise. When determining the coefficient of efficiency of utilization of electrical energy using technological electrical equipment, the following factors must be considered:

1. Target energy consumption;
2. Technical efficiency of utilization of electrical energy
3. Economic efficiency of utilization of electrical energy.

To obtain generalized efficiency index of utilization of electrical energy, we formulate two dimensionless indicators:

- relative specific energy consumption per unit of production;
- coefficient of efficiency of utilization of electrical energy in production

Indicators have different units of measure in tasks, and relatively normalized indicators are required, i.e. bring them to a single, preferably dimensionless, scale of measurement. The method is based on maintaining ideal values of the criteria $F_u=(f_1^u,\cdots,f_j^u,\cdots f_n^u)$, with the help of which the vector is reduced to dimensionless form:

$$E = (e_1^u,...,e_j^u,...,e_n^u) = (\frac{f_1}{f_1^u},\cdots,\frac{f_2}{f_j^u},\cdots,\frac{f_n}{f_n^u}).$$

where e^u_n - relative values of n- indicator, reduced to its value; f_1^u - effective value of the indicator; f_1^u - ideal value of the indicator.

The specific energy consumption per unit of production is taken in comparison with its lowest value in the industry, i.e., the relative specific electricity consumption:

$$K_{0,уд} = \frac{w_{0.эл}}{w_{0.н}},$$

where: $w_{о.эл}$ – specific energy consumption per unit of production, kW·h/measurement unit; $w_{о.н}$– standard (or smallest) specific consumption of electricity per unit of production by industry, kW·h/measurement unit

Economic efficiency of the use of electricity is determined by the ratio of the value added of the products during the processing of raw materials or half-finished products by technological electrical equipment to the spent electrical costs for the production of these products:

$$K_{эк.эф} = \frac{\Delta C_{доб}}{\Delta З_{ээ}},$$

where: $\Delta C_{доб}$ – added value of products during the processing of raw materials or half-finished products by technological electrical equipment, thousand UZS, $\Delta З_{ээ}$– - total electric costs for the production of these products, thousand UZS.

This coefficient is determined for individual or groups of the same type of technological electrical equipment and is calculated as the total added value in the production of products, as well as the costs of servicing the technological electrical equipment (payment for electricity, wages for workers, repair of technological electrical equipment, etc.).

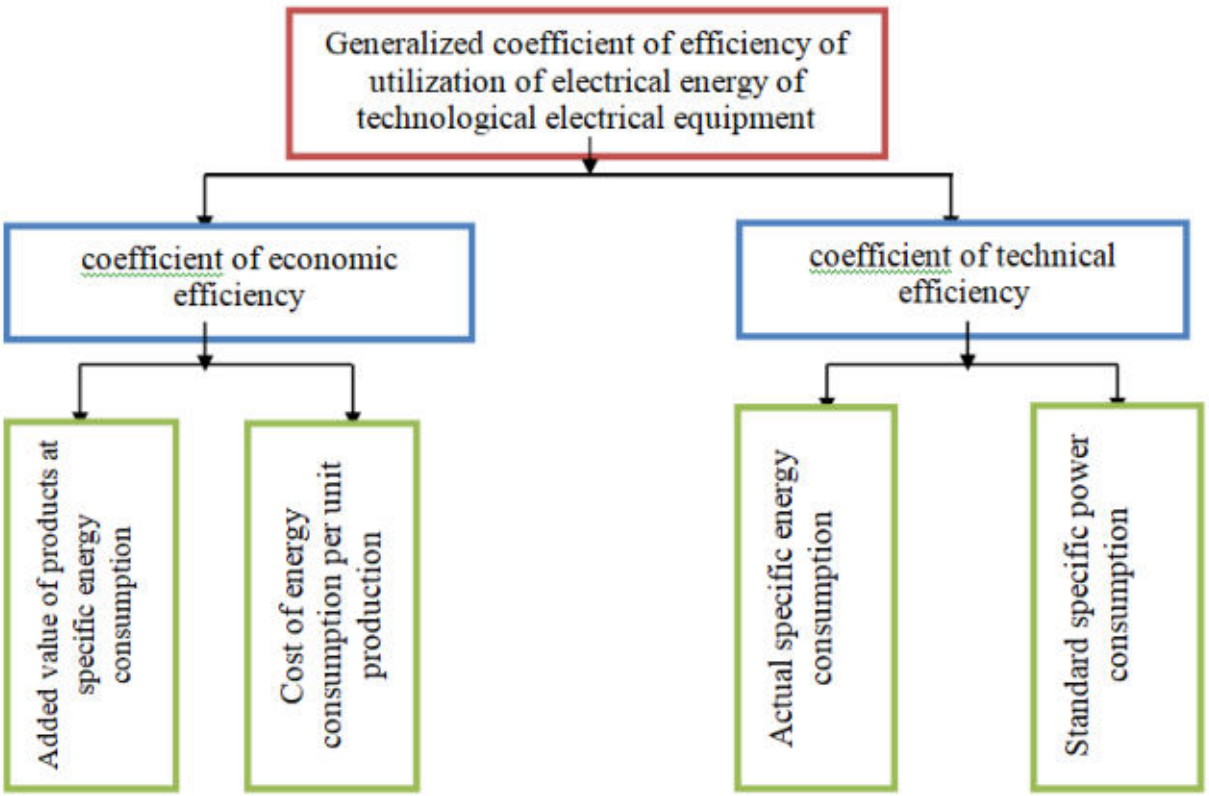

Figure 1 - Structure chart of the determination of generalized coefficient of utilization of electrical energy at the enterprise

Generalized coefficient of efficiency of utilization of electrical energy is determined by the following formula: (Weighting coefficients are set according to table 3.1. Ranking order is F1> F2).

$$K_{эи} = \sum_{n=1}^{2} \alpha_i (K_n) = \alpha_i (K_{эк.эф.} + K_{уд.р}) = \left(\frac{2}{3} \cdot K_{эк.эф} + \frac{1}{3} \cdot K_{0.уд} \right)$$

This coefficient characterizes efficiency of utilization of electrical energy in production. This allows separately examining effectiveness of SES and production, as well as developing detailed energy-saving measures.

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APPLICATION OF DIFFERENTIAL MOBILITY SPECTROMETRY FOR DETECTION OF WATER POLLUTANTS

Monitoring the chemical quality of water is required by environmental legislation. For this purpose, the development of fast, straightforward sample-preparation and detection techniques is one of the key issues in environmental analysis. Due to the potentially rapid spread of water contaminants within the public distribution network, the continuous improvement of an early warning systems, and the development of new online water monitoring methods is essential. However, most of the existing methods are laboratory-based and therefore require sampling. In many cases the derivatization or extraction steps are required. Therefore, interest in simple, inexpensive, and fast techniques for on-site monitoring has grown in recent years. Differential mobility spectrometry is a new types of sensor methods suitable for continuous monitoring of various target analytes. DMS provide quick, easy and sensitive way to analyze environmental samples and enables simultaneous determination of several compounds directly from liquid matrices. The working principle of DMS is based on the nonlinear dependence of the ion mobility coefficient (K(E)) on the applied electric field. At present, mobility spectrometry, is receiving increasing attention in environmental analysis, where it has been successfully applied for example to the detection of contaminants in aqueous media to prevent environmental accidents, and to the monitoring of hazardous vapors in both outdoor and indoor air[1,2].

Differential mobility spectrometers with direct flow of vapor samples from ambient air, or headspace over water samples, precludes artifacts from an interface yet can present the ion source and analyzer with a complex chemical mixture and severely elevated levels of moisture. Moisture will affect both ion mobility and reaction ion chemistry (i.e., response curves). The purpose of this investigation is to obtain measures of the influence of extreme moisture levels in a DMS and support the measurements with understandings from computational models.

The performance of a differential mobility spectrometer was characterized at ambient pressure and ten values of water vapor concentration, from 1.0×10^2 to 1.7×10^4 ppm using a homologous series of seven ketones from acetone to 2-dodecanone. Dispersion plots at 30 °C with separation fields from 35 to 123 Td exhibited increased alpha functions for the hydrated proton, protonated monomers, and proton bound dimers with increased moisture levels. Increases in the level of moisture were accompanied by decreased quantitative response with progressive suppression in the formation of the proton bound dimer first and then protonated monomer. Product ions for 2-octanone at 7 ppb were not observed above a moisture level of 4.0×10^3 ppm, establishing a limit for observation of analyte ion formation. The observation limit increased from 1.1×10^3 ppm for acetone to 5.7×10^3ppm for 2-dodecanone. These findings demonstrate that ketones can be determined with a differential mobility spectrometry analyzer near room temperature in the presence of elevated levels of moisture expected with the use of membrane inlets or headspace sampling of surface or ground waters. Moisture levels entering this DMS analyzer employed as an environmental monitor should be kept at 1.0×10^3 ppm or below and quantitative studies for individual ketones should be made at a fixed moisture level [3].

In addition, the Sensitivity of response was studied under influence of moisture from 1 to 4×10^3 ppm_v and temperature from 50 to 150°C for three categories of high, intermediate, and low proton affinity by IMS. Changes in proton affinity of the hydrated proton influence sensitivity of response and limits of detection. High proton affinity compounds demonstrated

minor changes in their response, while low proton affinity compounds had significant changes in their response. Compounds with intermediate proton affinity exhibit behaviour between the extreme responses [4].

These findings from DMS demonstrate that ketones can be determined with a differential mobility spectrometry (DMS) analyzer near room temperature in the presence of elevated levels of moisture. Also, the findings from IMS response compliment and reinforce findings with DMS for use in environmental monitoring and demonstrate that the deleterious effects of moisture on ionization chemistry can be compensated somewhat with temperature. Alternatively, selectivity to high proton affinity chemicals could be improved with suppressed response to compounds of lesser proton affinity with elevated (and controlled) moisture levels.

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APPLICATION OF METHODS FOR CALCULATING MULTIPHASE FLOWS IN USE OF GEOTHERMAL ENERGY OF THE EARTH

In December 2018 within the framework of international cooperation I visited 3 German Universities (RWTH in Aachen, RUB in Bochum , TUHH in Harburg) as a member of the University delegation. During our visit to RUB we have been acquainted with the developments in the field of geo-ecology – geothermal energy of the Earth. RUB is actively cooperating with the Geothermal Center in Bochum. I got interested in the scientific field of the mentioned center. I suppose this topic of research is of vital importance for our territory but unfortunately this method is not widely spread in the South of Russia even though the region of the Caucasus Mineral Waters possesses unlimited possibilities of using geothermal energy both in economy of the country and in ecology. However, this issue is not thoroughly studied in our country, so it is important to draw attention both of the scientific and political power of Russia to the said issue. In order to do it, on getting the theoretical knowledge about the topic. I undoubtably believe that geothermal systems can significantly benefit to the long-term provision of not only local, but international needs in energy, as well as solving the issues of environmental protection in oil and gas extraction.

Of particular the following topics are interest to me:

- applying the calculate methods of flow of multiphase mixtures in vertical and horizontal pipes for geothermal systems;
- analyses of using gas-lifts in geothermal resource wells;
- application of oversized features in calculating multiphase systems.

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ANALYSIS OF ENERGY SAVING AT THE MINE OF A MINING AND METALLURGICAL COMPANY

The solution to the problem of energy conservation and energy efficiency at the technological stages of mining and metallurgical companies can only be ensured by a comprehensive approach, including conducting energy surveys to determine energy efficiency and energy conservation potential, implementing an energy management system, developing a program of measures to improve energy efficiency, implementing the program, monitoring and confirmation effect of implemented energy saving [1]. The main objectives of the energy survey are: obtaining objective data on the amount of energy resources used; determination of energy efficiency indicators; determination of the potential for energy conservation and energy efficiency; development of a list of measures for energy conservation and energy efficiency and their valuation. When performing energy surveys, it is necessary to assess the technical condition of the energy system of the enterprise of electricity and heat supply, water supply, compressor facilities; determine the status of systems and means of energy metering and their compliance with regulatory requirements; determine the efficiency of energy use (identification of unreasonable losses, assessment of the energy rationing system, etc.); draw up the energy balance of the enterprise; determine the specific energy consumption for products (or types of work); to formulate the main energy-saving measures and conduct their technical and economic assessment; draw up an energy passport of the enterprise; if necessary, make an examination of tariffs for the production and transfer of energy. Thus, to increase the efficiency of energy use at the mine, it is necessary to conduct a comprehensive energy audit and develop a set of energy-saving measures on its basis [2].

The aim of the work is to choose the efficiency of electricity use at the mine of a mining and metallurgical company. The scientific novelty lies in the analysis of data on electricity and heat consumption, which made it possible to compare actual and normative indicators of energy efficiency based on a comprehensive energy survey of a mine of a mining and metallurgical company. The solution of the tasks is based on well-known theoretical principles and experimental data on the determination of indicators of electricity and heat consumption. The practical value lies in the analysis of the results obtained, which shows that in the technological consumption of the mine significant (from -14% to 32%) variations are observed between the planned and actual values of electricity consumption [3].

The mine in question is part of the Talnakhskoye mining department, which is a structural unit of the Polar Division of the Norilsk Nickel Mining and Metallurgical Company OJSC. In 1986, the work of the Skalisty mine began. The mine is built on the basis of three types of reserves of industrial ores: solid sulfide ores interspersed in the intrusion of gabbro-dolerite, copper - disseminated in sedimentary rocks and in lower intrusion rocks in the exocontact of solid ores. The Skalisty mine produces and ships to the consumer one type of marketable copper-nickel ore - rich marketable ore. The ore meets all the technical requirements for the quality of the shipped raw materials. Commodity ore arrives at Talnakhsky enrichment plant. The structure of the mine includes 3 industrial sites. The technological scheme of ore mass production includes: mining (drilling, blasting, mining); preparation of the filling mixture; delivery to ore passes; underground crushing complex; shipment of rock mass in skips; rise to the surface; ore mass transportation to a concentration plant; shipment of ore mass to the warehouse.

Analysis of the efficiency of energy use was carried out on the basis of data from reports on the consumption of fuel and energy resources (FER) of the main technological enterprises of the enterprise [3]. The following indicators characterize most fully the features of the energy

regimes of enterprises in general and of their individual productions: the volume of products (services provided, energy production) of technological and auxiliary production per unit time; general shop and (or) technological energy consumption for output; energy costs per unit (ECU) by type of product at appropriate intervals. An analysis of the tendency for these indicators to change at the initial stage makes it possible to preliminarily evaluate the energy efficiency.

In this paper, an analysis is made of the efficiency of electricity use in ore mining. The results allow us to draw the following conclusions: the dynamics of changes in ore production over the analyzed period is quite uniform; the values of the actual ECU were usually below the normative value. Analysis of the efficiency of energy use at the enterprise showed that, in general, the actual performance indicators are below the standard and recommended values. Nevertheless, the imperfection of the electricity metering system should be noted. For individual technological cycles, accounting is carried out by calculation, which does not allow for quality control of the rational use of electricity at the enterprise. Based on the reported data on electricity consumption by the enterprise, instrumental measurements and calculations of electricity losses, a balance was also drawn up on the electricity consumption of the enterprise, including the following consumption items: technological electric drive (53.81%); handling equipment (37.89%); welding equipment (3.13%); ventilation equipment (1.87%); operational-inevitable losses (1.26%); lighting (1.15%); other (0.89%).

In the period from 1980 to 2020, in the North Ossetia-Alania in North Caucasian Mining and Metallurgical Institute (State Technological University), a number of research projects were carried out for mining and metallurgical companies of the North Caucasus, devoted to issues of increasing the efficiency of energy use at these enterprises. Undoubtedly, an important and urgent task in the new economic conditions is to conduct an energy audit based on the methods available at the department at other mining and metallurgical companies of the Russian Federation.

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ANALYSIS OF THE ICE STORAGE SYSTEM INSTALLATION (THE INNOVATIVE THERMAL ENERGY STORAGE FROM RENEWABLE SOURCES)

The energy storage field is nowadays a highly ranking topic. This research deals about analysis of the heating system that combines heat pump, solar collectors and ice storage (Phase change material - PCM). The system can store the heat energy from sun into the ice storage tank. Research works with data from real operation captured in real time. The installation of ice storage system took place for the first time in Slovakia and Slovak Republic's conditions.

In Slovak conditions has yet not the ice storage system installed before and even tested. This is the first well known research which deals about the real installation and analysis of ice

storage heating system with special solar absorber, well known as the HDP (Header pipes), in the east of Slovakia.

The aim was to identify and describe the individual operating states from overall cycle of heating system. Research focused mainly on ice storage tank status and the time when behaved like phase change material. We managed to map out the entire spectrum of operating states, including the key part of the heating season.

The combined RES (Renewable Energy Sources) based systems using PCM heat accumulators are a new branch of technical solutions that are currently coming to the market, respectively in practice. It creates the space for mapping it out in more detail. In particular, this concerns the alternation of operating states differing in the behavior of the storage medium and the entire heating system. The big advantage is that in addition to the classic solar thermal circuit (heat from the air and solar radiation), this system also has another circuit with an ice tank. In addition, it is possible to store part of the heat from renewable sources in the ice tank for future use. The system therefore appears to be a potential system with low running costs, high efficiency, without adverse environmental impacts. Water is very specific material. It has many advantages as the large heat capacity, low cost and very common applications in the engineering field. Especially in the field of heating systems is water very beneficial. Moreover, depends on temperature behaves like PCM. The phase change materials are effective way how to gain and store energy. Heat thermal energy can be stored in three main forms: sensible heat, latent heat, and thermo-chemical energy. Ice storage system offers a space how to use latent and sensible heat. Especially the latent heat is one of the most useable energy forms in field of this type system. Thanks to the water capacity it is possible to recover the heat from the sun and store it into the tank (the storage). The phase change from liquid water to solid ice at 0 ° C releases as much heat as is necessary to heat the same amount of water from 0 ° C to 80 ° C. This represents 80 times greater energy. Phase transformations and the ability to extend as much as possible the time when storage behaves like PCM are very important part of the system. The specific enthalpy of the phase transformation is thus relatively high compared to the specific heat capacity. For water, the fusion enthalpy is 334 kJ / kg and the specific heat capacity is 4.19 kJ / kg. The result is that the energy density is considerably higher compared to hot water tanks. If one liter of water is cooled by 1 ° K, the 1.163 kW of energy is released. While the temperature remains constant at 0 ° C during icing, released the additional crystallization energy (93 Wh / kg) which can be used by the heat pump. It follows that storing the ice into a tank, has enormous energy importance. Phase conversion makes this system more efficient. Energy can literally be extracted from the ice. As the storage volume increases, so does the stored energy capacity and the PCM phase time. The results show that the thermal storage system is a highly effective system that increases the coefficient of performance (COP) heating factor.

The work was solved by the investigation method and analysis of collected data. The data were recorded in graphical and numerical form. Identifying specificities and thorough mapping is a prerequisite that it will be possible to efficiently adapt technical solutions based on conventional systems and optimize them for the new desired function, which undoubtedly lies in the importance of this work for the further development of science and practice. Analysis was performed and evaluated how effective this system is, in the energy storage point of view. The results shown the significant efficiency difference in favor of ice storage system compared to conventional heating systems. The seasonal coefficient of performance was almost 2 times higher than average.

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AUTONOMOUS COMPLEX FOR ELECTRO-THERMAL HEATING OF OIL WELLS FED BY A PHOTOVOLTAIC INSTALLATION

In the conditions of the low world prices for oil, even in the midterm, it will be extremely difficult to maintain the achieved level of oil production: the development of new fields will require additional funding by the state, and therefore it is necessary to increase the efficiency of production and transportation at the existing fields [1]. Currently, the Russian oil industry faces a continuing increase in the share of hard-to-recover reserves characterized by low-permeability reservoirs and high viscosity. In oil production, formation of paraffin deposits on the inner surface of pipe walls is one of major problems, causing significant complications in the operation of wells, oilfield equipment and distribution pipelinesAccording to the practice of oil production in the fields, the most intensive formation of asphalt-resin-paraffin deposits (ARPD) occur on the inner surface of tubing in wells. The formation of paraffin deposits results in a reduction in the cross-section area of pipes, an increase in resistance to fluid flow and rod string (for sucker rod pumping units) movement, increased loads on oilfield equipment, a reduction in the tubing throughput diameter, an increase in hydraulic resistance, a reduction in the performance efficiency of the pump units and a reduced production rate of oil wells [2]. In addition, the formation of paraffin deposits increases the risk of oil spills and causes substantial problems, including the following:

- oil production process shutdown;
- reduced system performance and efficiency of operation of pumping units;
- increase in costs for oil production;
- reduction in the overhaul period.

Currently, many existing methods are periodical and can only increase between-repairs run of the equipment, moreover, they have a number of other disadvantages, i.e. mechanical methods cannot be used for clearing the bottom-hole zone of a well, chemicals are not economically viable, special coatings for tubing are only a preventive method in terms of sedimentation of paraffin deposits, but do not eliminate its formation, magnetic and acoustic methods increase the rate of paraffin removal, but at high concentrations of paraffin deposits are not very effective [3].

To date, the most efficient methods of controlling the formation of paraffin deposits in tubing are thermal methods for providing thermal effect on a wellbore, based on the ability of paraffin deposits not to form a solid phase or melt at temperatures higher than paraffin crystallization temperature of 35-50°C [4]. From the analysis of the Russian solar power industry it was revealed that about half of the country's territory, not covered by the centralized solar power plant (SPP), is located in regions with high potential for using solar power. Based on the

analysis of potential for the use of solar power on the territory of Russia, close to oil fields, located far from the centralized power supply system, an autonomous complex for electro-thermal heating of oil wells fed by a photovoltaic installation was selected as a power source for the heating cable, providing thermal effect on the well.

An important task is to substantiate the structure and parameters of the electro-technical complex with a photovoltaic installation in order to increase the reliability and economic feasibility of the mineral resources sector facilities power supply. Heating of an oil well is carried out using a heating cable, placed directly in the inner space of the tubing in the oil well, which allows heating the wells to the required depth. Such a scheme for implementation of electric heating does not require underground work, and in some cases it does not need well shutdown.

Energy characteristics of a solar photovoltaic installation depend on two main factors: the parameters of the photovoltaic battery and the characteristics of its photovoltaic cells; solar radiation flux intensity in a particular place and under specific conditions. To calculate the flux of solar radiation, the method by John A. Duffie [5] was used. This technique considers the effect of the external climatic factor on the energy characteristics of the solar battery, thereby increasing the accuracy of forecast calculations in terms of power generation for the region under consideration.

According to the results of mathematical and computer modeling in the environment of Matlab Simulink, energy characteristics, design features and composition of the photovoltaic installation were determined with the aim of uniform distribution of the amount of solar radiation throughout the year. Thermal calculations were performed taking into account the VNIIneft methodology for determining the temperature of oil saturation with paraffin [6]; methods for calculating the heat transfer coefficient in the well [7]; methods Kuptsova S.M. to obtain the distribution of oil temperature in the borehole [8].

Thus, the possibility of using autonomous energy complexes based on a solar power station to power electric stations for heating oil wells using a heating cable is shown. It has been established that the concentration of paraffins in the produced oil significantly affects the required installed capacity of energy sources.

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DEVELOPMENT OF INFORMATION SYSTEM FOR FORECASTING PARAFFIN DEPOSITS IN PIPELINES

One of the most promising directions in the development of automation is the creation of forecasting systems. In oil industry, particularly, in oil transportation, an intensive search is being conducted for the possibility to predict paraffinisation of equipment [1]. The increased demand is caused by a continuing increase in the share of heavy oils in oil production and an increased number of transportation lines, located in regions with severe climatic conditions. Moreover, the development of such a system will help solve another important oil transportation problem: the risk of oil leakages [2].

The main problem, when it comes to creating a forecasting system, resides in insufficient state of knowledge as of the process of paraffinisation. To date, according to scientific papers, known is a number of factors affecting paraffin formation, but due to the complexity of this process, the creation of a formulaic dependence of paraffin formation on physical factors does not seem possible on the theoretical side [3]. The aim of this science work is to develop technically feasible and economically viable methods for determining the relative weight of physical factors in paraffin formation.

Studies of the latest techniques in the oil and chemical industries revealed, that the best and the only possible way as of today to achieve the goal formulated is to measure the values of all the affecting factors at the moment of paraffin formation and to perform further analysis of the array of measurements obtained that can be advantageously implemented via neural networks. Thus, the main problem on is the composition analysis of the minimal system of sensors and measurement protocols that can provide highly-precise determination of the values of all physical parameters at the moment of paraffin formation, as well as determine the method of collecting the desired data, characterized by minimal costs.

To fix the values of all physical variables at the moment of paraffin formation, first of all, it is necessary to provide the system of sensors with a device capable to identify the point of time for taking it as a point of reference, i.e. with a signaling device that notifies on the beginning of paraffinisation at early stages of formation of deposits. To date, the only known method that corresponds the task formulated is the detection of pipeline paraffinisation by comparing the attenuation coefficients of two gamma rays, located in a certain manner relative to the pipeline cross-section [4]. The measuring method is based on the Lambert-Beer law:

$$I = I_0 \cdot \exp(\mu \cdot \rho \cdot d),$$

where I is the intensity of the attenuated radiation, I_0 is the initial radiation intensity, μis the mass attenuation coefficient of radiation by the medium, ρ is the density of the controlled medium, d is the linear size of the controlled medium.

For forecasting of paraffinization it is necessary to determine the following physical values: the concentration of high molecular weight hydrocarbons of paraffin series, water-cut, the pressure in the pipeline, the speed of oil flow, the roughness of pipeline inner wall, the temperature of the oil flow, the temperature difference between the oil flow and the pipeline, the thickness of the formed layer of paraffin deposits. Based on conducted science work all desired data can be collected through developed measuring system. The developed system of sensors will include three, different in design, radioisotope measuring devices, a system of temperature sensors and standard electric drive sensors for pumping equipment.

To date, conducted science work presents a non-contact, fully automated, highly-precise measuring system, having no analogues neither in Russia nor abroad, capable of signaling on the formation of a paraffin layer at the early stages and recording the values of all physical factors

affecting paraffinisation. The developed system of sensors is characterized by the absence of contact with the medium being measured, full automation and minimum number of elements.

The implementation of the developed unit will increase energy efficiency of electric heating of pipelines by 36%, thereby bringing economic benefits to the enterprise even at the stage of data collection. The information obtained and processed via neural networks will be the main part of the forecasting system for controlling pipeline paraffinisation. The use of the collected information has great prospects for the creation of an algorithm that, according to the set parameters of the oil pipeline under construction and optimization (oil properties, climatic and geographical conditions), will be able to derive reliable and economically feasible systems for controlling paraffin formation and calculate its parameters.

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DEVELOPMENT OF A METHOD FOR SHORT-TERM FORECASTING OF ELECTRICAL LOADS

Regulation of the electric load schedules will allow to ensure a high value of the utilization factor of the installed capacity of power plants and to reduce losses in electric networks. However, when solving the tasks of regulating the schedule of electric loads, it is impossible to ignore the question of their forecasting. This process provides basic background information for decision-making in the management of power systems, including for consumer control of regulators and for the formation of the composition and functioning algorithm of energy storage devices.

To date, a large number of methods and models for predicting the electrical load of energy systems have been developed [1-3]. Existing methods can be divided into two categories: classical and intelligent forecasting methods. Among the classical ones, analytical, statistical and probabilistic methods can be distinguished. Intelligent methods include expert systems, as well as more modern ones: various types of artificial neural networks and machine learning. However, the analysis of the developed forecasting methods showed that their practical application is associated with some difficulties. Some methods lead to significant errors in the

estimation of predicted values due to the violation of certain assumptions used in the construction of forecasting models. Others are not widely used for solving practical problems due to the complexity of the mathematical apparatus. For example, analytical methods are practically not used to solve the problems of forecasting electric load in distribution networks in view of the large dimensions of mathematical models.

Given the above features of forecasting methods, three ways of forecasting from different categories are considered in the work: regression forecasting methods, a generalized method of exponential smoothing, and artificial neural networks.

The regression forecasting method is one of the simplest and most widely used statistical methods. The data method is based on the application of regression analysis (multiple regression). The term multiple regression is explained by the fact that one feature (resultant) is dependent on a set of independent (factorial) features.

The generalized method of exponential smoothing is popular in energy supplying organizations. The essence of this method is that the time series is smoothed out using a weighted moving average, in which the weights defy the exponential law.

An artificial neural network is a mathematical model of the human brain, consisting of many simple computational elements (neurons) working in parallel, the function of which is determined by the structure of the network, and the calculations are performed in the elements themselves. The role of the neural network in solving forecasting problems consists in predicting the future reaction of the system according to its previous behavior. Having the initial information about the values of the studied variable at the time moments preceding the prediction, the neural network makes a decision about what will be the most probable value of the predicted parameter at a given moment in time. Each of them was implemented in the Matlab software environment.

As part of the study, the task was to assess the impact of the nature of the load on the forecast error, since the analysis of the load schedules of enterprises in various industries shows that the uniformity of electricity consumption in them differs significantly, which can affect the accuracy of the forecast. To solve this problem, load schedules with various shape factors were modeled. This indicator characterizes the unevenness of the load schedule: when $K_f = 1$ the load practically does not change over time.

As a result of the simulation, the mean absolute error values were obtained for each of the selected forecasting methods for various shape factors of the predicted load curve. Hourly forecasting errors were also calculated. Having analyzed the obtained dependencies, we can conclude that the forecasting accuracy worsens with an increase in the unevenness of the load curve. It is also worth noting that the classical forecasting methods in some hours gave a more accurate forecast than the neural network and vice versa, on the basis of which it can be assumed that the most accurate results can be achieved through a combination of different methods. When modeling using the combined forecasting method, in which classical methods were used to predict the so-called basic component in load changes, and neural networks to predict the random component, the smallest error values were obtained for each form of the predicted load graph, which proves the effectiveness of its use.

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ENHANCING THE ENERGY EFFICIENCY OF THE RAW MATERIAL COMPLEX BY APPLYING INTELLECTUAL MONITORING OF THE DISTRIBUTION NETWORK

The paper proposes a structure of monitoring electrical parameters of a distribution grid and the transmission of data through a local area network in order to generate control signals, ands hence actions on power corrective devices to maintain high quality indicators of electric power among consumers of the raw materials complex.

One of the main factors providing both indicators of the quality of electricity and voltage levels in the nodes connecting consumers are reactive power flows. To ensure reactive power balance, additional sources generating reactive power Q_{CD} are installed near it's main consumers, and then

$$\sum Q_G + \sum Q_{CD} = \sum Q_L + \sum \Delta Q.$$

where $\sum Q_G$, Q_{CD} - generated reactive and additional power; $\sum Q_L$ - total reactive power of consumers; $\sum \Delta Q$ - the algebraic sum of the reactive power losses and charging power networks.

With minimum load conditions in the system there is an excess of reactive power, equation (1) violates, as a result, voltage in grid nodes and consumers increases. Hence required optimization of reactive power mode in the power supply system of an industrial workshop(raw-material complex), - selecting the type and power of compensating devices and their installation locations.

There are different compensating devices (CD) to reduce the reactive power flow in the grid elements. By adjusting the operating mode of the compensating device in accordance with the nature of the changein the reactive power of the loads in the network nodes, it is possible to maintain the voltage in these nodes within the specified limits and reduce the loss of active power and, accordingly, the loss of electrical energy in the network elements. The most effective CD option for reduction and increasing of reactive power is the inclusion of high-speed static reactive power compensators (SVC) [1].

As a rule, to control SVC included in a network node, an autonomous control system is used, which may not take into account the state in more remote nodes of a distributed grid. For a more correct effect on the network in order to maintain the required voltage or power factor, the SVC must be connected to a specific network design node, and it must be controlled by a control signal that evaluates the state of the monitored grid. For this purpose, the SVC control system is included in monitoring of the state of the network, as a result of which an adjusted control action is generating on the SVC control unit and the resulting effect on the network parameters is becoming more optimal.

Information about the state of the grid parameters is coming from current and voltage sensors located in the nodes of the distribution network and is being transmitted to the monitoring unit and the data processing controller via the data transmission module through the local area network. The network status parameters are being compared with the values set by the operator, as a result control signals are generated on the corresponding execution units. The control data, likewise, is being transmitted through the local area network to the control units of executive devices.

Additionally controller contains the module of pattern recognition of operating modes of consumers and emergency situations based on a neural network and known topological methods for analyzing electrical circuits.

The thing of interest about the proposed solution to the monitoring problem is processing of data in the distribution network parameter controller based on the combined matrix method[2, 3]. The concept of this method is to replace investigated by an electromagnetic circuit, which is understood as a combination of electrical and magnetic circuits connected by a winding system. Processes in such circuit are described by a system of equations for complex variables:

$$E_K = Z_K^E I_K + Z_K^{EM} F_K$$

$$0 = Z_K^{ME} I_K + Z_K^M F_K$$

where Z_K^E, Z_K^M, Z_K^{EM}, Z_K^{ME} - matrix of circuit resistances of an electric circuit, magnetic circuit, electromagnetic and magnetoelectric coupling, E_K, I_K - matrix EMF and circuit currents.

The loop current matrix is a solution for this system of equations:

$$I_K = \left[Z_K^E - Z_K^{EM} \left(Z_K^M \right)^1 Z_K^{ME} \right]^{-1} E_K$$

Loop resistance, loop current, loop e.m.f. matrices are connected with branch resistance, Z_K^E branch e.m.f., E_B branch current , I_B matrices by the following correlations:

$$E_K = G_{EE} E_B \qquad I_B = G_{EE}^T I_K \qquad Z_K^E = G_{EE} Z_B^E G_{EE}^T$$

where G_{EE} - contour-branch matrix of the electric circuit.

The parameters of the wire connections of the distribution grid of a raw material complex are entered into the data of the resistance matrix, on the basis of which the values of currents, capacities and voltages are generated in the required grid nodes.

The use of a matrix analysis of grid parameters in the monitoring grid of the distribution grid to generate control signals for corrective devices allows solving grid optimization problems by criteria related to minimizing reactive power losses in order to select and install reactive power compensation devices and control them.

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TECHNOLOGY OF INDUSTRIAL STORAGE OF ELECTRICITY: SOLID AKKUMULIRUYA POWER PLANT

Abstract: this thesis discusses the basic theory, principles of accumulation of electric energy with the help of technology in industrial drives electrical energy capacities more 300 MWh replacement of pumped storage power plants(PSPP) in a more environmental and safe solid-state storage power plant(TNPP).

Key words: electric energy, hydroaccumulators power, solid-state storage power plants, energy cell, loads, main drive, industrial drive.

The world is waiting for a radical change in the electricity industry, which will change not only the industry, but also our lives, because electricity for us all. Power generation is based on three components: generation, transmission and consumption of energy. In this chain there is a fourth element, which previously was virtually non-existent storage. It is fully pereformuliruem system. And therefore, there is a technology for the industrial storage of electricity. Are considered optimal and efficient storage of electrical energy with a capacity over 300 MWh: solid-state storage plant, the optimal solution on problems PSP (pumped storage plant).

First pumped storage plant consumes electricity in order to pump using a pump water from the lower pool to the upper, and at the same time produces it (energy) when water flows from the upper pool to lower under the force of gravity. This accumulation of pumped storage power plants, causes environmental damage and a large number of use of labour resources.

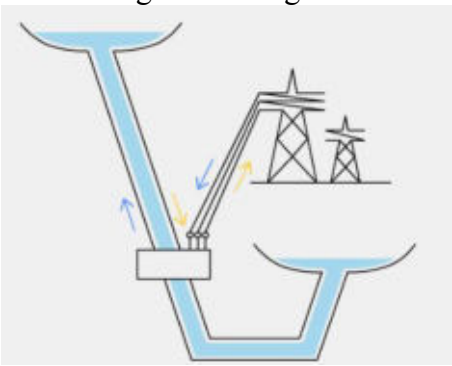

Figure 1 - The Principle of operation of HPSPP

The principle of operation of SSPP is completely analogous to the principle of operation of pumped storage power plants (HPSPP). That is, consumes power when lifting loads to a height of several hundred meters, and generates electricity when lowering the cargo, under the action of gravity. Specific capital costs for future capacity growth may fall faster, and increase power slowly and naturally become economically justified, since the values of capacity of 300 MWh.

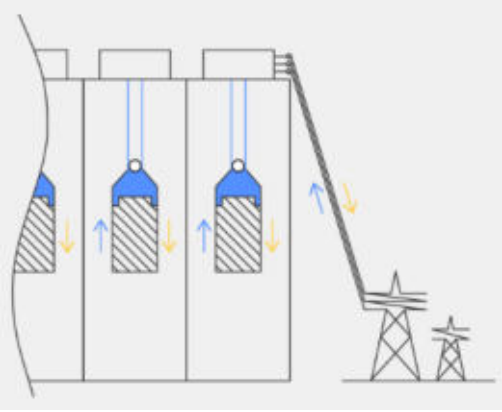

Figure 2 - the Principle of operation of SSPP

Technical advantages of SSPP on HPSPP:

1. can be built on any flat terrain;
2. environmentally safe operation;
3. the coefficient of performance of the cycle not less than 80%;
4. the use of automated management;
5. the device is resistant to seismic and wind loads;
6.there is no man-made threat outside the TPP.

This technology of an industrial electric energy storage device provides opportunities for future development and great market demand in the energy sector, which is so relevant and necessary today.

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THERMAL CONDITIONS CALCULATION OF THE POWERFUL THYRISTOR CONVERTERS

Traditional electric-power industry leads electricity market. World situation of this field wouldn't change a lot in the nearest future [1], so researches in this area are relevance. Hydroelectric power plants currently used synchronous machines with excitation systems. An excitation system is necessary to control the generator voltage, transmitted to consumers [2]. The excitation system of a synchronous generator includes an excitation transformer and an excitation cabinet. The excitation cabinet includes a thyristor rectifier. Currently the production faces the task of reducing the costs by eliminating design errors. So, it is extremely important to take into account all heat losses of the synchronous generators' excitation systems at the design stage.

The goal of research was to minimize design errors when calculating the heating rate of the thyristor converter for excitation systems of the synchronous generators with forced air cooling by creating software methods for calculating the main parameters of such systems. We chose the system with forced air cooling, because if we create the design procedure for such system, we can change it and create new the design procedure for excitation systems with self-cooling and forced water cooling.

That goal could achieved, if the problem of the most accurate selection of an analog for the excitation cabinet is solved at the development stage. An analogue is a ready-made excitation cabinet with selected elements of the system (semiconductor elements. heatsinks, coolers, fuses, etc.). The chosen analog is finished at further design stages. It was decided automatically increasing the number of excitation cabinets analogs taking into account the new line of thyristors by systematizing disparate design procedures and creating a single one with the specification of a reasonable margin in power (temperature) to increase the speed of preparation of technical and commercial proposals and to make more correct the cost of the products. Previously, the power margin was adopted by the empirical experience of the engineers.

The main sources of heat loss of the excitation cabinet were identified. These are thyristors; fuses; AC and DC buses; cooling fan motors; a field blanking machine; a controlled disconnector. A powerful rectifier takes up 60-70% of the cabinet space of the thyristor section, so the overall cabinet size and operating parameters determine by the efficiency of the cooling system [3].

It was said in the [3], that the heat removal from the thyristor is two-level. First, heat is transferred from the p-n junction through the valve body to the cooler and then ones is transferred to the volume of the section. At the second level, the total heat of the section is discharged into the environment. The literature provides many examples of studying the thermal

regime of the individual elements that are a part of the excitation cabinet. However, those solutions are not take into account the heat exchange of the elements with each other.

Thyristor is the most important converter part of the excitation system. The characteristics of the thyristor have a nonlinear temperature dependence, so itis important to maintain the crystal temperature not exceeding the maximum value that indicated in the documentation for the device. Also, the thyristor's thermal mode of operation has affected by the structure of the thyristor, its geometrical dimensions, the configuration of the cooler (heatsink), the presence and absence of forced cooling (in this work, forced cooling is carried out using a fan), operating parameters [4].

The heat that a semiconductor device could transfer to the environment determines its load-carrying capacity. Engineers uses the Larionov circuit to convert the alternating current of a three-phase network, i.e. a six-pulse bridge rectifier, for such systems. The main parameter of the converter is a rectified current. This current is called the continuous current-carrying capacity of the excitation system, which exceeds the rotor current by 10%. A continuous current-carrying capacity flows through the thyristor. Thereby it is determining its thermal operating mode and losses in it. The study took into account that additional heated of the thyristor section air is created by the fuses, the fan motors and the AC and DC buses. So the losses of excitation system busbar were clarified and reduced to the dependence on the continuous current-carrying capacity for the excitation system.

Thus, during the research, all the main types of excitation cabinet losses were clarified. The dependences of these losses on convertor's the continuous current-carrying capacity were also derived. The reduced busbar length of the excitation cabinets with forced air cooling was found. All of this was the basis of the design procedure for calculating the converter's parameters for the excitation systems of the synchronous machines.

In the course of work, the program in the MATLAB language was created to automatically select an analogue of the excitation system according to the set parameters of the generator. It has a graphical user interface. The program is used for the design of excitation systems for hydro- and turbogenerators currently.

The program was tested by using the accumulated base on the parameters of the installed excitation systems (Gomel TPP-2, TPP-12 Mosenergo, CHPP-22 Mosenergo) and it was based on using the data of the thermal tests of the excitation cabinet of the Volga hydroelectric station. The relative calculation error in comparison with the experimental data do not exceed 5%. Therefore, the developed method is correct and the program for automatic selection of thyristor sections is adequate.

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Session 8. CLIMATIC CHANGES, ENVIRONMENTAL ACTIVITY, AND PRINCIPLES OF SUSTAINABLE DEVELOPMENT IN THE MINING FACILITY

Sustainable development of regions and environmental safety

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ANALYSIS OF ECOLOGICAL IMPACT ON THE ENVIRONMENT OF QUARRY DUMP TRUCKS OPERATION

Heavy-duty mining trucks are widely used in the development of deposits of various minerals in an open way. The work of a column of cars in a quarry to transport rock from the face to a rock-crushing plant and screening plant is accompanied by a significant impact on the conditions of staying at the quarry of the employees, as well as on the environmental situation in the region.

The main factors that negatively affect the operation of a column of heavy-duty vehicles are exhaust gas emissions from diesel internal combustion engines, increased dust content from the interaction of wheels with the surface of technological roads, and also solid waste resulting from intensive tire wear. For example, the wear of only one tire of a mining dump truck with a carrying capacity of 60 tons during the full service life of three months leads to the formation of fine crumbs along the route up to 100 kg, and the gross emission of pollutants into the atmosphere from the engine of the same machine can be up to 4 tons.

The authors have conducted a quantitative analysis of the factors mentioned above and have developed the main ways for improving the environmental situation during the operation of mining dump trucks. Thy include the following: application of modern filters in the exhaust system of the engine; the formation of optimal technological routes taking into account the reduction of transient modes of operation of engines; constant monitoring of the condition of the surface of the tracks on the ledges of the quarry and the road from the pit to the crushing and screening plant and the organization of work to reduce dust generation during the movement of vehicles; development of recommendations for optimization of operating modes of machines, taking into account the climatic conditions in the quarry; development of projects to improve technological schemes using optimal dump trucks.

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TEMPORARY CITIES

Currently, about 7.5 billion people live on the Earth. There are 50 cities with a population of more than 5 million people; about 50 thousand cities are abandoned. And also temporary cities began to arise.

Let's take a look on some of them.

The first temporary city is built for the Kumbh Mela festival (a Hindu religious festival). 7 million people live in this city for 55 days, and another 100 million visit it. The construction of the city of 30 sq km (11,6 sq miles) takes 10 weeks.

This city has all the properties of a metropolis. The city plan is a system where each street passes across the river via a pontoon bridge. The city itself adapts to a place with changeable relief. There is physical infrastructure and social as well.

The city is built without a foundation. Five materials are used for construction: bamboo, ropes, nails or screws, corrugated metal or plastic and fabric, which are combined with each other. This set of materials is used within entire design. At the end of the festival, the whole city is disassembled and disappears within a week, leaving no trace behind. And the earth is getting covered with water again.

Burning Man festival takes place in the Black Rock desert in Nevada. Participants and organizers build a tent city in the shape of a semicircle there. This temporary city has necessary infrastructure. After the end of the fest, the participants and organizers take all the rubbish away.

About a billion people currently live in temporary settlements that look like slum camps. Here, the temporary becomes permanent. Here, urban development is not based on development opportunities, but on the ability to adapt. People build their homes from a set of materials found at hand (cardboard, corrugated metal, wood, etc.).

In Caracas, the capital of Venezuela, slums have captured almost 70% of the population. The slums determine the appearance of the city. In this city, people adapted for life the unfinished, abandoned tower of David, a 45-story office building located in the city center. The tower has been turning into a small city with a growing microeconomics and small business.

Another examples of temporary building that we can observe in everyday life are: temporary camps at the construction site, traveling circuses and markets. A temporary hospital of 1000 beds was built in 10 days in China. The hospital is a 2-story building, assembled from ready-made blocks. Such spaces are built quickly and such building can be easily and quickly disassembled into blocks. Moreover, this way of constructing is very economical.

Temporary 12-meter tower by (Architect) David Benjamin was built from brick, consisting of the fungus mycelium.

Microbiologist and artist Philip Ross discovered that the mycelium of mushrooms suits for building because of its high strength, moisture and fire resistance. Besides, it is stronger than concrete, while it is surprisingly light. It can be grown in any shape. And mycelium grows in just a couple of days. After each block is heat-treated and all organisms die, the fungi will not germinate again. This is an environment friendly material, since agricultural waste (for example, sawdust) and mycelium are used for its manufacture. Cement is used for concrete, which increases carbon dioxide emissions. Backwards, mycelium produces oxygen. Houses made of this material can be a serious step in the fight against global warming and climate change, reducing the cost of building materials and greenhouse gas emissions.

At Danish Design Week, the Creative Organization Company New Heroes and the biotechnology company Krown Design based their building project on mycelium usage. When the “walls” were ready, the creators pulled out the mycelium so that they would not continue to grow. It was difficult to predict what color and ornament the walls would grow; they formed a kind of organic skin instead of the flat white surface of artificial houses. However, the building turned out to be beautiful natural shades, with a unique texture.

We should think about the rational use of the planet resources to extend its life. In today’s approach to urban development, permanent solutions are used for something temporary, although it is uncertain whether this construction will be relevant in 10 years. A huge amount of materials, resources is spent on what may soon become unnecessary. We should move to the side where more space is given for temporary use. There is nothing more permanent than temporary.

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ASSESSMENT OF ECOSYSTEMS IN THE AREA OF MINING AND PROCESSING OF MINERALS

When mining and processing non-ferrous metal ores, the main environmental impact according to field studies is noted on the soil horizon. The impact on the soil varies depending on the source of pollution in densely populated areas, which usually occupy convenient and profitable locations. For this reason, the purification (restoration) of soils from excess masses of pollutants is a very urgent task. Its practical solution is still under development. One of the possible ways to solve this problem can be phytoremediation - clearing the soil cover from contamination by cultivating plants that actively absorb pollutants. Phytoremediation is a highly effective treatment technology for a number of minerals. Plants can be used for cleaning solid, liquid and air substrates [1-3]. Phytoremediation of polluted soils and sedimentary rocks is already used for cleaning military landfills (from metals, organic pollutants), agricultural land (pesticides, metals, selenium), industrial zones (organic, metals, arsenic), woodworking sites (PCBs). Urban wastewater, agricultural and industrial wastewater, and ground water can be subjected to phytoremediation [4].To achieve maximum cleaning efficiency, phytoremediation can be used in combination with other bioremediation methods and non-biological cleaning technologies. For example, the most polluted parts of the substrate can be removed by excavating, after which further cleaning can be carried out using plants.

In ecosystems with a mining and processing component, there is a multi-factor effect of production processes on the local ecosystem of the area, which contributes to the development of a negative impact on the flora and fauna, so research aimed at studying the development of each of the factors is an urgent scientific and practical task. Given the long-term observations of the population living in this zone, it can be stated that the level of destruction of plant growth and development reaches significant values due to changes in the taste of horticultural products(apples, pears), not to mention the manifestation of trends to the disappearance of some species of biodiversity. All the above mentioned served as the basis for the authors choice of the research object - local ecosystem of the Sadon lead-zinc mining complex.

The development of technology for detoxification of the soil horizon of technogenically polluted lands by the activities of the mining and industrial complex in the spurs of the North Caucasus mountains is an urgent scientific and practical task. As a result of research on the territory of mining facilities, a matrix will be created that includes the stages of using proven means and methods for neutralizing technogenic components introduced into the soil as a result of the development and operation of polymetallic ore deposits in the mountainous areas of the North Caucasus. Resuscitation of land contaminated with heavy metals will open up new opportunities for effective environmental management in the low-land conditions of mountain provinces. Conduct field studies of soil loss of plant nutrients due to the accumulation of heavy and toxic metals, and other man-made factors affecting the formation of soil horizon will allow you to create the recovery model of the soil in this area taking into account climatic factors.

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THE ECO-FRIENDLY PRODUCTION PROJECT

Industry makes up 1/3 of the GDP of the Republic of Kazakhstan, especially the industry of mining and processing. Most enterprises in this sector of the economy are city-forming, therefore, environmental connivance in this area is unacceptable and can cause environmental disaster. The development of anthropogenic civilization in the 21st century objectively requires the evolutionary process of restructuring metallurgical industries based on high technologies and highly efficient equipment. We present our main theses for creating environmentally friendly industries in following article. The eco-friendly production (EFP) project is considered by the example of ArcelorMittalTemirtau JSC [1,2].

We have proposed certain changes in the basic production technology and its hardware design, organization of closed production cycles; rational use of raw materials, reagents, materials and energy resources; reducing the consumption of extremely dangerous and highly hazardous substances and materials; use of secondary raw materials and energy resources; integrated use of raw materials and energy resources; organization of flows of pollutants; prevention of the occurrence and development of environmental emergency situations and actions in such situations; monitoring of sources of emission of pollutants and sources of waste generation [3].

The main actions and activities of a technical and technological nature, aimed at expanding and developing environmental marketing at industrial enterprises, including metallurgical ones, will be considered in accordance with our proposed development option for the Environmentally EFP Program (Figure 1).

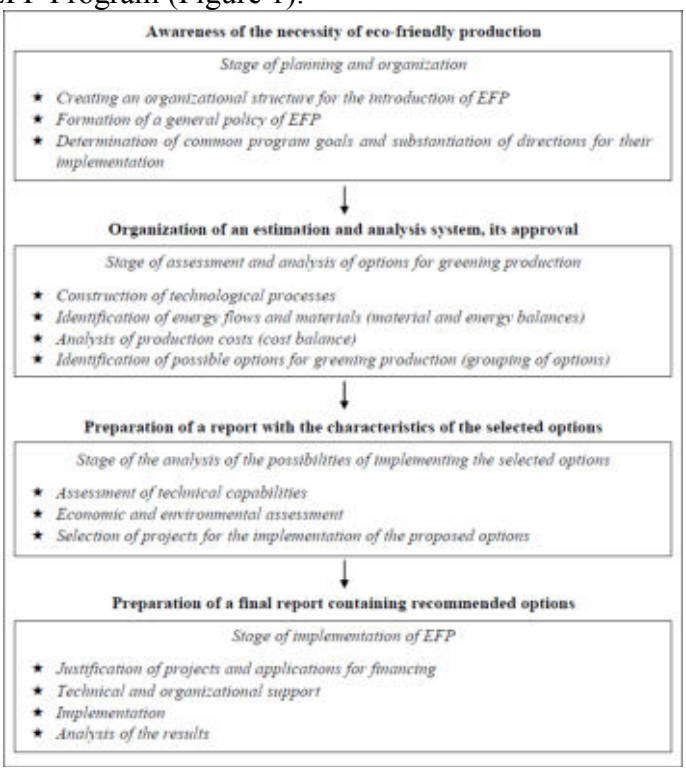

Figure 1 - The eco-friendly production process

The proposed activities, in our opinion, will contribute to the establishment of an environmental marketing system in the Republic of Kazakhstan. This is not a matter of one decade, but now it is necessary to lay the basic institutional foundation of this system. We think it is not superfluous to repeat that, unfortunately, environmentally friendly enterprises are present only fragmentarily, and they also do not take advantage of environmental marketing. It is necessary to make extensive use of foreign experience in this area. It began with the construction of strict environmental legislation with extensive economic subsidies for green initiatives of industrial enterprises. This is the main short-term task, which is essential for the green economy of Kazakhstan.

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CHALLENGES AND OPPORTUNITIES OF ENERGY TRANSITION AND IMPACT ON SUSTAINABLE DEVELOPMENT IN AFRICA

The natural gift of Africa's recent discoveries in oil and gas go along with the expansion of renewable energy generation. About 630million people live without reliable access to electricity, and 790 million people involuntarily rely on solid biomass to cook their food and heat their homes. The after-effects are pollution, deprivation, environmental damage, drudgery, and declined achievement in sustainable development.

This paper exposes key issues that will delay changeover from coal energy to renewable sources, benefits on sustainable development and possible recommendations of bringing modern energy to all in Africa.

Data collected for this paper mainly included secondary sources focusing on relevant literature including policies and legal documents, newspapers, interviews etc.

Observing a majority of fossil fuel industries in Africa, energy transition presents a slow movement on phasing out of coal through efficient renewable alternative (biomass, wind, solar, and hydro-power potential) and meeting up with the scale of a growing population using technologies. Modernization and expansion are major challenges of Africa's energy transition. The achievement of 2030 Agenda for Sustainable Development are and will be compromised because of the dual hindrance of vulnerability and least adaptation capacity on the present and future impacts of climate change in Africa.

Added to a shift and increase in labor demand as per this transition, the transformation from high-carbon to low-carbon and from more to less polluting technologies, processes, and products improve climate mitigation and environmental rehabilitation.

Contradictorily, the closing of inefficient coal mines involving pollution, energy and materials-intensive economic activities will eliminate some jobs that are coal reliant.

This paper recommends that developing and upgrading skills through education/training within the energy curricula, advancing entrepreneurship, engaging policies to facilitate foreign cooperation and investment will enhance sustainable development and efficient energy for all.

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THE METHOD OF DISPOSAL OF CELLULOSE AND LIGNIN-CONTAINING WASTES OF THE LEBANESE REPUBLIC BY OBTAINING OIL ABSORBERS

In the Lebanese Republic, the issue of the rational utilization of large-tonnage cellulose and lignin-containing wastes of woodworking and agriculture remains unsolved, and their storage in dumps is seriously harmful to the environment as a result of leaching of extractive substances, anaerobic decomposition and possible spontaneous combustion. At the same time, the modernization of oil terminals, oil pipelines and the upcoming development of offshore oil and gas deposits in the Lebanese Republic require studies to reduce the environmental burden while eliminating and localizing the possible ingress of oil and its components into ecosystems. From 5 to 10 million tons of oil products enter the environment annually into the environment (which makes up 5-7% of all extracted and processed raw materials). On average, during a single accident of an oil pipeline, 2 ... 2.5 tons of oil is emitted, rendering it unusable over 1 km2 of land. One ton of oil pollutes 12 km^2 of the water surface. The water content of petroleum products above 0.1 mg / l gives the fish meat an unavoidable aftertaste and a specific smell of oil. Petroleum products in the soil irreversibly inhibit the development of plants at a concentration of more than 2 g per 1 kg of soil (this is the threshold of phytotoxicity) [1].

The development of the technology for producing low-cost oil sorbents for the collection of spills of oil and oil products based on natural cellulose or lignin-containing waste with high sorption characteristics and having an organic base was the goal of this study.

Over ten samples of cellulose- and lignin-containing waste from woodworking and agriculture were selected in the Lebanese Republic. Preliminary mechanical processing of the samples was carried out to obtain oil absorbers: drying, grinding to a particle size of up to 1.0 mm by dry mechanical grinding in a mill and fractionation of laboratory sieves. An input structural and mechanical analysis of the samples was performed: relative humidity, pH of the aqueous extract, bulk density were determined; the amount of substances soluble in cold and hot water and subjected to alkaline decomposition. The analysis of the adsorption capacity for iodine and methylene blue samples for the production of oil absorbers. The method of "molecular probes" determined the total pore volume. Performed by analysis of the microstructure of the samples. Oil absorption, water capacity, buoyancy, and the degree of extraction of oil absorbers were determined by the methods described in [1].

It has been established that it is promising and economically feasible to use large-tonnage cellulose- and lignin-containing wastes of the wood processing and agriculture of the Lebanese Republic as local, affordable and inexpensive sinks in the process of liquidating emergency oil spills of oil products (treatment, concentration and disposal) due to the following factors:

- the studied wastes are capillary -porous structure and they can be attributed to volume-porous absorbe;
- the moisture content in the samples does not exceed 5% wt., which indicates high ability to dry samples; potentiometric titration established that the water extract has a slightly acidic environment, and the bulk density of the samples averages 20 ... 70 g / 100 cm^3, which is comparable with industrial absorbers;
- the static contact angle of the studied samples with water is greater than 90°, which allows us to predict their good buoyancy and water-repellent properties;

- iodine adsorption activity of the studied samples, characterizing the volume of micropores (about 1 nm) and the ability to sorb relatively low molecular weight organics, is comparable to the industrially produced enterosorbent brand "Polyfam" (about 30%).

- adsorption activity by methylene blue, which allows us to judge the content in the sample of pores with effective diameters of 1.5 ... 1.7 nm is similar to that given for activated carbon (about 210 mg / g).The treatment of samples with water and alkali, in most cases, leads to an increase in adsorption activity for methylene blue due to the formation of additional pore sizes of 1.5 ... 1.7 nm;

-using the molecular probe method, it was established that the samples under study are characterized by highly developed total porosity (total pore water reaches 0.5 ... 6 cm^3/g) with a wide distribution of pore sizes. According to this indicator, the proposed absorbers are comparable with industrial analogues, the total volume for activated carbon is not less than 0.8 cm^3/g;

- the proposed samples for the production of oil scavengers are superior to the analogues used in industry, both in terms of some basic performance characteristics (oil absorption, moisture capacity, buoyancy, degree of extraction), and cost. For crop waste, the cost-effective sorption capacity of absorbers in the untreated form of more than 3.0 g / g for oil, base oil and diesel fuel has been established. Heavy oil products (for example, base oil) are absorbed by all samples much more efficiently than light products (for example, kerosene), which is associated with an increase in the adhesive bond energy of the sorbed substance with the sorption surface and differences in the physicochemical properties of these oil products.It is noted that the oil absorption of the waste under study correlates with the cellulose content in the sorbent. The higher the cellulose content in the sample, the greater the degree of absorption of the oil product;

- the results of the analysis of sorption ability showed that the studied samples are suitable for collecting spills of oil and oil products both in untreated form and their residues after processing the feedstock with water and a weak aqueous solution of alkali.

A rational method is proposed for the disposal of cellulose or lignin-containing wastes of the Lebanese Republic by obtaining oil scavengers, due to the ecological purity of the waste, a wide raw material base, and sufficient oil intensity at low cost, they can compete with industrial analogs, and their use will reduce the environmental burden and have an economic effect.

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CRITICALITY OF PHOSPHATE FROM THE PERSPECTIVE OF EMERGING COUNTRIES: THE IMPLICATION OF SOCIAL AND ENVIRONMENTAL SITUATION OF MINING REGIONS

The first time the term critical appeared was prior to World War II in the Strategic and Critical Stock Piling Act of 1939 for the USA (National Research Council, 2008). The driver was the military needs. After that, the term appeared again after the oil crisis of the 80s, in the context of establishing the list of national critical materials. An update of criticality definition appeared in the late 2000s during the financial crisis. Thereby the (National Research Council, 2008) gave a broader definition to critical materials “to be critical, a mineral must be both essential in use and subject to supply restriction”.

The interest to assess the criticality of natural resources is linked to the national interest in the time of international economic crisis. In addition to the historical context of criticality assessment, the current way to calculate the criticality dimensions of a mineral has a narrow nationalistic view. Thus, the economic importance takes into consideration the interest of developed countries in opposition to the supply risk, which is expressed mainly by the socio-political instability of countries producing those minerals, which in many cases are emerging countries. This is a binary form to describe sustainable access to minerals in a globalized economy. This binary form of expressing criticality classifies the developed countries and the developing countries into two opposite and disconnected sides of the criticality equation. In global market conditions and according to a sustainable development framework, national interest cannot be entirely independent of international and global conditions.

Moreover, tackling the problem of material criticality from a national interest perspective is essential to increase the competitiveness of countries. However, solutions need to be designed to encompassing sustainable development values. The investigation on critical material needs not only to bear in mind the right of future generation to fulfill their need but also to achieve some of the SDGs such as no poverty, reducing inequality, achieving peace and justice. Thus, the emerging countries dependent on income from mining can be part of the solution, not only part of the risk.

This work aims to discuss the criticality of mineral from the perspective of emerging countries with a focus on the example of phosphate criticality. The criticality investigation has to be closely integrated into a dynamic global context. The hypothesis discussed in this article put forward the incompleteness of the current criticality definition and suggest that emerging countries can be of help to avoid and mitigate the criticality of minerals and to achieve a sustainable mineral supply.

The two dimensions of the criticality of minerals are supply risks and national economic importance. As a matter of fact, the mineral can also be critical to producing countries as the contribution of the mining sector to the national economy is very high. According to the fourth edition of the Mineral Contribution Index (MCI), the mineral sector remains the first driver of many low- and middle-income economies. The poorest countries remain dependent on mining despite a decline in commodity prices (International Council on Mining and Metal, 2018). Besides the national economy dependency on the mining sector, the mineral can be subject to supply risk due to internal conflict and social instability. The case of phosphate rock mining in Tunisia is a good example to show that phosphate mining is crucial for the health of the Tunisian economy. Meanwhile, the sector was suffering from a slowdown of production due to social instability in the region.

For instance, the social instability that took hostage the phosphate mining region in Tunisia since 2010 lead to a drop in the production of phosphate from 8 million tons in 2010 to 3.5 million tons in 2016. Since then, the phosphate-fertilizer industry suffered an unprecedented economic crisis. As the phosphate-fertilizer industry is one of the biggest industries for the Tunisian economy, its fall down and the propagation of the social strikes in other regions set a snowball effect on the rest of the economy's sectors leading to a national economic and political crisis.

In this article, the social and economic background and environmental context of the mining region are investigated, showing that the higher the environmental impacts, the greater the risk of social instability in the region and vis versa; the higher the social instability, the higher the risk of negative environmental impacts.

As a result, this article suggests a more inclusive criticality definition, and it points out that fostering more sustainable mining practices in developing countries would help to reduce their socio-political instability with the consequence of improving the sustainable access to these resources.

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HOW TO REDUCE AIR POLLUTION

How we can reduce air pollution in oil and gas company? There is some questions we can answer it. How much dose oil and gas pollute the air? What pollute dose oil produce? How we can reduce oil consumption? How dose oil and gas destroy environment? Way of the solutions and prevention from pollution?

Advance and defend policies to reduce environmental risks.

Why: While the oil and gas industry has made strides to reduce methane pollution, it's not enough. We need to defend federal policies and advance state policies that protect our climate and environment. How: We're fighting for methane standards at state and federal levels.

Research the full impact of methane on the climate.

Why: Uncombusted natural gas is mostly methane, which is much more potent than carbon dioxide. Until recently, no one knew how much of it was leaking into the air.

How: We are leading the effort to measure leaks across the supply chain, which will help us find practical solutions.

Use technology to find methane leaks.

Why: Methane is colorless and odorless, making it hard to detect leaks. Emerging data-driven technologies are making the job easier.

How: We've set plans in motion to develop a satellite designed to pinpoint methane emissions, and we've created a design challenge for new methane detection tools.

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NATURAL RADIOACTIVITY IN BUILDING MATERIALS OR BUILDING MATERIALS AS A SOURCE OF RADIATION

With the development of technology, people have a great impact on the environment, and it is diverse: the depletion of mineral resources, air pollution, industrial emissions and waste, deforestation. As a result, people's quality of life deteriorates. Radioactive contamination plays a special role in this issue. There has always been natural radioactivity, and there is no escaping it. Natural and anthropogenic ionizing radiation is involved in the formation of The earth's radiation background. Life on Earth was born and develops in conditions of constant radiation. One of its sources is the radiation from scattered in the earth's crust, soil, air, water and other environmental objects of natural radionuclides.

Radioactivity is present both in raw materials (crushed stone, gravel, sand, cement, etc.) and in finished products (concrete, bricks, facing tiles, etc.). Radium-226, thorium-232, and potassium-40 contain most building materials in different concentrations. Special attention is paid to radon - a radioactive gas that enters the atmosphere from soils, rocks and building

materials. Radon can seep from rocks through cracks in the floor, Foundation, or walls and accumulate in residential and industrial areas. The products of its decomposition come with the inhaled air inside the premises, due to this, it can pose a considerable danger to human health.

In this regard, the key control system of the biosphere is environmental monitoring. The most important component of environmental monitoring is radiation monitoring of the environment. Radiation monitoring is a regular observation of the radiation situation in order to control the dynamics of its changes and identify anomalies for research and surgical intervention [3].

Quality control of products of mining enterprises of the Republic, determining the specific effective activity of natural radionuclides, is carried out by the Testing laboratory of construction rocks on the basis of Petrozavodsk State University.

According to the State report [2], in the Republic of Karelia in 2018, the content of natural radionuclides was determined in 25 samples of building materials of mineral origin. According to the research results, the effective specific activity of natural radionuclides (Aeff) doesn't exceed the hygienic standards for materials used in residential and public buildings under construction and reconstruction (class I, Aeff. <370 Bq / kg).

The purpose of this work is to study and generalize theoretical and practical issues of natural radioactivity in building materials, the organization of radiation monitoring in the Republic of Karelia, as well as the study of the radiation background in Petrozavodsk.

Based on the results of the study, the results of monitoring the radiation situation in Petrozavodsk were analyzed on the basis of open state reports. A study of equivalent dose rate (MED) gamma radiation was conducted, and the obtained research results are analyzed of radiation control in Petrozavodsk. It is proved that the level of MED gamma radiation in the air of premises of apartment buildings of the city does not exceed the permissible values established by SanPiN 2.6.1.2523-09 standards of radiation safety NRB-99/2009 (item 5.3) [1]. Based on the results of field work, a Map of the results of measurements of the radiation gamma background was compiled, which reflects the actual state of the radiation situation in the surveyed territories. The main problems related to ensuring radiation safety of the population in the Republic of Karelia are identified. Practical proposals have been developed to reduce the natural radiation impact on the population.

The practical significance of the work is determined by the fact that the presented results can be used to justify and compile a base for further consideration of the problems of ensuring radiation monitoring and radiation safety of the population in the Republic of Karelia on a broader scale.

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THE CONDITIONS AND RISKS FACING THE OIL INDUSTRY OF THE REPUBLIC OF BELARUS

The oil industry of the Republic of Belarus is one of the main sectors of the country since it strongly influences economic growth. The industry specialises in oil and gas production which are the world's major energy sources. Therefore, the development of the country's oil industry is important.

The oil industry of the Republic of Belarus includes processes such as the oil and gas exploration, deposits research, drilling, extraction, transportation, processing of crude oil and gas, refining, and sale of products. The oil production in Belarus is carried by the oil and gas production department Rechitsaneft, a special division of the Belarusian industrial group Belorusneft. The industry is comprised of 1,000 wells, including 846 producing wells, 93 % of these wells are operated by means of mechanical method implying the use of electric submersible pumps and bottom-hole pumps. Major facilities of oil production are equipped with state-of-the-art telemetry systems. All the processes associated with production, transportation and preparation are automated [2].

In 2018, the oil production in the Republic of Belarus amounted to 1.6 million tons, while in 2017 this indicator was equal to 1.61 million tons [1]. However, such volumes of oil produced satisfies less than 30 % of the country’s demands for crude oil.

To date, the oil production has not been significantly developed due to limited resources, since about 65 mainly small fields are explored (or are still being explored), and 39 of them are being developed at present. It is predicted that there will be a decrease in oil production, since large fields are in their final stages of exploitation while newly developed fields are characterized as small-sized and with small-reserves. These reserves are difficult to extract, therefore, to slow down the rate of decline in oil production and stabilize it, it is planned to use high-performance oil production equipment to implement new ways of impacting oil reservoirs, and to increase in exploration and production drilling.

One of the conditions for the development of the oil industry is the development of new technologies for the search, exploration and production of oil and associated petroleum gas. Such technologies include: gas recirculation, which consists of carbon dioxide, forced flooding, steam heating, in-situ combustion, hot water injection, simultaneous and separate oil production of various categories, and three-dimensional mapping of open fracture zones at depths up to 5000 meters impact on the productive reservoir by the energy of shock waves, etc. In residual industrial stocks, the share of difficult to extract high-viscosity (heavy) oils is more than 50% and is constantly increasing. These days, growing oil reserves compensate not more than 60 % of oil production. In addition, discovered fields are considered to be quite small (up to 200-300 thousand tons) with the predominant share of hard-to-recover oils and low permeability reservoirs.

The consequences of these predicted changes for the development of the country and its regions may be:

1) Increasing in oil recovery factor up to 70 % of the resource base of traditional fields.

2) Maintaining a stable level of oil production, averaging 1.6-1.7 million tons per year, reducing both capital cost and ecological load on biophytocenosis. As a result, all these elements will contribute to achieving Sustainable Development Goals.

3) Creating more favorable opportunities in order to stabilize the share of mining industry in the GRP of the Gomel region; to ensure the economic security of the country in terms of the availability of motor fuel made from the hydrocarbons of own production; to form an economic base for the long-term development of the Rechitsa and Svetlogorsk regions; to preserve the labor potential of these territories.

Also, the development of the oil industry will be favorably affected by the activity of the state production association Belorusneft, including the discovery of oilfields in foreign countries, and increasing of oilfield services. Belorusneft is currently producing oil and gas in 61 fields in Belarus, 13 in the Republic of Venezuela, 1 in Ecuador, and 5 in Russia (the recoverable reserves amounted to over 40 million tons, annual production of oil and gas condensate is about 200,000 tons, natural gas – around 150 million m^3). The production potential of the company is about 432,000 tons of o.e. Further, new exploitations in India and Ukraine are to be expanded [3]. The incomes obtained from such exploitation are greater profit of Belorusneft as well as the expansion of the oilfield services market, and better conditions for increasing the contribution of services in the GRP of the Gomel region.

However, a number of factors such as political instability in Venezuela, aggravated relations with the Russian Federation, and higher financial and economic potential of foreign competitors of Belorusneft, may lead to the following: failure to fulfill long-term plans of the Belorusneft company, such as development of fields within foreign countries, and reducing the competitiveness of the company's oilfield services in the global market. These problems can negatively affect the development of the country's economy due to lower oil production in Belarus, weaker labour potential in the Rechitsa and Svetlogorsk regions, and the unique competencies of the labour force.

Based on the analysis, it should be noted that the oil industry of the Republic of Belarus has a number of problems, and the lack of its own raw material base is the most significant issue. In order to bring the country's oil industry forward, it is necessary to steadily stimulate the development of the oil industry, as well as to increase its overall importance within the country's economy.

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THE LONG-TERM EFFECTS OF UNDERGROUND MINING ON THE GROWTH OF TREE, SHRUB AND HERB COMMUNITIES IN ARID AND SEMI-ARID AREAS

Underground mining, as a disruptive human activity, has various effects on the vegetation in a mining area. Intensive underground mining can cause severe surface deformation, which

often leads to geological disasters such as subsidence, landslides, and ground fissures on the surface [1]; these disturbances often physically damage the roots of vegetation and bury entire plant communities, which will lead to the degradation and ecological succession of the plant community [2]. Moreover, this type of surface deformation and ground fissures will also change the hydrological processes such as infiltration of precipitation, soil evapotranspiration, runoff collection, and a decline of the water table [3]; while these changes in hydrological conditions may not lead to an alteration in the type of plant communities present, they often limit the growth of vegetation and the development of the plant community [4]. The two kinds of disturbance described above will cause short- and long-term effects on the vegetation of a mining area, and different plant communities may also show various degrees of response. The short-term effects of underground mining on plant communities have been well understood and evaluated, however, little attention has been paid to the long-term effects of underground mining on the growth of different plant communities.

To address these issues, a Vegetation Growth Contract Model (VGCM) was proposed, and six indicators including the growth trend (GT), annual growth (AG), normalized spectrum entropy (Hsn), as well as the average value of annual-average normalized difference vegetation index (NDVI; $ANDVI_{ave}$), annual-maximum NDVI ($ANDVI_{max}$), and annual-minimum NDVI ($ANDVI_{min}$) were selected. The long-term effects of underground mining were calculated by the difference in each vegetation indicator between the areas influenced and not influenced by mining. The effects on the vegetation in the area influenced by mining (E_m) were a result of phenology, climate, and underground mining; meanwhile, the effects on vegetation in the area not influenced by mining (E_n) only consisted of EP and EC during the same period. Therefore, we combined all these differences in vegetation indicators to present the long-term effects of underground mining on vegetation by giving each vegetation indicator its own weight. In addition, an adjustment index was also added to eliminate the effects of the initial status of different plant communities on their growth, because the plant communities with richer function, composition, and structure would have better performance in growth.

To evaluate the long-term effects of underground mining on vegetation, it is critical to detect those vegetation types that maintain the same type in both areas that influenced and not influenced by mining respectively. In this research, the LULC in Nanjiao mining area within 1987 and 2017 was investigated; the stable vegetation was extracted by combining the LULC results of remotely sensed images in 1987, 1997, 2007, and 2017. Considering that the plant species of the same type have similar spectral characteristics and NDVI ranges of values, we divided the vegetation into trees (natural forest, cultivated forest, mixed forest), shrubs, and herbs (high-coverage grassland and low-coverage grassland) based on existing LULC in the Nanjiao mining area. At last, the long-term effects of underground mining (EM) on the herb, shrub, and tree communities in the Nanjiao mining area, China, from 1987 to 2017 were evaluated.

The long-term impact of underground mining on the three types of plant communities was generally negative during the study period, having the strongest effect on the herb community and the smallest effect on the shrub community. As for the herb community, the four vegetation indicators affected by underground mining were all negative, and the degree of change and weight them were in order of $ANDVI_{min}$, annual growth, $ANDVI_{ave}$, and $ANDVI_{max}$. In addition, the annual growth, $ANDVI_{ave}$, and $ANDVI_{max}$ of the tree community were also negatively influenced by underground mining; the level of the effect they experienced also decreased from high to low. However, although the shrub community was generally affected by underground mining, the growth trend and H_{sn} showed a positive correlation with mining activities. The negative effect of underground mining was mainly attributed to the obvious drop of $ANDVI_{min}$, which accounted more than 50% of the total weight. In summary, the herb community was the most affected by underground mining, showing an overall decrease of 15.10%. The vegetation indicators of the tree and shrub communities were also negatively influenced by mining activities in general, declining by 6.79% and 4.03% in the vegetation

indicators. The herb community is likely to be disturbed by changes in water availability because herbs have shorter root systems, while the shrub and tree communities show a stronger tolerance to drought and a lack of water generally.

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MINING IN THE MIDDLE OF THE WORD, OPPORTUNITIES AND SOCIO-ENVIRONMENTAL IMPACTS IN ECUADOR

Ecuador is located in the middle of the world in South America. It gathers the glaciers of the highest active volcanoes of the region, its forests provide fresh oxygen to the planet and is the guardian of an important natural and cultural heritage made up of the Galapagos Islands, the colonial center of Quito city, and ancestral knowledge of 21 indigenous nationalities [1].

The Ecuadorian economy is base on the oil exportations, followed by the commerce of agricultural raw materials such as cocoa Theobroma cacao sp., Banana Musa paradisiaca sp., varieties of tropical fruits, exotic flowers, and fish products such as tuna species Thunnus albacares sp., and shrimp Protrachypene precipua [2].

This country has significant mining potential. Projects such as 'Fruta del Norte', 'Mirador', and small-scale mining produce 1,415 tons of gold concentrate; 2,411 ounces of gold; 540 ounces of silver; and 20,000 tons of copper concentrate. Its equivalent is USD 72.5 million of income for the country. During the first quarter of 2020, Ecuador exported USD 376.26 million, between metallic and non-metallic mining [3].

This work aims to study the impacts and opportunities that mining generates in Ecuador. The case of the province of Esmeraldas is taken. It is located on the northern coastal border of the country, where the practice of small and medium-scale, legal and illegal mining occupies 20% of the available labor in this province.

The opportunities that mining offers to society are linked to the distribution of benefits that contribute to the social development of this area, where 15% of the population is illiterate [4]. The contribution of mining can contribute to the improvement of health services for the care of children, youth, and adults [5].

The deficit in medical care has been evident during the COVID-19 health crisis. That has caused the death of at least 120 people directly or indirectly linked to mining. In addition, mining at the national level was reduced to 40% of its production capacity, due to biosecurity procedures implementation and the social distance required to stop the virus infection spread [3].

However, given the conditions in which the gold miner runs, it was determined in 2010 that, the contamination has affected the biota of fish, macroinvertebrates, and even the human population. At least 42,000 people in communities near the illegal mines have been exposed to

heavy metal contamination accumulated in the water. More than 4,000 plant varieties are at risk of extinction, and endemic amphibian and reptile species are dying before mankind had kept any registers [5].

Previous studies detected the presence of metals in rivers that feed the drinking water system. Aluminum exceeded the established environmental standard by 580 times, the iron standard by 33 times; 2.4 times the copper norm, and 1.3 times the manganese norm dying [6].

The revision of public policy for mining development does not respond to national interests. Article 313 of the Constitution of Ecuador establishes that the "State reserves the right to administer, regulate, control, and manage strategic sectors with the principles of environmental sustainability, precaution, prevention, and efficiency; as well as exceptionally delegate to the private initiative" [4].

It is concluded that the opportunities show an encouraging future for Ecuador, allowing income to its dollarized economic system that requires recovering from the impact of the pandemic. Mitigating the environmental impact in mining faces various challenges that must be addressed from scientific research. Among them: the treatment of acidic water containing heavy metals, the implementation of 'passive' wetland systems that have demonstrated efficiency in water treatment, the creation of wildlife habitats required for the sustainability of primary forests, and the forest restoration with endemic species.

Coordinated work with the academy is necessary for monitoring and remediation of environmental impacts on the quality of river water, air, and soil. The attention of cases of diseases related to mining, and research for the early detection and prevention of other potential impacts. Here the role of teachers is key to strengthen human talents that will join efforts to achieve the final goal: Improve the country's living conditions from the contributions of mining

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THE HYDROCARBON COMPOUNDS SOURCES IN SURFACE SEDIMENTS OF THE LAPTEV SEA SHELF

Amplified global warming in the northern region has caused rising rates of terrestrial and submarine permafrost degradation. The release of a vast amount of organic carbon (OC) stored in a vulnerable permafrost pool heavily affects the modern biogeochemical cycle. It was shown that an increased supply of remobilized ("old") OC may lead to severe acidification of the Arctic waters and significantly contributes to the greenhouse effect as a result of the OC to CO_2 transformation [1, 4].

The East Siberian Arctic Shelf (ESAS), represented by the Laptev Sea, the East Siberian Sea, and the Russian part of the Chukchi Sea, is unique because it occupies a huge area ($>2*10^6$ km^2) and has a shallow average depth (~ 50 m). The Laptev Sea is a representative of a terrestrial OC-dominated area being a heterotrophic biogeochemical province with low primary productivity, where the main OC input originates from coastal erosion [4]. Besides, it receives substantial input of the terrestrial OC from the Lena River. During the land-to-shelf transport, exported organic matter (OM) undergoes aerobic biochemical decomposition, oxidation to CO_2, or can be delivered to the deep-water part of the Arctic Ocean [1, 4].

Our research is aimed at characterizing the modern organic matter (OM) stored in the surface sediments of the Laptev Sea in order to estimate its composition variability and attempt to identify the OM sources along the profile "coastline - outer shelf".

We analyzed 14 surface sediment samples (horizon 0 - 2 cm) collected across the Laptev Sea shelf during the Arctic expedition onboard the Russian R/V Academician M. Keldysh during fall 2018 [1]. Grain-size (laser diffraction method; SALD-710, «Shimadzu»), pyrolytic (Rock-Eval 6 Turbo, VINCI Technologies), and GC-MS (Agilent 7890B (GC) – Agilent Q-TOF 7200 (MS)) analyses were performed. To provide relevant data for the modern OM an adapted Rock-Eval temperature program has been applied (start of sample heating - 180°C, holding for 10 minutes, then heating to 650 °C at a rate of 25 °C/min).

According to the pyrolysis data, Total organic carbon (TOC) varies from 0,4 – 2,71 % while a portion of free hydrocarbons and low molecular weight OM considered as a lipid fraction (S_1) ranges from 0,11 to 0,73 mg HC/g [2, 3]. The content of relatively termo-labile hydrogen-rich OM or biopolymers (S_2) and CO/CO_2 released by oxygen-containing OM or geopolymers (S_3) correspond to 0,67 – 2,92 mg HC/g and to 1,18 – 5,4 mg HC/g, respectively [2, 3].

The sediment distribution suggests relatively low HI (hydrogen index) and higher OI (oxygen index). Its ratio HI/OI < 1 may be compared to a mix of "Type 2" and "Type 3" kerogens for matured OM determining planktonogenic and terrestrial origin, respectively. The samples taken from the coastal part show the dominant terrestrial OM origin. However, the contribution of planktonogenic OM is clearly traced for the outer shelf samples. Comparison of HI and T_{peak} data is aligned with this conclusion to some extent.

According to the grain size analyze, sediments are dominated by clay (< 2 μm) and silt (2 - 63 μm) fractions. The sand fraction (> 63 μm) is almost absent. The positive correlation between HI and clay content (r = 0,71) is higher than connection between OI and clay fraction (r = 0,42). It suggests that clay particles may create a favorable depositional environment, and, therefore, partly preserve the mineral-associated OM from oxidation. Nevertheless, we would not mention the mineral matrix as a first-order control factor for OM preservation.

According to GC-MS analyze results, we performed the qualitative interpretation of n-alkanes distribution. Obviously, terrestrial input is a main contributor to the OM of the studied sediments. Overall dominance of the high molecular weight (HMW) odd C_{25} – C_{31} n-alkanes

indicates a significant portion of terrestrial OM exported with river discharge and thermo abrasion material [1, 4]. However, for many outer shelf samples both the hydrobiont markers of the autochthonous nature (C_{15}-C_{19} n-alkanes) and the terrestrial markers mentioned before are contrastingly expressed.

High values of Carbon Preference Index (CPI) (>> 3) indicate a prevalence of vascular land plants as a source of OM and low microbial degradation state. K_i (0,46) and OEP (1,28) indexes also confirm low diagenetic transformation of OM. TAR (terrigenous to aquatic ratio) traces an increasing supply of autochtonous OM with increasing distance from the coast. In the coastal zone sediments, the terrestrial component is clearly pronounced (TAR = 31,6) while for the outer shelf sediments the index is 4 times lower (TAR = 7,6). Pr/Phy ratio confirms the suboxidative environment revealed by the pyrolysis data (HI/OI indices).

In general, the GC-MS records are directly comparable to Rock-Eval data. Along the studied profile, the contribution of the terrestrial OM in the outer shelf surface sediments is clearly traced despite the great distance from the coastal zone. This is a distinctive feature of the Laptev Sea biogeochemical regime, which was previously noted by other researchers. Our results confirm and enhance their findings with new geochemical data providing an additional piece towards a deeper understanding of the modern biogeochemical carbon cycle in the Arctic.

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GEO-MONITORING OF CARBON DIOXIDE GAS EMISSION DECLINE DUE TO COVID-19

Carbon (iv) oxide (CO_2) is the most important greenhouse gas (GHG) in the atmosphere and is the greatest contributor to global warming (International Panel on Climate Change, 2014). The principal anthropogenic sources of CO_2 are fossil fuel combustion and industrial production, which are largely concentrated in urban areas (Gregg, Andres, and Marland 2008; Büns and Kuttler 2012). The decline in energy demand, therefore, driven by coronavirus lockdown is expected to trigger a fall in greenhouse gas (GHG) emissions worldwide. The International Energy Agency (IEA) predicted a drop of 8% (1687 million tons CO_2 eq.), almost six times the last record, set in 2009 (1.3% - 274 million tons CO_2 eq.) that occurred due to the effects of the economic crisis and an overall fall in GDP. In the Nairobi metropolitan area, the partial lockdown has led to a decline in human activities which has resulted in a substantial decrease in energy demand, hence a decline in CO_2 emissions.

This research aims at monitoring the trends in CO_2 concentration change during COVID-19 lockdown period and predict growth in CO_2 concentration over the post COVID-19 lockdown period through modelling and simulation. This will inform various mitigation measures that the government can take to keep CO_2 concentration as low as it was during the lockdown.

This study will use the Orbiting Carbon Observatory 2 (OCO-2) data because of its improved spatial-temporal coverage with small footprints which enables studying CO_2 concentrations at city scale. The data will be collected from the OCO-2 CO_2 Data Portal (https://co2.jpl.nasa.gov/). A database will be built to extract useful information from the original OCO-2 products, such as column-averaged dry air mole fraction of carbon dioxide (XCO_2), retrieval geometry, retrieval header, retrieval results, aerosol results, albedo results, metadata, pre-processing results, and others.

To validate XCO_2 retrieved from satellite data (Level 2 products), these products will be quantitatively evaluated using the data with higher quality and independently measured by other instruments. In this case, the satellite data will be validated with data from global network of ground-based Fourier transform spectrometers, the Total Carbon Column Observing Network (TCCON) and/or the ground-based data from the Meteorological Department in Nairobi.

The expected results from this research is that the CO_2 emissions started declining when the lockdown began on 6th April 2020. The cessation of movement in and out of the study area and the 7 p.m to 5 a.m curfew led to a decline in CO_2 emission due to decrease in the number of vehicles accessing the study area, decreased time for human activities, and decline in industrial activities due to compulsory leave and lay off of employees in the industrial area. The concentration of CO_2, however, began rising towards the end of May 2020 when residents of the study area began resuming normalcy even though the partial lockdown was still on.

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CUSTOMISED SIZING OF A SUSTAINABLE PASSIVE MINE WATER TREATMENT SYSTEM: SUCCESSFUL UPSCALING OF A PILOT PLANT

Contamination of water resources by mining activities is one of the most complex and costly environmental problems worldwide. Most prominent is the occurrence of acid mine drainage (AMD) as a result of sulphide mineral oxidation, releasing ferrous iron, acidity, sulphate and associated metals into aqueous environments. Progressing aeration and neutralisation of AMD lead to precipitation of hydrous ferric oxides, resulting in impaired usability of water resources and complete destruction of aquatic ecosystems [1]. At the turn of the century, environmental liabilities associated with AMD were estimated at 100 billion US-$ worldwide and thus rated the greatest environmental liability facing the mining industry [2]. A considerable part of respective contaminated or hazardous sites are abandoned or legacy mines where remediation and water treatment unavoidably rebound upon public funds [3]. In many

cases, mine water treatment is a long-term burden that requires continuous operation of adequate treatment plants long after mine closure. Conventional treatment plants predominantly operate through addition of chemicals such as alkalising agents for neutralisation and flocculants for subsequent metal (mainly iron) removal in highly efficient, yet energy-intensive reactors. Ferruginous, circumneutral mine water can be treated in passive systems by using and enhancing natural processes, thereby saving costs, resources and energy. However, the current sizing approach for passive surface-flow systems for iron removal from circumneutral mine water (e.g. settling ponds, constructed wetlands) is based on an area-adjusted removal factor that doesn't reflect the kinetic background of respective biogeochemical and physical processes [4]. Consequently, sizing of passive systems is a complex challenge, especially where low or residual iron concentrations in combination with strict legal limits are concerned. In-depth research is needed to prevent serious and costly oversizing or particularly undersizing of passive systems.

In the course of this study, we conceptualised a composite passive mine water treatment system for reliable iron removal at circumneutral pH. A respective three-stage pilot plant was implemented at a former open-cast lignite mine in the historic district of Upper Palatinate (Germany) next to an operational conventional treatment plant. The pilot plant received untreated ferruginous seepage water from a former open pit via a bypass in the feeding pipe of the adjacent full-scale conventional plant. The composite pilot system was designed to facilitate efficient and sustainable iron removal by way of successive pre-treatment, fine treatment and purification in serially connected settling ponds, surface-flow constructed wetlands and sediment filters, respectively. The primary purpose of the pilot plant was to (1.) demonstrate reliable treatment to compliance despite the unusually strict legal discharge limit for total iron of 1 mg/L, and (2.) provide comprehensive monitoring data for upscaling of the pilot plant to full-scale. Secondary objectives included removal of other contaminants (such as manganese, ammonia or, if present, aluminium and arsenic), cost saving, resource and energy conservation and overall sustainable yet cost-effective water quality amelioration for years to come.

Over the course of two years, iron removal in the pilot plant averaged 97.9% with average inflow and outflow concentrations of 8.4 mg/L (±2.4) and 0.2 mg/L (±0.09), respectively. Manganese removal strongly depended on flow rate, ranging from 69 to 95% (interquartile range), which was predominantly attributed to surface-catalysed reactions in wetlands and sediment filters, likely enhanced by bacterial activity. Other contaminants such as aluminium and arsenic were only present in small amounts and consistently removed to below detection limit. Altogether, treatment performance of the composite passive pilot system was comparable to the conventional treatment plant for iron. As manganese is not removed in the conventional treatment plant, passive treatment offers a sustainable way to further improve water quality. Moreover, it is important to note that addition of lime slurry for pH-stabilisation and $FeCl_3$-solution as flocculating agent in the chemical treatment plant lead to increased calcium and chloride concentrations by about 5 and 10%, respectively, which is avoided by passive treatment technologies.

As stated above, the established area-adjusted sizing approach is inapplicable for low iron concentrations such as observed at the project site. Therefore, the critical iron removal processes for the mining-influenced seepage water were identified and quantified by combining the extensive monitoring datasets from the pilot system with targeted laboratory studies on individual rate- determining processes. Our holistic approach allowed estimation of the necessary hydraulic retention time for natural iron removal and thus specially tailored, kinetics-based sizing of a full- scale passive system for treatment of the mining-influenced seepage water. Compared to simple linear upscaling of the pilot plant, the kinetics-based approach may considerably reduce land consumption and thus potentially prevent costly oversizing of the large-scale passive plant. More importantly, compared to the established area-adjusted sizing approach, the specially tailored and kinetics-based approach prevents considerable and legally critical undersizing.

Altogether, operation of the pilot plant was a thorough success. The collected data proved the overall reliability and treatment efficiency of the three-stage composite setup, and beyond that provided an extensive foundation for sound sizing of a full-scale passive treatment system. At this point in time, a respective large-scale passive system is in the planning stage and designated to eventually replace the conventional treatment plant, reducing operational costs and environmental impacts of the long-term water treatment liability. Total land consumption for the full-scale passive system (including all infrastructure) is currently estimated at approximately 1 ha, most of which will be vegetated and unvegetated surface-flow ponds. The full-scale passive system will be the first of its kind in Germany and is intended as a "lighthouse project" to increase confidence in the sustainable, ecologic treatment technology.

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HOW TO OPTIMIZE PROVINCIAL $PM_{2.5}$ REDUCTION TARGETS IN CHINA? BASED ON GAME-EFCAM

In 2012, large-scale, high-intensity haze erupted in China, thereafter, $PM_{2.5}$ emission reduction became a focus of Chinese society[1]. Based on the reduction requirements of the "Three-year Plan on Defending the Blue Sky" issued by the Chinese government, this study evaluates and optimizes provincial $PM_{2.5}$ reduction targets[2]. In this study, $PM_{2.5}$ emission quota is regarded as a limited resource in the production process and can be distributed among various regions using reasonable allocation methods. The resulting difference between the allocated $PM_{2.5}$ emission quotas and $PM_{2.5}$ emissions in the base year is set as the $PM_{2.5}$ emission reduction target. This approach is used by Dong et al. (2018) in research on China's carbon emission reduction strategy, which treats carbon emissions as limited resources in the production process within China's provinces, and China's future carbon emission quotas are allocated among the provinces to determine China's provincial carbon emission reduction targets[3]. This research not only helps China optimize provincial $PM_{2.5}$ reduction goals, but the proposed allocation method is also applicable to the overall planning of national resources utilization.

First, the total $PM_{2.5}$ emission quotas in 2020 are calculated according to the policy. Then, provincial $PM_{2.5}$ emission quotas are determined under the equity principles of historical egalitarianism, population egalitarianism and pay-ability egalitarianism.

In addition, a Game Cross Equity Fixed Cost Allocation Model (Game-EFCAM), combined the principles of efficiency and equity, is adopted to allocate the $PM_{2.5}$ emission quotas from the perspectives of gaming, equity and efficiency. The objective function of Game-EFCAM utilizes the convergence principle, which is selected from the three equity principles by inequality indexes. To facilitate the function, a linear transformation suitable for the convergence function in this research is developed.

Finally, based on the allocation results of Game-EFCAM, the $PM_{2.5}$ reduction pressure index of each province is determined. The provinces are segregated into four classes based on the relationship between $PM_{2.5}$ reduction pressure and economic development.

The research supports several conclusions. (1) Among the three egalitarian principles examined, pay-ability egalitarianism is the fairest, which serves as the convergence principle of Game-EFCAM.

(2) The "two mountains and two rivers" area has the largest $PM_{2.5}$ emission quotas, while the provinces in western China have small $PM_{2.5}$ emission quotas. In addition, the distributions of $PM_{2.5}$ emission quotas per unit of population, per unit of gross domestic production, and per unit of area all show significant regional clustering.

(3) Shandong and Hebei have the largest amount of $PM_{2.5}$ emission reduction requirements, while Tianjin and Hainan have the smallest. Xinjiang and Beijing have the largest $PM_{2.5}$ reduction pressure indexes, while Tianjin and Shanghai have the smallest.

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ENVIRONMENTAL PROBLEMS OF RARE-EARTH ORE PROCESSING

In the article, the author gives an overview of environmental problems associated with the processing of rare-earth ores. They are mainly associated with the use of chemicals and the release of harmful dust gases. Also, a problem is the presence in the ores of radioactive elements. An analysis of the projects revealed a significant range of uranium and thorium in the ores.

Development of deposits and processing of ores containing rare earth metals (REM) is associated with environmental risks associated with high levels of environmental pollution. In this case, the main problems in the processing of rare earth raw materials are: a significant amount of use of chemicals (acids, alkalis, solvents); emission of fluorine-containing gases during electrolysis; the content of Th and U in ores, the need for their separation during processing and subsequent storage; the presence in the process of dust that contains radioactive substances.

The main production of rare earth products in the world is concentrated in China. The study of the environmental impact of the technological chain at Chinese enterprises showed that the production of 1 ton of REM oxides at the Bayan Obo field entails the formation of 63 thousand m3 of harmful gases containing S and F; 200 m3 of acidified wastewater and 1-4 tons of radioactive waste associated with Th. According to the China Rare Earth Metals Society (CSRE), the production of 1 ton of REM produced is accompanied by the release of 8.5 kg of fluorine and 13 kg of dust.

During the processing in China of ion-adsorption kaolin clays containing 0.03-0.5% REM oxides, ammonium sulfate leaching is used, while the solution is injected directly into the wells drilled in the ground. The collection of leach solutions is on average up to 70%, and in waste solutions formed without trapping ammonium ions, their content reaches 4000 mg / l, with trapping - 300 mg / l.

The rare-earth metals of the cerium group are obtained by electrolysis in a fluoride melt, up to 45 g HF / kg of rare-earth metals in the exhaust gases are contained in the exhaust gases, and 0.6 g HF / kg of rare-earth metals in the emissions after purification. The volumes of emission of perfluorocarbons generated during the electrolytic production of rare-earth metals into the atmosphere were estimated, it was revealed that the release of 1 ton of conventional rare-earth metals is accompanied by the release of 30-74 g of CF4 and 3-12 g of C2F6 on the anode.

A study at the Bayan Obo deposit showed that the average dose from Th-containing dust for the ore involved in the crushing stage (1.71 Bq) is significantly higher than the exposure experienced by other workers (from 0.39-0.68 Bq). Thus, the probability of mortality from lung cancer among workers in the process of crushing rare-earth ore workers increases significantly.

To reduce the dependence of the world market on the supply of rare earth raw materials from China, various companies announced the implementation of new projects. They are associated with the development of over 30 REM deposits in a number of African countries, in Canada, the USA, Australia, South Africa and others.

The analysis of these projects showed that these deposits are characterized by a wide range of U contents in ores - from 1 g / t to 0.4%, Th - from 7 g / t to 3%. High contents of U and Th are mainly associated with the presence of monazite in the ores.

The ores of the following REM deposits are characterized by increased levels of radioactive elements - Steenkampskraal (South Africa), Nolans Bore (Australia), Araxa (Brazil), Longonjo (Angola), Kvanefjeld (Greenland), Strange Lake (Canada). The development of these deposits will be characterized by a high level of costs for the separation of radioactive elements into individual products and their safe storage.

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ANALYSIS OF THE ENVIRONMENTAL TAXES IN MINING AND THE TERRITORIAL CONTRIBUTION FOR THE SUSTAINABLE DEVELOPMENT OF MOA

The research aims to analyze the environmental taxes and the territorial contribution to create the bases for an efficient management of the Municipal Administration Council. To this end, a series of actions are proposed that will favor the protection of the environment. The bibliographic review confirms that there are economic obligations towards the budget of the Cuban State, due to the use of mineral resources. The current distribution of the incomes generated by the environmental taxes in Cuban mining establishes that the Mining Canon, the Geological Compensation and the Royalties constitute a direct contribution to the central bank of the state as established in the mining law [1], without expressing a significant contribution for the local government nor to assess the possibilities, potential or needs of the local environment to counteract the pollution generated by the mining industry in order to compensate society; reason why the municipal management presents financial incapacity, showing the absence of sufficient income destined to reduce the undesired effects, the negative externalities of the Nickel industry in the territory. In Moa, the final destination granted to 45% of the territorial contribution has not been aimed at guaranteeing the sustainable development of society as established by the Ministry of Prices and Finances [2].

According to the Mining Law in its chapter XIV-article 76, the Cuban state receives from the licensees of the mining community of Moa, by Mining Canon, the annual amount of 2, 5 and 10 pesos during the sub-phases of prospecting, exploration and exploitation respectively. Article 77 states that the amounts listed in article 76 are entered into the State Budget and payments are

made by advanced annuities. According to article 80 of the referred law, between 3 and 5% of the finished production of Nickel is destined to the central state budget for Royalties. The foregoing highlights the centralization of the income generated by environmental taxes from nickel mining in Cuba.

In 2015, the Special Contribution for Local Development, known as the 1%, was extended to all the provinces and municipalities of Cuba, the 45% of these ceded incomes, must be used in actions to guarantee the local sustainable development. In 2017, a 4,798.2 MP tax was collected as a Ceded Income to the municipal distribution account of which the Municipal Directorate of Finance and Prices is the owner, transferring an amount of 2,399. 09 MP to the Local Development Contribution account, which represents 50 percent of the total collected. In this same period, in the municipality of Moa, 2,275.9 MP for Current and Capital Expenditures were distributed through agreements of the Municipal Administration Council to six budgeted units and three companies in the territory. The expenditures for the protection of the environment in the municipality Moa by organisms were 11,531.5 MP in 2017, according to an economy report presented in 2018 by the Local Office of Information. The Ministry of Energy and Mines executed 2090.9 MP in actions for water protection, 15.3 in actions for the protection of the atmosphere and to the treatment of solid waste the amount of 9425.3. The Municipal Administration Council destined 11.3 MP in 2013 to the environmental protection, without expenditures in the last 5 years in actions for the environment. The final destination that has been given to 45% of the property tax has been inadequate because it can only be used for current and capital expenses when there is non-compliance with the assigned income and in the event of the immobilization of 3 months of the resources from the territorial contribution for local development and in 2017 there was an overcompliance of the assigned income of 19,662.00 MP, in addition to the fact that no expenses were executed for the protection of the environment by the Municipal Administration Council. The above is a sample of an inadequate perception between actors and local authorities in relation to the territorial contribution to local development, it's possible uses and destinations [3].

It is exhorted to train and overcome the Municipal Government Directorate in issues related to sustainable development in mining areas. Based on the CEPAL's criteria, to consider the possibility that the income generated by environmental mining taxes represents a direct income within the municipality's budget. To use a considerable amount from the income ceded by the Nickel producing companies, for environmental actions, in order to mitigate the negative externalities of mining activity in the territory. Carry out a more accurate planning of the use and destination of 45% of the Territorial Contribution for Local Development, with a focus on economic, ecological and social sustainability, in order to achieve endogenous development harmonious with natural resources [4].

The bibliographic review showed that the contribution of environmental taxes in nickel mining is destined directly to the central budget of the state of Cuba. The study of the Territorial Contribution for the local development of Moa, based on the existing regulations and the environmental dimension of sustainability, provided timely information for decision-making by the Municipal Administration Council. The analysis of the final destination of 45% of the territorial contribution showed that this economic instrument has been used to finance current and capital expenses, without considering the importance of treating the environment with monetary support, as provided in the Guideline 101 of the Economic and Social Policy of the Party and the Revolution of the Republic of Cuba, to direct actions that mitigate the negative externalities of the nickel industry.

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INFORMATION SYSTEMS IN ENVIRONMENTAL MONITORING

With the growing number and scale of industrial production, mankind has faced the growing destructive impact of economic activity on the environment. One of the elements to regulate this impact is environmental monitoring. Collecting and analyzing the results of environmental monitoring using IT technologies allow to identify trends in changes in the state of the environment and ecosystems, and to respond to potential threats in due time [1-2]. Much attention has been paid to the ecological problems, including environmental monitoring, in the works of Ashikhmina T.Ya., Venitsianova E.V., Gracheva A.V., Israel Yu.A., Kuzenkova G.V., Murtazov A.K., Ramazanova S.K., Syutkina V.M. and many others. However, this topic is not sufficiently revealed in terms of the impact of information systems (IS) on the effectiveness of monitoring.

In the Lugansk People's Republic, environmental monitoring is carried out by the Ministry of Natural Resources and Environmental Safety (Ministry of Natural Resources), using data obtained from 6 other ministries and 36 environmental companies [3]. A large number of participants in the process leads to difficulties in collecting, systematizing and accumulating monitoring data, which requires the formation of a single information platform available to all participants in the process and interested parties. As part of the formation of a single information platform, the authors propose an environmental monitoring information system (hereinafter EMIS), the architecture of which is shown in Figure 1.

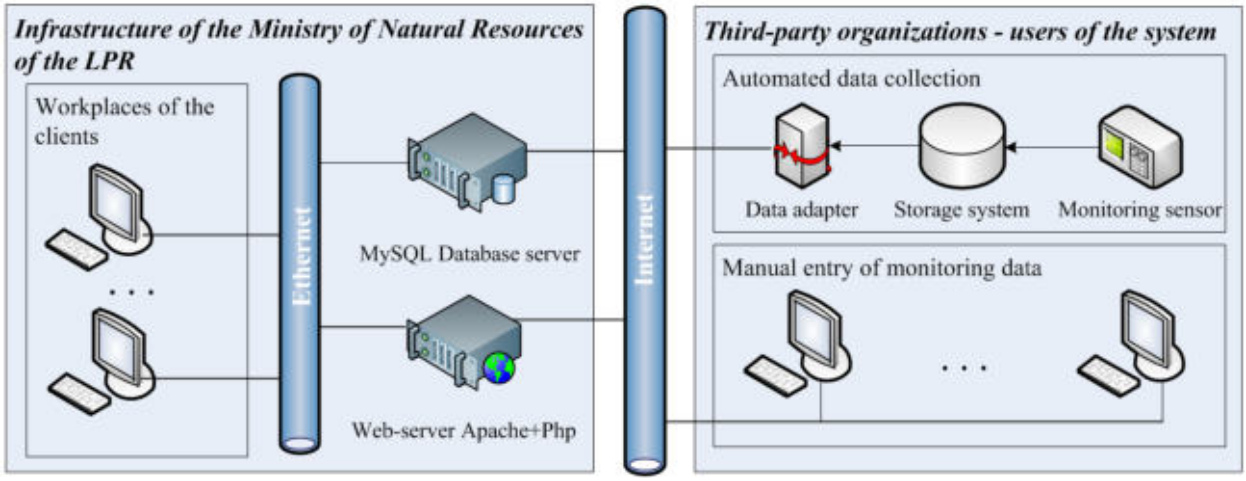

Figure 1 - EMIS architecture

It is planned to provide monitoring data storage on the basis of the information infrastructure of the Ministry of Natural Resources. Using EMIS client modules installed at the Ministry of Natural Resources employees workplaces, the main activities will be carried out to work with the system. Third-party users, participants in the process of collecting and registering

of the data, connect to the servers using either the EMIS client module or through the web interface. In the future, it is planned to realize the possibility of automated collection and import of the data into the system through special adapters.

The functional capacities of the EMIS are shown in Figure 2. The system management and administration module allow regulating flexibly the access to information and determining the tools for its processing depending on the access rights. The data input module has a convenient user interface, which allows reducing user input errors. The data presentation module offers a wide range of tools for processing and presenting data; it can be used by managers to make managerial decisions on regulating environmental impact on the environment, as well as by a wide range of users to obtain up-to-date information on the state of the region's environment through the Internet.

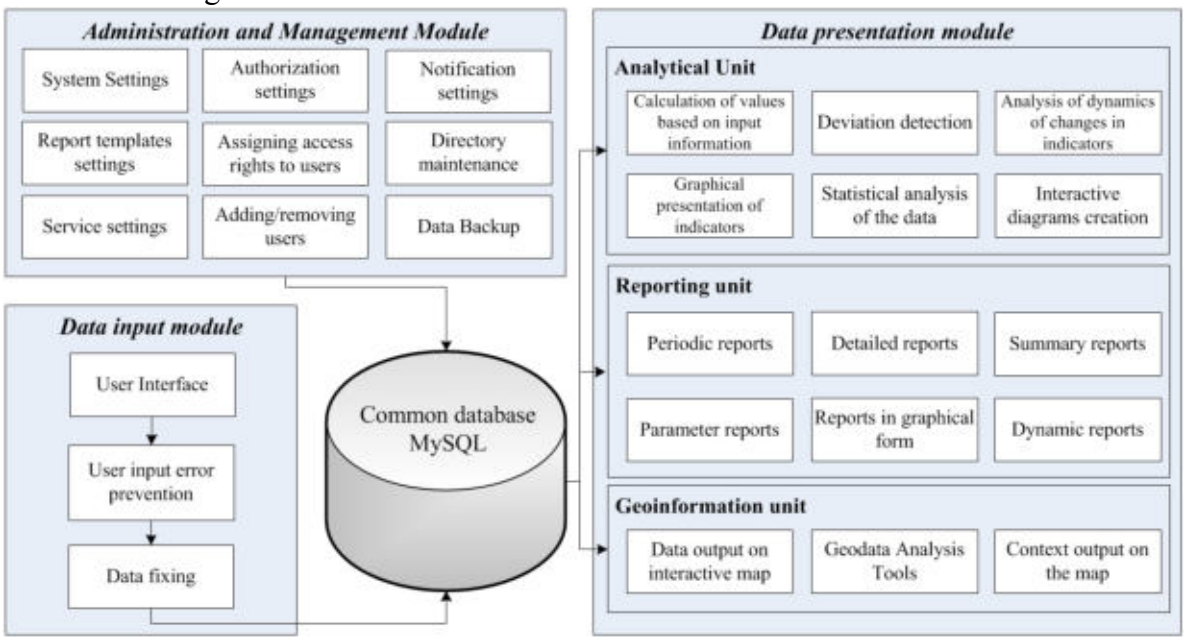

Figure 2 - Functional diagram of the EMIS

The proposed EMIS has been implemented and tested by the authors. The economic effect from the implementation of the EMIS (on the example of LPR) was estimated. It amounted to more than 600 000 rubles per year, which confirms the expediency of using this information system in environmental monitoring tasks.

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MODERN MATERIAL SOLUTIONS IN RENEWABLE ENERGY SOURCES

The global energy sector, due to projected in long-term forecasts - the demand for electricity increasing up to threefold, focus on searching for simple and effective energy renewable resources (RES). These sources will not only be a necessary alternative to constantly diminishing non-renewable resources, but will also help to partially solve the global problem of emissions of CO_2, which is harmful to the environment and the climate. Currently, as a result of human activity in the world, more than 20 billion tonnes of carbon compounds and 700 million tonnes of other gases and dust are emitted into the atmosphere annually. It is forecast that by the end of this century the amount of carbon dioxide in the atmosphere may increase by up to 30%. That is why actions supporting the limitation of harmful compounds to the atmosphere are extremely important. Of the numerous renewable energy sources, solar energy converters are currently the most popular for researchers due to the least impact on the environment [1]. Among many photovoltaic solutions, dye-sensitized solar cells (DSSC) are considered to be extremely promising generation of photovoltaic technology, which is due to their biomimetic principle of operation, easy preparation and relatively low production costs. One of the main elements in DSSC is a photoanode made of environmentally friendly metal oxides with high chemical stability among which tin oxide stands out. The good optical properties of this material have contributed to many studies in the field of using it as a photoanode, and these properties are not without influence from the SnO_2 synthesis method [2].

Of the various one-dimensional nanomaterials, metal oxide nanostructures are interesting contenders for many applications, such as the construction of modern solar cells, optoelectronic and acoustic devices, liquid crystal devices and detectors. To date, scientists have paid attention on ZnO, TiO_2 and SiO_2, but publications on other 1D simple oxides, including SnO_2, are increasingly appearing. This material in terms of optical and electrical properties can be a promising alternative to the widely studied other semiconductor oxides, which results from a width energy gap of 3.1-4 eV, as well as electrical conductivity and optical transparency. To date, many methods have been developed for the production of one-dimensional nanomaterials, including chemical and physical vapor deposition methods, controlled liquid phase growth, template synthesis, nanolithography or electrospinning from solution. However, the last of these methods has a special advantage over the others. This method is simple, repeatable, economical and doesn't require expensive equipment, moreover, it allows the production of materials not only in laboratory conditions, but also on an industrial scale. In addition, its unquestionable advantage is the possibility of conducting the process in room conditions - without the need to reduce pressure or the use of a protective atmosphere, the ability to control process and environmental parameters so as to obtain a product with the desired physical and chemical properties. Another advantage is the fact that the materials obtained in this way are of good quality even without the need for functionalization or purification and are often characterized by electrical, optical, magnetic or electrochemical properties much more favorable than their equivalents obtained by another method [3, 4].

Therefore, it's necessary to produce one-dimensional nanostructured tin oxide by a hybrid method combining sol-gel technique and electrospinning from a solution, because it presents a different approach to obtaining this type of material.

The aim of the work was to produce crystalline SnO_2 nanowires using electrospinning from solution with subsequent heat treatment and to determine the impact of the applied

electrospinning and calcining process parameters on the morphology and structure of one-dimensional (1D) SnO_2 nanostructures, with particular emphasis on the influence of the structure of this nanomaterial on its optical properties.

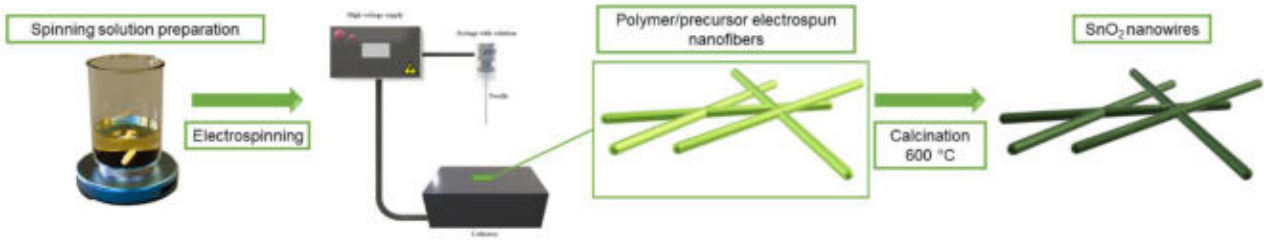

Figure 1 - Scheme of SnO_2 manufacturing process

To sum up, one-dimensional nanomaterials based on SnO_2 produced using a hybrid method of electrospinning and calcining are a revolutionary solution in the field of building innovative solar cells. Further research into their development should be carried out, for example by doping with other oxides or ions.

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CELLULOSE: AN ECOLOGICAL ALTERNATIVE OF FUEL-BASED POLYMER MATERIALS

Versatile and inexpensive fossil fuel-based polymers are almost irreplaceable in various areas of modern industry. However, their further life is associated with heavy drawbacks such as weakly developed recycling procedure, increasing hardness of its deposition in landfills due to spacious, financial and sustainability limitations [1]. Possible way to overcome these problems is to develop promising alternate to non-ecological plastics, for example, cellulose materials which are non-toxic, biodegradable, biocompatible and could be obtained from renewable sources [2].

Cellulose is the most plentiful naturally occurred polymer. It is fibrous, water-insoluble polysaccharide consisting of chains of β-1,4-linked glucopyranose units [3]. The degree of polymerization depends on the source and synthesis conditions. Cellulose is an essential component in plant cells structure. Thus, treatment of raw plant material is conventional synthesis method. South of Kazakhstan has cotton as the main export plant crop, which according to Piotrowski et al. [4] has cellulose content around 90 %. Therefore, main focus of this experimental stage was to obtain microcrystalline cellulose using cotton fiber as a precursor via various acidic hydrolysis techniques.

Moreover, cellulose could be obtained from various non-plant sources, for instance, algae and bacteria. Nanostructured cellulose can be produced by some species of bacteria, including

the non-pathogenic Komagateibacter, such as K. xylinus [2]. Several strains of K. xylinus produce extracellular cellulose forming a protective biofilm of varying thickness with the purpose of maintaining a high oxygenation of the colonies near the surface [5].

In order to synthesize films of nanostructured bacterial cellulose multistep process was employed. Strain of K. xylinus was introduced into growth medium, which contains macro- and micronutrients required for bacteria growing. During that process organic nutritive compounds, consumed by bacterial strain, entered the Krebs cycle, phosphorylation with catalysis and following isomerization, producing uridine diphosphoglucose, which serves as a precursor for cellulose production. Factors that must be taken into consideration are pH of medium, temperature and amount of oxygen available in solution. The resulting product of one-week synthesis process is ultra-pure, flexible, porous nanostructured cellulose film, which could be successfully used for variety of applications.

A comparative analysis of samples obtained by chemical (acid hydrolysis) and biological (using bacteria strain) approaches showed that both samples are stable, do not contain lignin and hemicellulose, as well as heat-resistant impurities, have a crystalline structure. The bacterial cellulose sample has a higher degree of crystallinity and chemical purity. The resulting cellulose modifications have broad prospects for further use. The characteristics of this bacterial cellulose are suitable for medical purposes: wound healing, well-absorbing, high-strength dressings. Cellulose microcrystals can also be used for biomedical purposes due to its developed surface. It should be noted that these materials, being chemically pure cellulose, are environmentally friendly biodegradable materials.

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LIQUIDATION OF EXPLORATION PIT No11 FROM ROZNA URANIUM DEPOSIT

The aim of this article is to introduce the history, characteristics and liquidation of one of the first exploratory borings of the Rozna-Olsi deposit. Based on available characteristics of the main mine workings and the local geology (Vokurka, 2019) a draft of liquidation was created to fulfill the legislative framework of Czech Republic as well as possible (Decree, 1997). The draft was then executed by backfill with unconsolidated rock material (Rankine, 2007) and subsequently by securing the surface pit mouth of the main mine workings by closing bulkhead placed on micropiles (Wojktkowiak, 1999). The finishing works included modifying the surroundings of the exploration pit by land machinery and smoothing the previous mining activity down, so that it doesn´t disturb the local morphology.

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ASSESSMENT OF SNOW COVER POLLUTION OF TERRITORIES LOCATED IN THE ZONE OF INFLUENCE OF CEMENT PLANTS

The cement industry is one of the sources of air pollution. The environmental impact depends on production volumes. The effectiveness of the use of snow cover to assess the technogenic impact on the environment has been proved by many researchers because of its long-term occurrence and the ability to accumulate pollutants. There are large cement plants In the Kemerovo (Topki town) and Novosibirsk (Iskitim town) regions. The annual cement production of these enterprises is 3.7 million tons and 2.1 million tons of cement. The aim of this work is to conduct a comparative analysis of the ecological and geochemical state of the studied territories.

In the winter of 2016, snow cover samples were taken in the vicinity of a cement plant in the Kemerovo region. In 2019, snow cover samples were taken in the area of the cement plant in the Novosibirsk region. Snow cover sampling points were located according to the vector system taking into account the prevailing wind direction (southwest). In total, 15 and 16 samples were taken in the studied territories, respectively. Snow cover samples were taken in areas affected by cement plants, limestone and clay open pits, as well as in cities.

Sampling was carried out by the pit method for the entire thickness of the snow cover, excluding 5 cm above the soil. The weight of each sample was 18-20 kg. Snow sampling and preparation works were carried out in accordance with the methodological recommendations [1, 2, 3]. Snow cover samples melted at room temperature, snow melted water was filtered through a blue ribbon paper filter. A solid snow precipitate obtained after filtration and drying was sieved through a sieve (mesh size of at least 1 mm). Dust load was calculated according to the formula [3]:

$$Pn = \frac{P_o}{S \times t}$$

where P_0 is the mass of solid snow sediment, mg; S is pit area, m^2; t is the number of days from the beginning of snow formation to the day of sampling. Using the accepted gradation in dust load [1] with additions [2], the degree of pollution and environmental hazard of the territory was determined. The study of the material composition of samples of solid snow sediment in Topki town and Iskitim town was carried out by X-ray phase analysis in the laboratory of electron-optical diagnostics of the geology department of the TPU Engineering School of Natural Resources using a BrukerPhaser D2 powder diffractometer and a Hitachi S-3400N electron microscope with a Bruker XFlash 4010 attachment.

The value of the background dust load is 7 mg/(m^2·day). The values of dust load in the residential part of Topki town correspond to a low level of pollution and exceed the background by 3 times. The level of dust pollution of the residential part of Iskitim town also corresponds to

a low level of pollution, but exceeds the background by 10 times. Within the sanitary protection zones of the studied plants, the dust load is different. There is a very high level of pollution around plant in Topki. There is a a high level of pollution around plant in Iskitim. In the area of the limestone and clay open pit, the dust load values are different: in Topki town it corresponds to an average degree of pollution, in Iskitim town - a very high degree of pollution. According to the results of X-ray phase analysis, it was found that the analyzed samples of the solid phase of the snow cover of the studied territories are represented by crystalline (79.8% - 92.0%) and amorphous phases (11.1% - 20.2%). Samples of the solid phase of snow are represented by minerals such as calcite ($CaCO_3$), quartz (SiO_2), brownmillerite ($Ca_2(Al, Fe)_2O_5$), hatrurite ($Ca_3(SiO_4)O$), magnesite ($MgCO_3$), albite (Na $[AlSi_3O_8]$), muscovite ($KAl_2[AlSi_3O_{10}] (OH)_2$), Mg-Fe-Ti-oxide. Brownmillerite and haturite are minerals of Portland clinker, affecting the rate of hardening of cement, its porosity and durability [4].

As a result of analysis on an electronic scanning microscope, samples from the zones of influence of cement plants contain particles of calcium and iron-calcium composition, as well as aluminosilicate spherules with calcium impurities.

Consequently, the degree of dust pollution of the territories, as well as the mineral-material composition of samples of the solid phase of snow, was determined from the results of the studies. In Iskitim town, the value of dust load in the living part of the town is higher than in the living zone in the Topki town, which is probably due to the location of cement plants in relation to the living parts of the town. The results of the analysis of the mineral-material composition of the samples confirm the influence of the cement plant on the state of atmospheric air in the form of found particles of various sizes and minerals of Portland clinker.

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ENVIRONMENTAL BENEFITS OF RECLAIMED ASPHALT COMPARED WITH HOT MIX ASPHALT USING LIFE CYCLE ASSESSMENT

Asphalt pavements serve a vital role in domestic economic development and have significant values in circular economic. As a byproduct of petroleum, bitumen is an important component of pavements made of asphalt. Globally, asphalt is the most recycled material by weight, as Reclaimed Asphalt Pavement (RAP) materials have significant quantities and technically feasible to mix with virgin asphalt. With growing highway mileages in China, the application of sustainable pavement construction and rehabilitation materials has increased. In recent decades, more and more RAP materials have been generated and used as a replacement of virgin aggregate and binder in the production of new hot mix asphalt (HMA). It is therefore important to evaluate and compare the potential life cycle environmental benefits of incorporating RAP in asphalt paving mixtures.

In this study, an attributional process-based life cycle assessment (LCA) analysis is conducted to compare the carbon dioxide emissions and energy consumption of recycled asphalt mixtures containing RAP. The LCA study adopts a "cradle-to-laid" approach in which 1 ton of asphalt (either conventional HMA or HMA with 25% of RAP) is considered as the initial functional unit. A case study is performed for the Third Southern Ring Road in Xuzhou, China, that will undergo full rehabilitation to figure out the environmental benefits of RAP.

Figure 1 displays the system boundaries of the Recycling and construction of asphalt pavements. The upper part of the figure shows the life cycle phases related to HMA with RAP (phases 1 to 7) and the lower part of the figure illustrates the phases that are relevant for conventional HMA (phases 1 to 5).

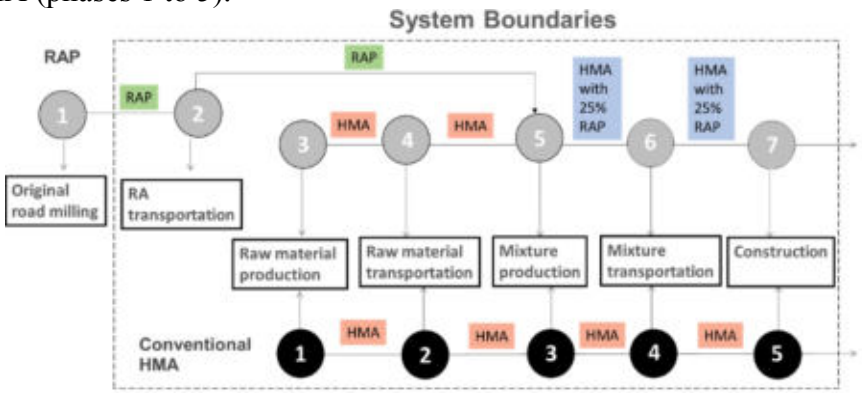

Figure 1 - System boundaries of the LCA analysis

For the Third Southern Ring Road project, it is estimated that the total mass of asphalt concrete is 55,738 ton. According to the energy consumption and CO_2 emissions per functional unit of alternative paving mixtures, the following conclusions can be drawn:

(1) Compared with conventional HMA, applying 25% RAP in paving can save energy consumption by 13% and reduce CO_2 emissions by 11%.

(2) The production of raw materials and mixtures accounts for the majority (> 70%) of the energy consumption and CO_2 emissions during the pavement life cycle, for the HMA with and without RAP.

(3) For the case study considered, approximately 400,000 MJ of energy and 25,700 kg of CO_2 can be saved for each kilometer of the roadway if HMA with 25% RAP is used instead of the conventional HMA.

Finally, the accounting of environmental burdens for the pavement entire life cycle has proved the outstanding benefits of RAP. Also, as a recycling material, the usage of RAP directly achieved a large quantity of amount decrease of bitumen, a main byproduct of petroleum, which will be a large relief of petroleum industry. Together with the remarkable energy consumption reducing performance, it is also a reducing of fuel usage in another way.

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AN IMPROVED GAS CONCENTRATION PREDICTION ALGORITHM BASED ON GRU

KEY WORDS: Gas Concentration Prediction; Deep Learning; Recurrent Unit Network; Stacked Denoising Auto Encode.

Aiming at the problems of low accuracy and poor robustness of traditional gas concentration prediction algorithms, This paper proposes a gas concentration prediction model based on improved GRU network. The model uses the idea of combining advantages to replace the input layer of the gated neural network with SDAE, and adds a dropout layer to optimize the algorithm convergence speed. Experimental results show that the accuracy of the improved model is 35% higher than that of the single model and 6% higher than the accuracy of the combined model. Experiments show that the improved model effectively improves the prediction accuracy of gas concentration.

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RESEARCH OF FORMATION OF A SALT PILES BY MEANS OF HYDRAULIC FILL

The demand for potash products activates «Belaruskali» to intensify the development of «Starobinskoe» potash deposit. The intensive development increases the anthropogenic load on the geological environment.

The main measure to prevent complication of technogenesis should be considered the implementation of methods of storage of processing waste. One of such actions is the use of waste slurry pits as the basis for the expansion of salt piles by hydraulic fill. This reduces the withdrawal of additional agricultural land for salt piles [1].

Halite waste is a loose three-phase system consisting of a mixture of solid mineral particles, saturated brines and all kinds of gases. The analysis of the chemical structure of halite waste at the flotation method of enrichment shows that the predominant component in them is NaCl with small impurities of KCl and other salts. During the storage of halite waste in salt piles, the liquid phase present in them under the influence of gravity forces and pressure from the weight of the overlying layers begins to separate from the dispersion medium and come out through the edge zones and the base of the salt piles.

Halite wastes are deformed as a result of brittle fracture with a distinct residual strength effect. Therefore, only the value of the internal friction angle should be taken into account when predicting the stability of salt piles slopes. Stored halite waste acquires high strength and filtration properties over time. These properties are close to the strength properties of halite and rock, ensuring the stability of salt piles.

The identified regularities of changes in physical and mechanical properties of halite waste determined by the presence of water-soluble salts and the presence of highly mineralized brines. As a result of compaction processes there are significant changes in composition and state of dispersion phase and dispersion medium of halite waste and formation of crystallization structural bonds. Based on the changes, a salt piles with high values of density and strength formed. As a result of the formation of crystallization structural bonds, the stored halite waste

undergoes spontaneous processes of compaction, dehydration, denudation and condensation that develop over time. This contributes to the formation of halite waste of new physical and mechanical properties in their high-altitude storing [2].

In general, during hydraulic fill, halite waste fed into the salt piles as a solid part of the pulp, and saturated brine used as a carrier fluid. As a general rule, the area under the salt piles is large.

Halite waste washed in the upper part of the area and fine particles and brine accumulate in the lower part. The height of the salt piles in most cases is 35-45 meters. The height of the dams at the bottom of the salt piles, where fine particles accumulate, is up to 10 meters.

Washing of the first tier of the salt piles done at the foot of the working area. As the next tier is lavish, a new outline of shafts for the next tier formed and further lavish made. The formation of the hydraulic deposition circuit after 24 hours carried out with ripper bulldozers. During the hydraulic deposition process, the tier is divided into sectors so as to ensure that the brines are passed to the lower point.

This process must ensure that the tier filled evenly throughout the whole hydraulic deposition period. For this purpose, it is necessary to mine surveying the tier with the angle of tier formation.

The implementation of the research on the formation of the salt piles by hydraulic fill at the site of the waste sludge storage «Belaruskali» will reduce the geo-ecologic consequences and reduce the withdrawal of additional agricultural land for salt piles in mining region of Soligorsk.

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ANALYSIS ON THE PATH OF ECOLOGICAL RESTORATION, PROTECTION AND UTILIZATION OF PETROLEUM INDUSTRY HERITAGE IN QAIDAM BASIN, CHINA

The site of the Lenghu Petroleum Base is located on the northwestern edge of the Qaidam Basin, where the ecological load is extremely fragile, and adjoins the largest Yadan landform group in China. The problems of environmental pollution and geological disasters in the region are more prominent. How to formulate feasible renovation measures on the one hand without exceeding the environmental carrying capacity[1]; on the other hand, respect the original pattern of industrial heritage and explore the integration of industrial sites and natural landscape The economic, cultural, and scientific value of this is a question worth considering in the process of protecting and using the heritage of the Lenghu Oil Base.

As a few industrial sites located in ecologically fragile areas in China, the future protection and utilization of the Lenghu Petroleum Base site must not only follow the environmental threshold rules of the green development concept, but also take into account the sustainability of the "natural-cultural-economic" multi-system coordination and sharing Science[2], plan the protection path scientifically, strengthen environmental pollution control within the scope of the ruins, and take the comprehensive recycling of human landscapes and natural resources as the core to create a wealth of functions rich in tourism, exhibitions, cultural and creative, scientific research and patriotic education Oil ruins town[3].

The strategy of ecological restoration, protection and utilization of the Qaidam oil industry heritage site is instructive to the future development trend of industrial heritage in resource-depleted areas. It contains four important links: era memory, industry characteristics, tourism cultural creation and science education. Adhering to the concept of ecological protection, the use of ecological restoration technology, landscape reconstruction methods and expansion projects planned and developed according to local conditions have created a perfect emotional experience and injected new vitality into the icy oil industry heritage [4].

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EVALUATION OF THE INFLUENCE OF CLEANING STRUCTURES ON THE ENVIRONMENT

Ecologically harmful production and business facilities, which are abnormally concentrated in one region, as well as excessive use of mineral resources, are the most important factors forming and exacerbating the ecological crisis.

The results of many years monitoring studies indicate a significant environmental hazard of waste storage areas and territories of sewage treatment facilities. For example, only with the discharge of 55 million m3 of mine water, 200 thousand tons a year of dissolved salts enter the Donbass rivers. With waste water from enterprises, 18.8 thousand tons per year of suspended solids, 15.6 thousand tons ar year of nitrates, 6.4 thousand tons a year of organic substances, 1.6 thousand tons ar year of ammonia nitrogen come to treatment plants. . with their further accumulation in sludge and sludge traps. All this becomes the main cause of environmental risk.

Any waste accumulators, including sludge traps, regardless of their purpose and method of operation, are dangerous sources of environmental pollution. The negative impact extends to all components of the environment. Public utilities, on the one hand, create favorable conditions for the population to live, but, thereby, negatively affect the ecological condition of the territories.

The most negative impact of waste accumulators is on the state of atmospheric air, which also causes a negative reaction of the local population. This is because the functioning of the sludge trap. It is accompanied by the release of significant volumes of gases (ammonia, hydrogen sulfide, etc.) that have an unpleasant odor. So, on the example of the sludge traps of urban WWTP in Makeevka, field studies were carried out to measure the concentrations of pollutants. During the study, the distance from the boundaries of the sources of air pollution to

the control point was determined according to the standard dimensions of the sanitary protection zone (CVD) - 500 m.

According to the concentration of pollutants obtained as a result of the study, it follows that the zone of influence of the sludge traps goes beyond the normative 500 m of SPZ.

The main factor of possible soil contamination from the sludge tanks is the wind dispersion of dust and gas emissions. In the process of deposition of emission components on the earth's surface, secondary dispersion halos are formed in soils. The main components of emission from the studied objects are hydrogen sulfide and ammonia. During the oxidation of these gases, sulfur dioxide and nitrogen oxides can be formed. Local pollution of soils from the sludge traps is possible in dusting during the dry and frosty periods of the year, when dry waste beaches are exposed to wind erosion.

The waste accumulated in the sludge tanks is characterized by a peculiar chemical spectrum, which differs from the geochemical spectrum of primary soils. This makes it possible to determine the boundaries of the dust halo localized in the soil layer.

In most of the studied territories, an admissible degree of total soil pollution is noted. An increase in the degree of pollution is observed when approaching to the sludge settlers to moderately dangerous, dangerous and extremely dangerous. The waste itself corresponds to an extreme degree of pollution. The halo of dust dispersion extends to the first tens of meters from the boundaries of the sludges.

Elevated concentrations of arsenic, zinc, mercury and lead in the soils are determined by emissions from burning rock dumps located in the south-west of the studied territories. At the same time, the waste of sludge traps can accumulate these elements, converting them into water-insoluble sulfides.

Thus, the impact of the sludge trap is superimposed on a high level of soil pollution by sulfates, due to the activities of other sources - waste dumps and residential areas.

According to the study, the total pollution of groundwater in the studied territories with components that determine organoleptic and toxicological properties is at the level of a moderately dangerous and dangerous degree. However, the effect of silt ponds on groundwater pollution is insignificant, since the main sources of pollution are rock dumps and unauthorized dumps of industrial and household waste.

Based on the foregoing, it can be concluded that the impact of the sludge trap is superimposed on a high negative background formed by other pollution sources, including cross-border transfers from large industrial enterprises in Makeevka and Donetsk.

In order to improve the environment it is suggested to make reconstruction of treatment structures using the technology “PLATON”. This technology allows to reduce the number of sediments in 2,3 times, the number of ejections into the atmosphere in 2.9 times.

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THE UTILIZATION OF PETROCHEMICAL WASTES IN BITUMEN COMPOSITIONS

Petroleum bitumen is widely used as the organic binder in road construction. The annual increase in the load on motor roads leads to an increase in requirements for the quality of bituminous binder. In this regard, petroleum bitumens used as binders in road construction are modified with various additives. In most cases, polymers are used as bitumen modifiers, but because of their high cost, other additives are considered, including various wastes from petroleum and petrochemical industries. Oil sludge can be considered the largest-tonnage among them. It is formed in large quantities during the production, processing and transportation of oil. Also crumb rubber and carbon black obtained from utilized car tires can be mentioned [1]. An estimation of the possibility of their introduction into bituminous compositions is an urgent issue, due to their low cost, also as a possible way for their utilization [2].

The research considers the possibility of oil sludges, rubber crumb and carbon black usage as modifiers of bituminous binders.

The objects of research are road petroleum bitumen of penetration grades 40/60, 50/70 and 90/130. The oil sludge, which is a complex mixture of petroleum products, mechanical impurities and water combined with polyethylene production wastes; crumb rubber, which is crushed rubber, obtained by destruction of used car tires, with a particle size of 0.1-0.5 mm.; carbon black, which is a highly dispersed amorphous carbon powder, the product of used car tires recycling, have been studied as additives for bitumen modification.

Softening point, low-temperature properties, penetration and plastic-elastic properties were evaluated for all samples of modified binders.

The research discovered that the modification of petroleum bitumen with the studied additives can improve softening point of the binder, but the introduction of additives leads to a decrease in extensibility and an increase in the brittleness temperature. The modification of bitumen with the studied additives reduces the penetration index, which leads to a change in the bitumen grade to a more viscous one, so it should be taken into the consideration in order to obtain a certain penetration grade of bituminous binder. Oil sludge and crumb rubber affect the improvement of the elasticity index at certain ratios of bitumen and modifier.

Based on the analysis of the studied additives influence on the bituminous binder properties, it was found that the oil sludge in the concentrations of 1.0 % wt. and 2.5 % wt. affects bituminous binder characteristics in the best way. However, the bituminous binder modified with the oil sludge does not meet all the requirements for PBB brands according to current standards. That is why the possibility of the complex modification of bitumen with the oil sludge and polymers was studied. Sevilen, a copolymer of ethylene with vinyl acetate, related to the class of thermoplastics, and Kraton, a thermoelastoplastic, being a block copolymer of styrene and butadiene, were studied.

As the result of the study it was revealed, that the complex modification of bitumen with the oil sludge and Sevilen does not lead to an improvement of the elastic properties of the binder. However, the samples of modified bitumen with oil sludge and SBS block copolymer Kraton in the following ratios of the components: 1.0 % wt. of the oil sludge and 3.0 % wt. of Kraton; 2.5 % wt. of the oil sludge and 2.0 % wt. of Kraton; 2.0 % wt. of the oil sludge and 3.0 % wt. of Kraton, meet all the requirements for PBB 40 and PBB 60 according to Standard of Russian Federation 52056-2003.

In the project the technology for the industrial production of modified bituminous binder has been developed. The technology includes a pre-mixing stage, the stage of homogenization in a colloid mill, and ripening stage of a modified product. PFD (Process Flow Diagram) and P&ID (Piping & Instrumental Diagram) installation diagrams have been developed [3].

The economic efficiency of the project has been estimated. At the cost of 1 ton of products in 14981 rubles, the NPV index is 101 million rubles. The return on investment is 6.45 %. The internal rate of return is 110 %. The payback period of the project is 2 years.

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A COMPARISON OF ADSORPTION CHARACTERISTICS OF LOCALLY SOURCED MATERIALS FOR REMOVAL OF LEAD IONS (PB^{2+}) FROM NAMIBIAN MINE WASTE WATER

Heavy metal such as Lead (Pb), Mercury (Hg), Arsenic (As) and the like are constantly being released into water streams from battery, paper and pulp, mining, electroplating, lead smelting, metallurgical finishing industries and many more [1]. These heavy metals such as Lead, are known to be toxic even in small concentrations, and it affects the central nervous system, kidneys and gastrointestinal system. It is of great importance that these heavy metals are removed from waste water before being discharged to the environment [2].

High cost, incomplete adsorption of metals and increased sludge production continue to pose great challenges to mining industries in removing heavy metals from mine waste water in Namibia. Many processes have been studied to remove heavy metals such as reduction and precipitation, coagulation, flotation, adsorption on activated charcoal, ion exchange, solvent extraction and membrane filtration processes, of which the adsorption method showed the highest potential [2, 3]. Therefore, in this study, efforts have been directed towards comparing the adsorption capacities of biomass materials (spent tea bags and rice husks) with conventionally used activated charcoal in the removal of Pb^{2+} ions from Namibia mine waste water.

1g of the adsorbent materials was mixed in a batch test with 300 ml of mine waste water. Samples were drawn at 5, 10, 30, 60 and 90 minutes and filtered. Both the filtrate and the residues were characterized using ICP-OES and XRF. The adsorption capacities and kinetics of

the process were also determined. Statistical analysis was done to determine the difference in adsorptivity of the locally sourced materials and the Langmuir models were used to represent the equilibrium data of Pb (II) adsorption. ANOVA and T-tests were also used to represent the data statistically.

The results showed that the tea bags adsorb more heavy metals than both the activated charcoal and the rice husks. This will create a cost-effective material for heavy metal removal from mine waste water in Namibia. For future studies, more materials should be studies such as coir pith, peach stones, and rice bran and saw dust to compare their adsorption capacities and to see if they will be better alternatives.

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DESIGN OF ENERGY EFFICIENT ADVANCED OXIDATION REACTOR FOR WASTEWATER TREATMENT

Modern mining is an industry that involves the exploration for and removal of minerals from the earth, economically and with minimum damage to the environment. Mining is important because minerals are major sources of energy as well as materials such as fertilizers and steel. Mining is necessary for nations to have adequate and dependable supplies of minerals and materials to meet their economic and defense needs at acceptable environmental, energy, and economic costs [1].

The environmental problems arising due to mining activities are natural land degradation, air and water pollution with heavy metals, organic and inorganic waste, negative impact on terrestrial and aquatic ecosystems, human health and socio-economic. Possibly, the weightiest after effect of a mining is its effects on water resources. The impact of mining on surface and groundwater is due to spill erosion, sedimentation, acid mine drainage, etc [2].

Advanced oxidation methods (catalytic and photocatalytic oxidation) [3], chemical precipitation, adsorption on various media, etc.. These technologies can be applied successfully to remove pollutants that are partially removed by conventional methods, e.g. biodegradable organic compounds, suspended solids, colloidal substances, phosphorus and nitrogen compounds, heavy metals, dissolved compounds, microorganisms that thus enabling recycling of residual water [4].

In this case study, a reactor is designed using three proposed methods to degrade the pollutants, which are: Fenton Oxidation Process, Photocatalysis using Titanium Dioxide Catalyst, and UV light. The reactor is unique in configuration and designed for large amount of

waste water which is operated on solar energy hence energy efficient. It consists of 17 single tubes arranged parallel inside a shell and connected in series, which gives easy maintenance and no shutdown requirements. More than 90% of pollutants degradation will be achieved since these methods are strongly working together, with less environmental impact and high efficiency.

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PRODUCTION OF BIOCHAR FROM LIGNOCELLULOSIC BIOMASS RESIDUES IN THE UAE

The world suffers from a serious problem of energy shortage, the thing that has led to looking for new renewable sources of energy and renewable source for materials and chemical. One of the promising renewable sources is the biochar that is produced from the lignocellulosic biomass residues. Biochar is considered as a multifunctional material related to carbon sequestration, contaminant immobilization by adsorption, greenhouse gas reduction, soil fertilization, and wastewater and industrial effluent treatments. The advantages of using the biomass residue include its low cost, together with being more environmentally friendly than fossil resources. The UAE is one of the countries that head towards using this source, making use of the available amounts of biomass residues in the country. Typical biomass residues in UAE include agricultural residues and solid wastes. In UAE, the agricultural waste represents about 7% of the UAE's non-hazardous solid waste, and these big amounts are currently underutilized. This work is proposing to produce biochar from lignocellulosic biomass of palm tree residues in UAE. There are around 44 million date palm trees in the UAE and each tree produces approximately 20 kg of waste per year, indicating availability of huge lignocellulosic biomass in the country. Also, the UAE produces more household waste than many other countries, and the majority of the organic wastes accumulates in the municipal landfills and the total of the wastes in the UAE is 4.892 million tons. All these records indicate that the UAE is rich in biomass that can be turned into biochar using different ways. There are three types of pyrolytic reactions that differ in the processing time and temperature of the biomass, and they are the slow pyrolysis featured by lengthy solids, gas residence times , low temperatures, and slow biomass heating rates . There is also the flash pyrolysis that is characterized by the rapid heating rates, temperatures between 400 and 600C, vapor residence time of this process is less than 2 second, and flash pyrolysis produces fewer amounts of gas and tar when compared to slow pyrolysis. The third process is the fast pyrolysis that produces bio-oil and gas at temperatures of 650 to 1000°C depending on the desired amount of bio-oil or gas products. A slow pyrolysis is the promising thermal conversion process by which biochar is produced. Biochar is the solid product that remains after heating the biomass to high temperatures in the range of 300°C and 700°C under oxygen conditions (pyrolysis process).

The biomass chains start breaking down into smaller molecules in the form of gases, tars, oil and solid biochar under specific conditions. The decomposition of these components depends

on the reactor temperature, biomass heating rate, pressure, reactor configuration and feedstock. The first step is removal of moisture content of the biomass followed by grinding to reduce the particle-size, and then the processes of slow pyrolysis. Then, the biochar is separated from the syngas and bio-oils by a cyclone separator. On the other hand, the gases flow to the quench system to quench with cold water and the bio-oil start condenses. Finally, the produced bio-oil is stored in the oil tank before transportation and storage.

Regarding the operating conditions, there are specific requirements in the different process for the temperature, reaction time, pressure and so on. These pyrolysis rection conditions will greatly affect the quality of the biochar to produce and its application. Biochar has received much attention during the last few years for its potential applications in various agronomic and industrial sectors. Biochars have a tremendous range of physical and chemical properties, which greatly affect their wide applications. Recent evidence suggests that the feedstock and the method by which the biochar is produced has a significant impact on biochar characteristics, including concentrations of elemental constituents, density, porosity, and pH, which collectively impact the ability of the biochar for various applications. The main aim of this work is to determine the optimal pyrolysis condition to produce a high-quality biochar for a specific application.

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LUBRICANTS WITH ADDITIVES OF WASTE ENGINE OILS

Of great importance for the economy of our country is the state of the resources of various energy carriers, primarily oil, natural gases and coal, and their consumption. And the reuse of already used materials through regeneration can significantly affect the country's economy.

The problem of disposing of used lubricants is an acute one, since getting into the environment, they can cause enormous damage to flora and fauna. Meanwhile, the need for lubricants in developed countries is partially covered by the creation of lubricants from regenerated oils. Modern regeneration methods provide literally absolute restoration of the quality of waste oils.

The existing methods for the production and compositions of greases require the use of expensive and limited resources, such as petroleum base oils and additives, and their production technology is energy intensive and costly.

Used motor oils are a product requiring disposal, while they contain a heavily contaminated base oil base and a residual supply of additives, which under certain conditions can be used in the production of secondary oils and lubricants.

Removing from used motor oils, resins, asphaltenes, carbenes, carboids will make it possible to obtain a practically oil base - a dispersion medium for greases, while unlike traditionally used expensive base oils, refined waste oils contain 25-30% antioxidant, antiwear, anti-corrosion additives , which increase the operational properties of the dispersion medium and, consequently, the properties of grease [1].

The grease studied in this work was prepared with the addition of used mineral automotive oil “M-5z / 12g SAE 10W-30” - a universal multigrade mineral oil. It is recommended for use for highly accelerated fuel engines that operate under severe operating conditions, and highly accelerated diesel engines with naturally aspirated or slightly supercharged engines. Multigrade mineral automotive oil. It looks like a dark opaque liquid with a characteristic odor.

Its physico-chemical characteristics are presented below:

- kinematic viscosity at a temperature of 40 ° C - 26 mm^2 / s;

- flash point in an open crucible - 100 ° C;
- mass fraction of mechanical impurities not more than - 1%;
- mass fraction of water no more than 2%;
- density at 20 ° C - 0.905 kg / m^3

Lubricant preparation technology is divided into 5 successive stages [2].

Analyzing the data obtained, we can conclude that the properties of the lubricant prepared with the addition of used oils (base oil + OMM 30/70) do not have large distinctive properties from lubricants prepared from base oil oils (Table 2).

Table 2 - Properties of lubricants prepared with base oils and with additives from used oils

Name of oil	**Kinematic viscosity, mm2 / s, at a temperature of 40 ° C**	**Protective ability in the G-4 thermal moisture chamber, in points**	**Washability, %**
Base oil	62,6	0,5	7,4
Spent Engine Oil + Base Oil (30/70)	66,5	0,5	7,4

Consequently, the development of simple technological processes for the purification of used oils from impurities and contaminants, and the production of demanded greases on their basis, makes it possible to solve the multifaceted urgent problem of resource saving, reducing the cost of purchasing lubricants and rational solving the problems of utilizing used oils at their places of consumption.

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STUDY OF THE SETTLING, COMPRESSIBILITY AND CONSOLIDATION PROCESS IN PHOSPHATE TAILINGS AND THE IMPLICATIONS OF THE USE OF INORGANIC AND ORGANIC FLOCCULANTS UNDER EFFECTS OF SALINITY

The management of the disposal of low-density tailings by the wet way, such as that of phosphate, is extremely relevant in the mining industry, being essential a detailed characterization of the fine tailings, whose consolidation process is not governed by the classical Terzaghi theory proposed for Classical Soil Mechanics [1]. Much of the literature presents conventional characterization tests of the material, involving several limiting assumptions, such as small deformations and constant coefficients of consolidation and hydraulic conductivity.

Thus, it is essential to carry out studies improving a fundamentally consistent depositional model, related to the large deformations experienced by the tailings during the consolidation process. Therefore, this thesis developed an analysis methodology from the sedimentation process (by means of column tests), the consolidation process, carried out by the flow-induced density test (an unconventional test in particular).

The refuse coming from the beneficiation stage of the Bayóvar Mine, in Peru, allowed to assemble the specimens for different levels of solids, with values of 8.5%, 11%, 13.5%, 16%,

18.5% and 21%. To accurately determine the settling rate and the compressibility and permeability ratios for low density tailings pulps, referring to the different conditions of the solids content.

The salt content in the phosphate tailings was obtained by tests of solids content, the obtained value of 4576 ppm showed that the tailings had a very high salt content, a value that influences the settling and flow-induced densification tests, logically in the final disposal process. Regarding the salt-induced aggregation, the reaction kinetics depends on the electrostatic repulsion between the particles, which is dependent on salinity for the variation of settling rate [2].

The presence of salt in natural water produces cations and free ions that cause a decrease in the energy barrier and, finally, an elimination for medium to high concentrations of salt [3]. The increase in salinity considerably reduces electrostatic repulsion, the use of sea water and its salinity content is responsible for the settling rate and turbidity of mining waste [4].

Knowing in detail the behavior of phosphate tailings from northern Peru will guarantee a better disposition of the material in tanks with better filling simulations and standardization, even better with the help of flocculating agents. The inorganic flocculant when working with phosphate tailings under conditions of high salinity presents a better performance with a low solids content, obtaining satisfactory settling rate, where the peak for an acceptable speed is with a solids content of up to 13.5% with 16% the performance starts to decrease until the content of 21%. Due to the cationic electrolytic chains that can adsorb via electrostatic interactions on the surface of the phosphate tailings particles, that by increasing the solids, the inorganic flocculant considerably decreases its flocculating action when it does not achieve the bridges between the particles.

However, the organic flocculant, a highly efficient cationic flocculant, was shown to be a more appropriate flocculant for phosphate tailings as it shows a better performance in the different stages of sedimentation. This flocculant also presented a more reasonable concentration-solids ratio, as it could create more bridges between the particles, considering that for a higher solids content the concentration must be increased, but the settling rate is much lower when compared to levels low.

A good agreement was observed between the curves obtained in the simulation performed. The tendency was for a slight increase in the curves obtained by the compressibility law over time, but converging to a predicted final time very close, for complete filling. In the computational numerical simulation, the conventional staggered filling showed a resulting curve that compared to the curves obtained in the field, where a good agreement of results from the beginning of the filling up to 350 days was observed. However, there was a distancing of the curves for the final levels of the filling, justifying the staggered simulation with the consideration of the correction of the nominal filling curve for the two tanks.

As recommendations, an implementation of an algorithm that numerically simulates the step of phosphate tailings sedimentation in the reservoir filling process, since the application software considers the void index associated with the zero effective tension as the maximum value, that is, it simulates only the consolidation step. Simulations of tanks on a laboratory scale, with instrumentation, enabling continuous monitoring and evaluation of the variables involved in the layout, including non-invasive tests.

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CARBONDIOXIDE CAPTURE USING SODIUMCARBONATE

Carbon capture is one of the daunting task because it is a solution for the global warming, climate change and air pollution throughout the universe. Carbon dioxide constitutes for 60% of the greenhouse gas effect. One of the main sources of carbon dioxide include coal fired from mining plants. Coal burning is responsible for one-third of all carbon dioxide pollution (CO_2). Coal mining environmental effects stays for years after the coal is removed. The global coal resource was estimated to be 847 billion; According to the mining experts study the potential cost of dealing with the climate change caused by this CO_2 will be up to 20 percent of the world's GDP by 2100[1].This can be seen in China one of the largest country in mining sector, facing enormous pressure to save energy and reduce greenhouse emissions [2]. Therefore carbon dioxide needs to be captured and stored safely for clean environment.

Stating the previous facts, and the threat it can present globally certain preventative measures should be taken to mitigate this effect. Carbon dioxide capture and sequestration technologies has to be developed in various ways. One of these is using dry sorbent technologies. Considering all the available methodologies and their benefits sodium carbonate and fluidized bed is used for this project.

This project is designed for capturing carbon dioxide from a coal-fired power plant using the dry carbonate process. The solid used is sodium carbonate due to its various advantages, it is estimated to capture up to 90% of carbon dioxide. The uniqueness of this project underlies on the use of fluidized bed along the process. Not only that but the main reason for the selection of this design is based on lower cost, energy saving and safety. To reach the desired prototype all the design calculations including material and energy balance are done accordingly. In the project besides the environmental benefit of the business value is as well considered. Keeping in mind the competition in the market this project should be valuable and profitable. Therefore a cost estimation is done which shows a promising future of the project.

The selected methodology follows the process to capture the desired amount of carbon dioxide. In this project sodium carbonate is used because of its efficiency, ease of transporting the material, price compared with other sorbents After fabricating the prototype, lab scale experiments were conducted to validate the fluidization of sodium carbonate. The design constitutes two main reactors including carbonator and regenerator. As per the design calculations 2930.5 kg/hr [3] coal-fired flue gas is used as feedstock for CO_2 absorber (Carbonator). The CO_2 along with Na_2CO_3 is converted to $NaHCO_3$. The Sodium bicarbonate is transported to Regenerator, where the $NaHCO_3$ converted to hot sorbent Na_2CO_3 that is recycled back to the CO_2 absorber. While the CO_2 goes to the compressor which is collected and stored safely.

In this project the carbon dioxide capture by the dry carbonate process is designed based on the assumption of 90% absorption efficiency. The material and energy balance calculations resulted in the design feed rate and design temperature of the reactors. Based on this calculation a $1/20^{th}$ scale down prototype model was fabricated. The basic cost estimation calculations

shows that this technology is not only helpful for the environment but profitable. This technic has very promising future towards clean environment.

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VISUAL ANALYSIS OF RESEARCH FOCUS AND EVOLUTION OF GARBAGE CLASSIFICATION

With the continuous development of economic and cultural globalization and changes in human lifestyles, the production of municipal solid waste (MSW) is also rapidly increasing. Companies and households in 28 EU countries / regions generated approximately 2.5 billion tons of waste in 2012, and China expects to produce nearly a quarter of the world 's urban solid waste by 2025.Improper MSW management not only regulates , Environmental Protection, and Resource Management have adverse effects, but also cause energy shortages, environmental degradation, and increase social governance costs.

From the perspective of bibliometrics and visualization, there is almost no research on garbage classification. The knowledge structure in this field is analyzed to understand its main knowledge applications and current challenges. Document data visualization can not only mine useful information from the data, but also visually display the results of the data information to the reader in a visual way.

Lopez Ruiz, Luis Alberto mentioned that globally, construction waste has priority in many policies due to mass production of construction waste and its improper management. The low product recovery rate and the manufacture of new building materials can have a serious impact on the environment. In this case, the circular economy is an effective solution in many sectors, which can use natural resources and energy more effectively, thereby reducing waste production and environmental impact. It is also a potential economic opportunity. Kim, Jeawon further discussed the pressure on the environment caused by the waste of food, causing huge economic losses to society and families. And expand the research approaches traditionally used in social marketing and co-design processes to reduce household food waste. It proves the value of applying social marketing and co-design process to solve the problem of food waste at home.

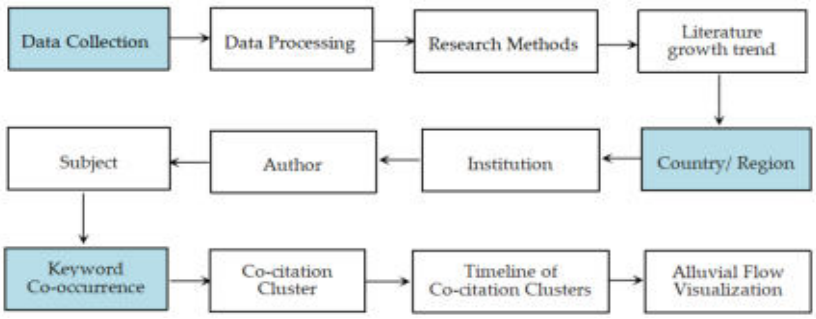

Figure 1 - Research procedure

The study found that the amount of garbage classification papers showed an increasing trend in time series. China, the United States and the United Kingdom are more prominent in the global garbage classification research. The research hotspots are mainly concentrated in four major areas, №1 and №2 demolition waste, №4 municipal solid waste worker, №5exploring critical success factor, №6 health risk assessment.

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APPLICATION OF ACID TAR WASTE AS FILLERS IN BITUMINOUS MATERIALS

Acid tar waste is formed by sulfuric acid purification of mineral oils, by the production of sulfonate additives, in alkylation processes where sulfuric acid as a catalyst is used. This type of waste causes a serious environmental problem [1]. Acid tar waste accumulates in dumps and open storage ponds where the acid is washed out by atmospheric precipitation and as a result SO_2 and SO_3 is released, that results in contamination of the water and air pools [2, 3]. Acid tar is one of the most difficult products to waste dispose [4]. At the same time the acid sludge is a valuable secondary material resource for the production of certain products including commercial petroleum products [5]. Acid tars are highly viscous liquid petroleum products consisting of a mixture of heavy hydrocarbons and sulfuric acid.

The aim of this research is to observe the process of the neutralization of the acid tar waste during the production of the sulfonate additives with dolomite flour and chemical water treatment sludge at the CHP plant, produced on the basis of the neutralization products of bituminous materials.

As a neutralizing agent a natural mineral – dolomite powder was used. The sludge of chemical water treatment from a combined heat and power plant was used as a second neutralizing agent, which has not found qualified use and accumulates in dumps. The content of calcium carbonate and pH value in the sludge are significantly higher than in dolomite powder. The treatment of acidic tar waste of the production of sulfonate additives of JVLL"LLK-NAFTAN" is carried out in two stages. The acidic tar waste was heated to a temperature of 80-110°C and mixed with neutralizing agents (dolomite flour and chemical water treatment sludge at the CHP plant (CWTS)) are added at 5…20 wt. on acidic tar waste.

It is established that the degree of change in the acid number is approximately the same at 80, 90 and 100°C and a significant decrease in the acid number by more than in 2 times is relative to the initial value which is found upon neutralization at 110°C. This is probably due to the fact that during heat treatment of acid tar waste at 110°C there is a low-temperature decomposition. The neutralization process is more effective when one uses CWTS which correlates with the pH of the neutralizing agents. Almost neutral product can be obtained with

the addition of CWTS of about 10% by weight as well as the same acidity value only with a 20% additive of dolomite flour. Based on the products of neutralization of acid tar waste it is proposed to obtain bituminous roofing bitumen according to GOST 2889 since various dust-like fillers and, in particular, fine-grained dolomites are used to produce this mastic. As a bituminous binder for the preparation of mastic, oil road bitumen BND 60/90 is used. The addition of the acid tar neutralization product leads to a significant increase in its hardness. The needle penetration depth decreases by more than 2 times with the involvement of twenty percent by weight of the neutral product. Also heat resistance increases, which might be the result of possible additional structuring processes. The main characteristics are determined (the brittleness temperature in the freezer, the flexibility and heat resistance), it is established that the obtained values do not exceed the normative values for bituminous mastic for roofs. The comparison of the obtained mastic based on neutralized acid tar with an industrial analogue showed that the obtained product satisfies the requirements of GOST 2889 and is suitable for further use.

Thus, the product of neutralization of acid tar waste from the production of sulfonate additives by chemical water treatment sludge at the CHP plant can be disposed of by mixing with bituminous binders and obtaining bituminous mastic for roofs. For neutralization dolomite flour is used but with double volume for neutralization.

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DEVELOPMENT OF THE UNIVERSAL BIODEGRADABLE DETERGENT’S PRODUCTION AND APPLICATION TECHNOLOGY

As a result of patent investigations the most relevant patented solutions to the present research were analyzed in the following areas: liquidation of emergency oil and oil product spills on the soil surface; washing of oil-contaminated surfaces, including oil sludge storage tanks; oil-sludge neutralization. The analysis showed that there is no detergent on the Russian market that is universal for use in all relevant areas and has biodegradability. [1]

In accordance with the principles of resource saving and energy efficiency [2], a technology for the production and use of three brands of universal biodegradable detergent from surface-active substances (surfactants) with demulsifying properties to intensify the processes of phase separation of hydrocarbon-containing media (further - Detergent) was created.

The developed Detergent should comply with the requirements of the created technical conditions and the technological regulations for its production and use, approved in the established manner. Organoleptic, physicochemical and technological indicators of the Detergent must comply with the requirements and standards specified in Table 1.

Table 1 - Requirements and standards for detergent

№	Indicator	Characteristics and standards for brands		
		«Liquidation of oil spills»	**«Washing of oil-contaminated surfaces»**	**«Oil-sludge neutralization»**
1	Appearance	Light yellow liquid	Light yellow liquid	Light yellow liquid
2	Biodegradability	+	+	+
3	Corrosion inhibitors	+	+	+
4	Activation temperature, ºC	55-60	55-60	55-60
5	Hydrogen indicator of 1% solution (pH), no more than	6,9	6,9	6,9
6	Density, g / cm^3, 20 ºC	1,0	1,0	1,0
7	Cleansing ability,%, not less than	95	95	95
8	Demulsifying ability,%, not less than	80	80	70
9	Foaming ability, cm^3, no more than	30	15	15

The processing of the results obtained in the series of experimental laboratory studies shows that the most relevant detergents are inferior to the developed Detergent in terms of the main required indicators (foaming ability, activation temperature, biodegradability, cleansing ability) or do not contain information about them (demulsifying ability, pH).

Based on the developed program of pilot-scale tests, tests were carried out on the technology of purification of oil-contaminated wastewater using Detergent. The treatment line shown in Table 2 included three stages of wastewater treatment.

Table 2 - Technological line for the treatment of oil-contaminated wastewater

№	Process	Units
1	Oil-contaminated wastewater treatment	Detergent preparation unit
		Homogenization unit
		Static separation unit
2	Centrifugal separation	Centrifugal separation unit
3	Oil-contaminated wastewater after purification	Filtration unit
		Biological treatment unit

The calculation and analytical study of the experimental results showed that the oil content in the aqueous phase was reduced from 22.5 ± 8.5 mg / kg to 0.23 ± 0.05 mg / kg, the water hazard class became the fourth. The washed waste becomes the 5th hazard class. Due to

the biodegradability of the detergent, further purification of water with the help of biological products-oil destructors is possible.

The compound of the Detergent obtained corresponds to the principles of resource conservation and energy efficiency [3]. After the treatment of oil-sludge with this product, wastewater and treated sludge are classified in hazard classes 4-5, which reduces resource consumption during their disposal. In addition, the activation temperature of the Detergent is lower than that of similar detergents (55-60 °C), which also complies with the principles of energy efficiency.

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CO_2 STORAGE WITH IMPURITY GAS IN DEPLETED GAS RESERVOIRS

CO2 storage in depleted gas reservoirs is an important strategy of carbon capture and storage (CCS) for slowing down the atmospheric CO2 emissions and mitigating the global warming and climate change, whereas the lack of financial incentives limits its application in large-scale [1]. It is estimated that the processes of carbon capture and gas separation dominate the overall cost of CCS, thus co-injection of CO2 with impurity gas can be a cost-effective strategy for CO2 storage [2]. In this work, CO2 with the main impurities from the flue gas that is the main source of CO2 emissions, i.e. N2 and O2, were applied for the injection into a depleted gas reservoir.

The gas mixture with three different concentration of impurities were applied for co-injection, including the gas with low (abbreviated as L Impu), medium (M Impu), and high concentration (H Impu) of impurities, which corresponding the component of 98% CO2 + 1% N2 + 1% O2, 91.5% CO2 + 5.5% N2 + 3% O2, and 85% CO2 + 10% N2 + 5% O2, respectively. A typical depleted gas reservoir with the thickness of 50 m and located at the depth of 3000 m was used for simulation [3]. The horizontal and vertical permeability of the reservoir are 10 mD and 5 mD, respectively. The reservoir porosity is 15% and the irreducible water saturation is 25%. The original pressure of the reservoir is 30 MPa. When the depleted gas reservoir is dedicated for CO2 storage, the gas was injected into the reservoir without gas production until the average reservoir pressure reach to the original pressure of the reservoir. There are two stages for the CO2 storage with enhanced gas recovery (CSEGR). The first one is gas injection associated with CH4 production until the mole fraction of CH4 in the produced gas is lower than 90%, and the second one is gas injection without production until the average reservoir pressure recover to the original pressure of the reservoir.

Figure 1 shows that the CO2 storage capacity decreases with the increasing concentration of the impurities. Specifically, the impact of the N2 and O2 on the CO2 capacity is proportional to the impurity gas concentration. The reason is that the density decrement of the mixture gas is approximately proportional to the concentration of impurities at the reservoir conditions. Figure 1 also shows that the solubility trapping capacity of CO2 increases with the increasing primary gas recovery and the decreasing of the reservoir temperature. This tendency is the same as that of the total CO2 storage capacity, indicating the depleted gas reservoir with a high primary gas recovery and low temperature is favorable for CO2 storage.

Figure 2 shows the mole fraction of the gases in gaseous and aqueous phase at a monitoring point when CO2 was co-injected with high concentration of impurities into a depleted gas reservoir with flowable water. It can be seen that CO2 migrates to this point in gas phase at the time of approximately 1 year, while the occurrence of N2 and O2 is about 0.5 year. This phenomenon occurs in both gaseous and aqueous phases. It means that the N2 and O2 can be detected approximately 0.5 year before the CO2 at the monitoring location. Therefore, the detection of N2 and O2 front could be regarded as a signal of potential CO2 leakage after a time lag.

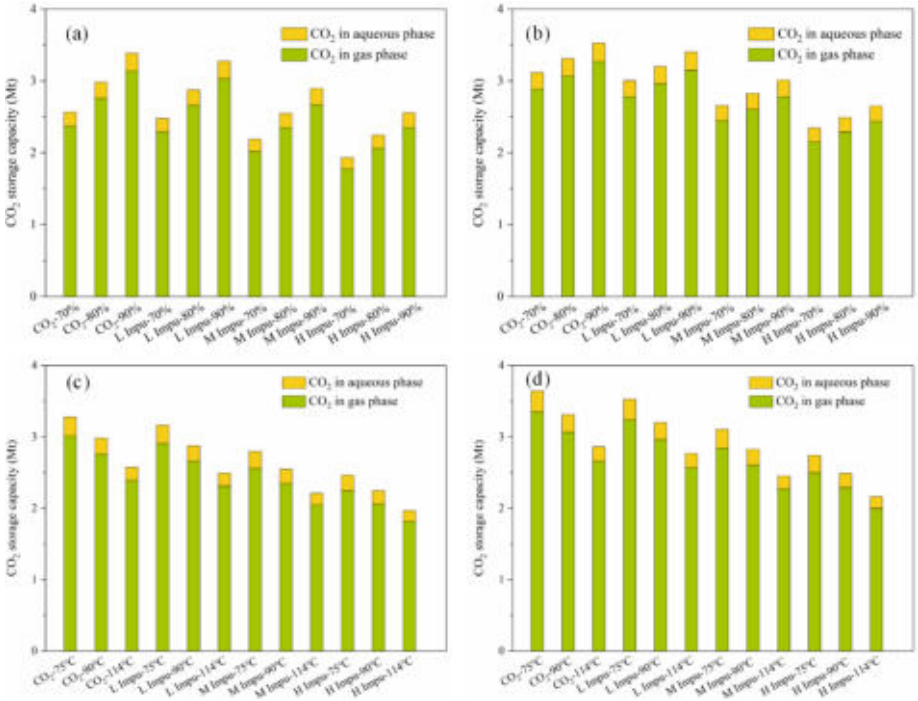

Figure 1 - The CO2 storage capacity for (a) CO2 storage with different primary gas recovery; (b) CSEGR with different primary gas recovery; (c) CO2 storage with different reservoir temperature; (d) CSEGR with different reservoir temperature

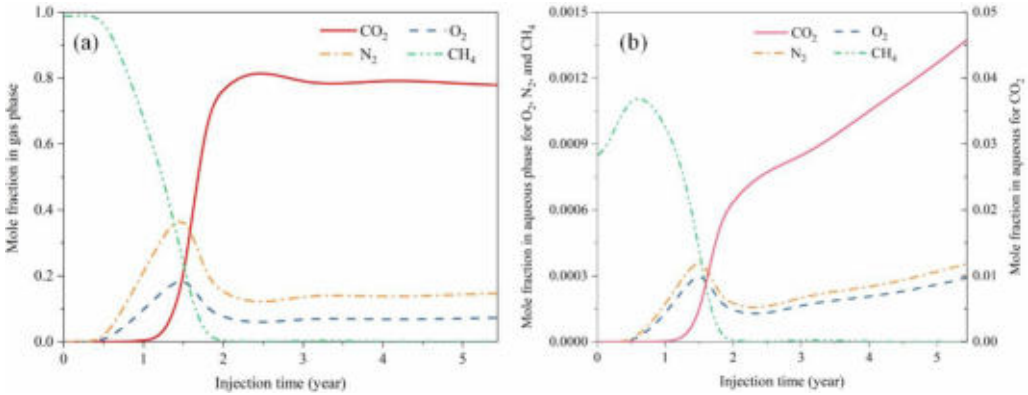

Figure 2 - The mole fraction of the gas in (a) gaseous and (b) aqueous phase for the injection of high concentration of impurities into a depleted gas reservoir with flowable water.

The CO_2 contained the impurities of N_2 and O_2 is feasible to be injected to a depleted gas reservoir for CO_2 storage and CSEGR. The depleted gas reservoir with a low temperature is favorable for the CO_2 storage capacity. It is suggested to produce the CH_4 as possible before the operation of CO_2 storage and CSEGR. In the given depleted gas reservoir in this work, the CO_2 storage capacity decreases proportionally to the concentration of impurities. The detection of N_2 and O_2 could be used as a monitoring strategy for the potential CO_2 leakage.

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EFFECTIVE DRILLING WASTE MINIMIZATION STRATEGY FOR SUSTAINABLE AGRO-OPERATIONS

Studies have shown that oil and gas drilling fluids comprises of chemical reagents and additives which can pose environmental concerns through waste generation [4]. Across continents, strict government regulations have been imposed in order to ensure proper management and minimization. Common wastes generated during oilfield drilling operations include: drilling fluids and drill cuttings [2]. An effective surface waste management plan involves source reduction, recycle and disposal [3]. In this paper, we will focus on analyzing new sustainable solutions to effectively manage drilling waste for environmental protection and sustainability.

Waste minimization in oil and gas drilling operations is aimed at reducing the quantity of waste produced as a result of drilling operations. Several waste minimization approaches have been deployed in waste management programs. Source reduction basically deals with applying measures that are aimed at reducing the level of toxicity in the generated waste [4]. In relation to oil and gas drilling operations, the mud engineer who is saddled with the responsibility of selecting, testing and monitoring drilling fluids must take waste minimization into consideration during these activities. This can be done by selecting drilling fluid additives based on minimum toxicity level, biodegradation and cost effectiveness [1]. Other effective source reduction approach includes: solid control, adopting an automation process, constant monitoring, maintenance and the replacement of worn-out equipment. Recycling has to do with reuse of waste as substitute for various sustainable programs (waste to soil conversion for agro-operations, mud treatment for reuse, waste to energy conversion etc.) [2]. The recycling and reuse of drilling fluid often leads to a significant reduction in operational cost and environmental pollution [1].

Studies show that oil and gas drilling waste can be successfully applied to soil for sustainable agricultural operations. However, several factors must be considered to ensure success of sustainability of agro-operations.

- Drilling waste: soil ratio and loading rate
- Soil content
- Waste toxicity level
- Drilling Fluid mineral content
- Soil Electric conductivity

- Soil Hydraulic Conductivity
- Plant growth rate
- Plant growth index

Table 1 – Effective waste minimization strategy

Waste minization in drilling operations		
Recycling	**Source reduction**	**Disposal**
Mud treatment for reuse	Application of biodegradable additives in drilling fluids (Synthetic based drilling muds, biodiesels, biopolymers etc.)	Injecting waste slurry into disposal wells
Waste to soil conversion	Equipment monitoring and maintenance	Land spread
Waste to energy conversion	Application of digital technology through automation	Onsite burial pit disposal
Waste conversion to concrete for bricks, road construction etc.	Enhancing Drilling Operations to fit environmental concerns and geological configurations	

Despite large volume of drilling waste generation, oil and gas researchers have studied and provided sustainable ways and approaches in which generated wastes can be properly managed. Several waste management approaches have been applied by industry operators. These include: waste recycling, source reduction and waste disposal. In the waste recycling strategy, conversion of waste to soil for agro-operations can be considered a reliable approach towards achieving an efficient waste management program. Experiments have shown that oil and gas drilling waste can be successfully applied on soil to enhance agro-operations. It is recommended to select drilling fluid with biodegradable additives. These additives which are considered less toxic are easy to treat and convert to soil for agro-operations.

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ELECTRO-KINETIC DEWATERING OF COPPER MINE TAILINGS

Mine tailings remain after the separation of valuable ores in the processing phase and often carries a significant amount of water into a storage facility and can trap water for a long time. Electro-kinetic method is a potential technology of fine-grained soil dewatering and remediation. In this study, the effect of the electro-kinetic process on the extraction of trapped water in tailings slurry of a copper mine was investigated. 3 scenarios were performed over 144 hours, by taking into account the polarity reversal in two series of experiments with voltage gradients 1 (V/Cm) and 2 (V/Cm). To compare the experiments in terms of the amount of water extraction and energy consumption, 3 indices for each test were calculated as the index of dry tone (IDT), index of water extraction (IWE), and index of normal water extraction (INWE). Fourie et al. (2007) applied electro-kinetic methods to dewater very fine tailings by utilizing geosynthetics corrosion-resistant electrodes [1]. The use of dimensionally stable anode with variable voltages in the dewatering of a tailings slurry has been reported by Lee et al (2016) [2]. Shang & Xu (2019) by using almost similar setup, observed the efficiency of electro-dewatering on nickel hydrometallurgical tailings. They eventually classified the method as an efficient technique for the in situ dewatering of mine tailings [3].

The electro-kinetic phenomenon involves the injection of an electric current into the soil by conductive electrodes and the creation of an electric field between the anode and cathode. One of the main conditions for the occurrence of electrochemical processes in soil is the presence of moisture and pore fluid in the media. In addition, to facilitate transport processes, the task of moisture is to regulate the conductivity of a media and reduce its electrical resistance [4].

The sample was taken from the slurry of the inlet channel to the dam. An electro-kinetic setup box made of Plexiglas material with dimensions of 50×20×10 (length(cm)×height(cm)×Width(cm)) was designed to evaluate the potential of electro-kinetics in water extraction and moisture reduction of the tailings. 3 series of experiments, T1, T2, and T3 were performed. To compare the efficiency of the experiments in the most optimal times and energy consumption, the extracted water was measured in 3, 24, 48, 72, and 144 hours and 3 indices of IDT, IWE and INWE were calculated. Finally, the effect of each experiments on chemical variation of the tailings was evaluated.

First experiment, T1 involved the use of a voltage gradient of 2(V/Cm), equivalent to applying a voltage of 60 volts along the 30 cm sample over a period of 144 hours. The total amount of extracted water reached in 48 hours of T1, was 244 ml. With the descending trend of the electric current after 48 hours, no more water was extracted in T1. The potential of T1 in water extraction declined due to the decreasing moisture content of the tailings and so increasing the resistivity. The second experiment, T2 was conducted to investigate the effect of polarity reversal on the enhancement of water extraction and chemical reactions by applying gradient voltages 2(V/Cm). During the T2, 4 series of polarity reversion happened. As a result, 265 ml of water was extracted in experiment T2 over 144 hours. In the Experiment T3, the voltage gradient was reduced to 1(V/Cm), to investigate the effect of this drop on the amount of extracted water for less energy consumption. The total amount of 250 ml of extracted water was observed in T3 with the least energy consumption.

In the first 3 hours of the experiments, where the moisture variation in the tailings was not high compared to the entire period of the experiments, the amount of extracted water of T1 and T2 was almost twice of T3 system. 24 hours after starting the experiments, the water extraction is approaching to approximately the same value for every 3 experiments. The reason for this can be related to the electrical resistivity of the media and the amount of moisture content. Over time, the factors that reduce moisture content including hydrolysis, heat generation, and water extraction in T1 and T2 experiments, carry on at a faster rate than T3. thus reduces system efficiency faster than experiment T3. The maximum volume of water can be extracted in all three experiments, are reached in 24h hours, and subsequently, the water extraction by using electro-osmotic become difficult to perform due to the reduction of moisture content. The amount of INWE and IWE indices are optimal in the T3 experiments for the first 24 hours. The minimum values of the IWE and INWE are 0.39 and 72.95 respectively. In this situation, the energy consumption of the system was 0.084 (kWh) and extracted water was 214 ml. Among the 3 implemented experiments, the highest extracted water was related to scenario T2 by the polarity reversal and voltage gradients 2(V/Cm). However, The IWE and INWE indices showed the first 24 hours of T3 as the optimal scenario with respect to energy consumption.

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CIRCULAR ECONOMY OF ELECTROPLATING INDUSTRY WASTES

KEYWORDS: Electroplating, waste minimization, metals recovery, recycling, circular economy.

Metal finishing industries are often associated with the generation of wastes and the electroplating industry is not an exception in this regard. Waste streams of electroplating industry, such as utilized process solutions, solvents, wastewater, and sludge, generated in huge amounts on a daily ba- sis represent a huge environmental threat because of the high toxicity and natural hazards. Furthermore, the waste streams typically contain a sub- stantial concentration of valuable metals used for the plating process, such as nickel, chromium, silver, gold, and others, recovery of which is essential taking into account economical considerations of the question. From these perspectives, waste minimization is of crucial importance and can be per- formed through operational improvements and process adjustments. The purpose of the present study is to characterize wastes generated in the elec- troplating industry as well as to review the existing handling processes for its minimization. A variety of techniques for treatment and regeneration of waste streams are summarized and discussed including neutralization, crys- tallization, electrodialysis, and others. The work also inquires into the possi- bility of applying a circular economy concept to the electroplating industry as a prerequisite for shifting to a more environmentally-friendly production process.

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TECHNIQUES OF PROCESSING THE KUZBASS ASH AND SLAG WASTE FOR PRODUCING CONCENTRATES OF RAREAND RARE EARTH ELEMENTS

The Development Program of the Coal Industry in the Russian Federation until 2030 envisages an increase in the average annual gain in coal reserves from the current 380 million tons to 530 tons, and in the Kemerovo region - up to 260 million tons. For Kuzbass, being a coal-mining region, the problem of utilization and processing of ash and slag waste (ASW), which are generated as a result of the operation of thermal power plants and state district power plants, is especially urgent. This waste is placed in ash dumps, occupying gigantic areas, causing great harm to the environment in the region. Currently, the percentage of ash and slag processing in Russia is extremely low (about 10%), at the same time, it is known that ash and slag are an important resource, since they contain a large number of valuable components, in particular, rare and rare earth metals, without which it is impossible to create modern high-tech devices [1, 2].

To obtain a concentrate rich in rare and rare-earth elements (REE), two methods of coal industry wastes enriching were used in the work. The first method is based on breaking up the ash and slag materials using chemical reagents (mineral acids), subsequent processing of the obtained extract by leaching, and further re-precipitation of rare and rare earth metal oxalates [3]. The second method is based on the concentration of ash by ion flotation.

After treatment of 1000 g of “G” grade ash of the Kotinskaya underground mine and “D” grade of the Kamyshinsky open pit mine, taken from Kemerovo State District Power Plant, with 5M of nitric acid and holding for one day, a gel of orthosilicic acid and silicates were formed. Further on, multiple washing and filtration of the suspension was carried out, as a result of which an extract was obtained for further neutralization with an ammonia solution to pH 5. In the process, a large amount of brown precipitate Fe (OH) 3 fell. After filtering the precipitate, the pH of the extract was adjusted to 8.5 with an ammonia solution for the co-precipitation of rare earth hydroxides and aluminum.

After separation and drying in air, the precipitate was re-dissolved in 0.5 N. nitric acid solution, while the pH of the solution was 0-2, then a saturated solution of oxalic acid was added to the extract. As a result, a white micro-fine precipitate of rare earth oxalates was formed. With an increase in the pH of the solution to 8, complete precipitation occurred with the precipitation of alkaline earth metal oxalates and, in part, element hydroxides. The mass of the separated precipitate was 5.494 g. The resulting substances were dried in air.

The ion-selective flotation method is used to extract substances from solutions with a very low concentration of components, including rare, scattered and rare-earth metals, which is why it is effective for applications with ash and slag waste [4]. In the flotation concentration method, sodium tetradecyl sulfate and sodium dodecyl sulfate were used as collector reagents and surfactants; isooctyl alcohol was the organic phase. According to the method, 2000 cm3 of water, 52 cm3 of 2-ethylhexanol (the ratio of the organic and aqueous phases is 1:40) and 2.01 g of sodium dodecyl sulfate as a collector reagent and surfactant were added to 500.14 g of fly ash.

The suspension was aged for 10 minutes, after which flotation extraction was carried out at pH 7.5-8.5 on a laboratory FL-240 flotation machine. The result is stable gray foam. Rare earth elements form stable hydrophobic compounds with the collector, as sodium dodecyl sulfate is a highly selective reagent for the formation of complexes with lanthanides. After drying in air, the mass of collected particles was 0.690 g.

The content of valuable components in the ash and slag waste processing products was defined by IR spectroscopy performed on an Agilent Cary 630 FTIR spectrometer in the range of 4000-650 cm^{-1} and by inductively coupled plasma optical emission spectrometry on an iCAP

6500 DUO spectrometer. Based on the results of the studies, it can be concluded that both techniques of the recovery of rare and rare-earth metal concentrates are quite effective, relatively simple and do not require expensive equipment. However, it is more promising to use the method for opening ASW with chemical reagents at higher contents of valuable components in the samples. Therefore, to enrich and concentrate REE in depleted ash and slag raw materials, it is proposed to combine flotation extraction along with chemical methods.

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OBTAINING NEW BITUMEN MATERIALS BY USING PET WASTE

The global plastics industry is growing by 5-6% annually, while the market for polyethylene terephthalate (PET) is the fastest-growing. But as the demand for PET grows, the amount of waste generated naturally increases. Today, PET waste makes up more than 20% of all plastic waste. Every year in the Republic of Belarus, on average, 15 kg of polyethylene terephthalate waste is produced per person, a small part of which is processed to produce secondary products.

PET is highly resistant to external factors, which leads to its widespread use, but it also leads to certain problems in its disposal. In recent years, scientists have turned their attention to PET as additives to petroleum bitumen in view of its strength and physico-mechanical properties [1]. Existing works indicate improved operational properties and increased road life when using modified PET bitumen. The use of PET waste in the production of polymer-bitumen binders (PBB) seems promising, because improves the strength properties of binders and allows to solve the problem of their processing. Despite the availability of publications on the preparation of polymer-bitumen compositions using crushed secondary PET in practice, this is not feasible.

Using PET as a bitumen modifier is associated with several problems [2]:

1. the PET-bitumen system is thermodynamically unstable;
2. the melting temperature of PET is 260°C, therefore, the process of obtaining homogeneous PBB must be carried out at elevated temperatures, which will lead to increased oxidation of the organic part and, as a result, a decrease in elastic properties;
3. PET is insoluble in the maltene part of bitumen and most organic solvents;
4. PET waste is often heterogeneous in composition and may contain additives of other polymers (stabilizers, dyes, etc.).

Thus, the creation of stable PET-bitumen compositions is possible with chemical and thermal pre-processing of PET waste, the use of PET solvents, high temperatures and high shear forces.

Thereby, the optimal way to obtain homogeneous polymer-bitumen binders based on secondary PET is to pre-dissolve the PET before introducing it into bitumen. Using a solvent also allows to remove various contaminants (dirt, aluminum, foreign polymers) from PET waste, which makes this method very attractive. The collected PET waste was pre-crushed and dissolved in various solvents [3]. In the work, the solubility of PET in various organic solvents was studied and a solvent with a high dissolving ability was selected.

Modifiers based on PET waste obtained by dissolving the latter in a solvent were obtained and studied. A biodegradable, low toxic organic solvent was selected that readily dissolves PET waste within 5 minutes at a temperature of 130-150°C.

The obtained modifiers were introduced into petroleum bitumen and the operational properties of the resulting binders were determined. The introduction of modifiers based on PET waste leads to an increase in softening temperature, an extreme change in penetration. All compositions obtained were homogeneous. An extreme change in the penetration of binders with an increase in the amount of introduced modifier is due to the intensive restructuring of the disperse system. The introduction of such a modifier leads to a decrease in the temperature of brittleness of the compositions.

In conclusion, the data obtained in this work indicate the possibility of using solutions of PET waste as modifiers to petroleum bitumen to improve their operational characteristics. At the same time, the use of PET waste as a bitumen modifier also allows to solve the ecological problem of its recycling.

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ACTIVATED CARBON FROM SUGAR BEET PULP AS A SORBENT FOR MYCOTOXINS

One of the main problems that farm around the world face is the different types of mycotoxicoses in farm animals. These are diseases caused by toxic substances produced by various types of fungi, such as Fusarium, Aspergillus, and Penicillium, which are formed on plants and feed. The article presents general data on mycotoxins: the main species that have the greatest negative effect on the body of animals and birds, as well as studies on the use of various

sorbents as detoxifying agents. A method for obtaining activated carbon from a biowaste in the form of beet pulp is presented.

Natural toxins are harmful organic compounds of natural origin that can be found in foods and feeds, causing acute or chronic toxic effects. Current toxins can be divided into five main categories: mycotoxins, bacterial toxins, phytotoxins, plant toxins, and zootoxins. Mycotoxins are toxins produced by fungi, bacterial toxins – by bacteria. Phytotoxins are produced by algae and enter fish products through the food chain. Plant toxins are produced by edible plant species, and zootoxins are produced by animals. Plant toxins and zootoxins are integral components of plants and animals. According to mycotoxins, bacterial toxins and phytotoxins can be produced by microorganisms, these toxins are classified as bio-pollutants. Mycotoxins that enter the body of an animal can cause fertility problems and histopathological changes in the kidneys and liver. In addition, in vitro studies have shown that mycotoxins can regulate signaling pathways in animal cells, leading to oxidative stress and mitochondrial-dependent cell death. Such clinical manifestations are called mycotoxicoses. The toxic effect of mycotoxins is mainly associated with genotoxicity, carcinogenicity, immunotoxicity, and mutagenicity [1-3]. The similarity of mycotoxicoses lies in the etiological factor and environmental damage.

Detoxifying agents can be divided into two different classes, namely: mycotoxin binding agents and mycotoxin modifiers. These two classes have different mechanisms of action; binding mycotoxins adsorb the toxin in the intestine, which leads to the elimination of the toxin from the body naturally, while mycotoxin modifiers convert the toxin into non-toxic metabolites [4].

Activated carbon is considered a universal antidote that can adsorb various compounds, including mycotoxins [5-8].

The production of crystalline sugar from sugar beets leads to bio-waste such as beet pulp, filter cake and molasses. Beet pulp is sugar-free brown beet shavings with a specific smell. In the investigation on the obtaining of activated carbon, commercial beet pulp, manufactured by Hidalgo, Altai Territory, Barnaul was used as a precursor. The feedstock was subjected to mechanical grinding to a dimension of 500 μm, followed by washing with water in order to separate from mechanical impurities, dust and other pollutants. After that, the washed samples were dried in an oven at a temperature of 85 to 105 ° C for 12 hours. The carbon material was obtained by preliminary heat treatment in an argon atmosphere in the temperature range from 100 to 600 ° C with a heating rate of 10 ° C / min for 2 hours. The process of carbonization of beet pulp was carried out in isothermal conditions. In order to obtain a microporous structure of coal and thereby increase the specific surface, the obtained sample was subjected to chemical activation using NaOH. The carbon powder obtained after carbonization was mixed with dry NaOH at a mass ratio (1: 2.5), after which the sample was immersed in a reactor for further heat treatment in an argon atmosphere in the temperature range from 700 to 750 ° C with a heating rate of 10 ° C / min within 1 hour. The obtained carbon material from beet pulp was analyzed using energy dispersive X-ray fluorescence spectrometry on a JED-2300 Analysis Station Plus instrument and a Quanta 200i 3D scanning electron microscope.

Heat treatment of beet pulp with further post-activation with sodium hydroxide leads to the formation of a solid residue and pyrolysis gases, which are a mixture of condensing vapors and non-condensed gases. The structure of beet pulp has mainly porous particles. After heating at a temperature of 750 ° C, the particles are in the form of aggregates consisting of layered formations with a developed internal pore system. The differences between chemical activation with KOH and NaOH are associated with an additional stage of intercalation of potassium or sodium metal. Potassium metal can intercalate all materials, unlike sodium, which can intercalate only unorganized carbon atoms. Intercalation causes the separation of carbon layers, which gives rise to micropores. Carbon derived from polysaccharides has an unorganized structure. Therefore, activation with NaOH is more effective for micropore formation. Upon activation with NaOH, a loose structure is formed, consisting of particles of nanometer range material collected in aggregates of various sizes. The pore space is formed as a structure of addition and

represents free gaps between aggregates and particles. In this article were presented the main types of mycotoxins, which are considered the most dangerous for the health of animals and birds, as well as on the sorbents used to detoxify these mycotoxins. Also, the possibility of obtaining activated carbons from beet pulp was shown.

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SYNTHESIS OF CARBON NANOTUBES FROM PLASTIC WASTE

The article represents investigation on the synthesis of carbon nanotubes by chemical vapor deposition method. The products of thermal decomposition of polyethylene waste were used as precursor of carbon. The influence of the decomposition temperature of polyethylene on the carbon nanotubes synthesis was provided. Cenospheres, preliminarily impregnated with aqueous solutions of nickel and cobalt nitrates, were applied as catalysts for carbon nanotubes synthesis. It was determined that in the framework of research, the best results for CNTs production were achieved at polyethylene decomposition temperature of 450 °C with catalyst based on cenospheres impregnated with nickel and cobalt nitrate solutions.

Synthetic polymers and products of their application are widely used in everyday life, technics, construction sector, automotive industry and so on. Among the various classes of polymer waste, the leading positions are occupied by polypropylene and polyethylene waste [1,2]. According to Conversio Market & Strategy GmbH [3], a high level of polymer waste recycling in Europe could be observed in Sweden, Norway, Germany, Ireland, the Czech Republic and Spain, whilst in the rest of EU countries, the level of processing is within 20%. Regarding developing countries, the level of processing rarely reaches 10%. Combining the problem of recycling polymer waste and nanotechnology development has led to the improvement of areas related to waste recycling for the synthesis of nanomaterials, including carbon nanotubes. Carbon nanotubes have the prospect of application for obtaining various types of composite materials [4], flexible heating elements [5] and various other practical applications.

Many factors impact on the synthesis of carbon nanomaterials from polymer waste, in particular, polyethylene: polymer type, polymer decomposition temperature, deposition time, presence of catalysts, the atmosphere in which the synthesis is carried out, etc.

Plastic bags was used as an initial material. In the beginning the polyethylene waste was pre-crushed and subjected to cleaning. Cleaning was carried out by washing the crushed sample with hot water and surface-active substances. After washing, the samples were dried under normal conditions. At the end of the drying process, the crushed samples were melted without chemical degradation in a porcelain dish by heating at temperatures up to 130 °C in order to obtain compact samples of polyethylene which could be conveniently loaded in the reactor. To investigate the decomposition process, a three-zone furnace with a quartz reactor was used. The inner diameter of the pipe is 6 cm, length is 120.7 cm. A study on the effect of temperature on the decomposition process of polyethylene was provided. The process of decomposition of polyethylene wastes in the temperature range from 200 to 450 °C was investigated as well. It was established experimentally that at 200 °C there is no thermal destruction of polyethylene waste and only slight sintering of the patterns could be observed. At a temperature of 300-350 °C a slight destruction of the sample occurs, however, this temperature is not enough for complete destruction of polyethylene waste. Thus, it was experimentally determined that at the temperature of 400-450 °C, complete thermal destruction of the original polyethylene samples proceeds. Thermal decomposition of polyethylene waste occurs with release of white smoke with a specific smell. As a result, thermal decomposition of polyethylene without oxygen access resulted products, which subsequently were subjected to cold extraction for further IR analysis. Synthesis of carbon nanotubes was performed by thermal destruction of polyethylene waste. Synthesis process was carried out in a three-zone furnace. In the first zone, a quartz cuvette with polyethylene samples with a mass of 4 g was installed, where the temperature was set at 400-450 °C. Cenospheres (P'100/500) were used as a catalyst basis for the synthesis of CNTs. The cenospheres, which were used as the basis for the catalyst, are hollow spherical structures. Their sizes vary in the range from 100 to 500 microns. The composition of cenospheres: SiO2 – 58-68 %, Al2O3 – 32-38 %, Fe2O3 – 1.4-2 %, CaO – 1.9 %, MgO – 1 %, K2O+Na2O - no more than 1.5 %. Cenospheres melting point is 1350-1500 °C. The wall thickness of the microsphere diameter is 5-10 %.

In order to prepare the catalyst 10 g of cenospheres were impregnated with an aqueous solution of nickel nitrate, cobalt nitrate or their mixture with a concentration of 100 g/l. Next, the catalyst samples were dried at 70 °C for 2-3 hours until complete removal of moisture. Quartz cuvettes with a catalyst weight of 1-2 g were installed in the third furnace zone. The temperature in the second and third zones of the furnace were set at 700 and 800 °C, respectively. Nitrogen with a flow rate of 540 cm^3/min was applied as a transport gas. Synthesis time was 30 min. During the synthesis, nickel and cobalt nitrates had decomposed to form nickel and cobalt respectively.

The study of the effect of plastic waste decomposition on the synthesis of carbon nanotubes showed that the process of decomposition of polyethylene waste begins with a temperature of 400 °C, but the optimum temperature for synthesis of carbon nanotubes is 450 °C. During the synthesis process, Ni/Co catalysts based on cenospheres demonstrated the best catalytic activity. In that case, the content of amorphous phase impurities is minimal; the diameter of carbon nanotubes varies from 40 to 100 nm.

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MODERN METHODS OF RECULTIVATION OF TOXIC WASTE LANDFILLS

The author in the article raises the problem of ensuring the environmental safety of the landfill. The basic elements of the recultivation project structure are considered. It is shown that the project must include all acceptable technological solutions related to landfill disposal and focus on environmental protection and environmental safety of the area.

When assessing the impact of destructive pollution of the Krasny Bor test site on the state of the environment, according to the researchers, the level of emergency is extremely high and unparalleled. The toxicity of this landfill is an extremely dangerous technogenic phenomenon that threatens the one of largest city of the Russia, St. Petersburg [1,2]. The development of any region should conform the standards of sustainable development [3]. Otherwise, the anthropogenic factor will lead to a radical negative transformation of landscapes and a violation of the sustainability of the ecological and economic structure of the North-West of Russia. Doubtless, the problem of reclamation of the Krasny Bor landfill is extremely relevant for creating and protecting favorable living conditions for local residents [4].

The location of the Krasny Bor landfill for the disposal of chemical waste of hazard classes I-IV was chosen in accordance with the requirements for soil characteristics and the classification of waste disposal technologies. However, no attention was paid to studying the risk of soil shear under the conditions of their swelling. In other words, the landfill is in conditions of increased accident rate and risk of environmental emergencies.

First of all should note two actual problems. The first is related with determination of the chemical composition of substances in pits. The second is related to solving the problem of stopping the spill of waste into the environment.

The methods of recultivation could be a possible solution to ensure environmental safety in the region. Inorganic and organic wastes are undertaken complete processing at the first stage. Further it is removal of local soil contamination. Finally, it is covering recultivationed areas with a Teflon membrane screen. Soil is poured on top and a filtrate collection system is created and discharged into municipal wastewater treatment plants. Part of this plan has already done implemented by “Rosproekt”.

There are alternatives. The method of thermal neutralization in an acidic environment was proposed by the Ecology and Natural Resources Scientific Center of the Russian Academy of Sciences. According to our reckoning, this method does not guarantee the release of dioxins formed during the combustion of organochlorines into the atmosphere. As an alternative, destruction technology was proposed: a plant using hard ultraviolet radiation and ozone.

However, there is no guarantee that extremely hazardous and harmful substances can be disposed of in this way.

Therefore, all possible useful technologies advisable to integrate into one project. Among them are the method of lithification with using the KAMK sorbent, the technology of localization and neutralization of environmental , also the method of decomposition in the MSW photochemical reactor. There is another way to dispose of toxic waste. These are modern two-chamber incinerators with the possibility of safe combustion of organochlorine compounds without emissions of dioxins into the atmosphere.

Thus, a systematic assessment of the state of the landfill as a whole allows us to predict the negative scenario of its operation and its transformation into the main factor that poses a threat of environmental disaster. A proposal to resolve this problem based on the state of the object in question.

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AN OVERVIEW OF THE LATEST INVESTIGATION ON THE ENHANCEMENT OF THE EFFECTIVENESS/ EFFICIENCY OF PHYTOREMEDIATION TECHNIQUES OF WOODY PLANT PINUS HALEPENSIS THROUGH SOIL ORGANIC AMENDMENTS FOR REMEDIATION OF ABANDONED MEDITERRANEAN MINES AREAS

KEYWORDS: Sustainable remediation, phytoremediation, Pinus halepensis, contaminated sites, reclamation.

The reclamation of contaminated sites is a very technically complex and economically costly process. The reclamation of highly degraded abandoned mine and metal(loid)s tailings of arid and semi-arid Mediterranean region mine is no exception.

From the environmental point of view, any reclamation process of abandoned mine and metal(loid) tailings is called to properly address the complex dynamic interplays between (mine waste) pollutants with the abiotic factors that adversely impact on pollutants’ weathering processes and climate change stressors.

Climate change abiotic factors/stressors such as, such as drought, heat, seasonal heavy rainfalls, leaching, soil wind erosion and scarcity of vegetation are set to have increasing harmfully effects on weathering and reclamation processe of polluted soils and related soil toxic chemical concentrations rate, which can worsen the risk of transferring the pollutants into the soil, water and food chain.

Phytoremediation is among the more promising technique for a sustainable, cost effective and eco- environmental friendly remediation of contaminated soil.

Unfortunately, phytoremediation processes of heavily polluted mines and metal(loid)s tailings may take decades to reduce the residual metal concentration to acceptable levels. A constrain that sometimes may render phytoremediation a non-viable socio-economic choice.

For overcoming this constrain, many investigation findings indicate that apt phytoremediation technique combining suitable phytoremediation plant/s species with tailor-made supplementary and /or balancing soil amendment/s might significantly increase the

phytoremediation process efficiency, which, in turn, can effectively lower the overall reclamation time span.

The same scientific findings suggest that the more suitable/best performing phytoremediation plant/s species are the metal tolerant autochthonous phytoremediation plant species, which have pioneered the contaminated site. This plants, in addition to have adjusted to the severe conditions of its contaminated site, are also well adapted to the local climate and do not interfere with the floristic, vegetation dynamics and local biodiversity.

This survey overview the latest findings about the mutual interplay between pioneer metal tolerant autochthonous phytoremediation plant species and soil amendments that take place in the in situ phytoremediation process of metal(loid) contaminated sites, which are the most practiced reclamations of abandoned mine and tailing' sites of arid and semiarid Mediterranean regions.

Within this frame, the survey highlight the, so far little investigated, the phytoremediation capabilities of woody plant Pinus Halepensis which seems very promising when employed for in situ long term phytostabilization and re-vegetation reclamation techniques for the reclamation of abandoned mine and tailing' sites of arid and semiarid Mediterranean regions.

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PROCESSING WASTE SULFURIC ACID TO HIGH-STRENGTH GYPSUM BINDER

Gypsum binders have valuable properties such as: lightness, low heat and sound conductivity and fire resistance, decorativeness, comfort and aesthetics. With high consumer properties, they have a low cost compared to other building materials. The effectiveness of gypsum materials has been proven in practice by various countries of the world. The binders obtained from gypsum are not allergens and do not cause silicosis, and building materials produced on their basis have high properties.

In the technological cycle of production of heat-resistant fiber Arselon annually are formed about 7,000 tons (recalculated on 100%) of diluted 52-55% sulfuric acid. Currently, for the purpose of its disposal, neutralization is carried out and further dumping into the river. At the same time, the presence of high-quality carbonate raw materials in the Republic of Belarus was a prerequisite for their selection with waste sulfuric acid as a raw material for the production of synthetic calcium sulfate dihydrate, which can be obtained from a chalk suspension or a suspension of calcium carbonate and spent 52-53% sulfuric acid [1].

Samples of synthetic gypsum were obtained by reacting waste sulfuric acid with a chalk suspension. After the interaction, the suspension of synthetic gypsum was aged to create conditions for the further growth of $CaSO_4 \cdot 2H_2O$ crystals. After crystals were sent for filtration to separate them from the mother liquor [2]. The studies found that the efficiency of separation of the precipitate from the mother liquor depends to a greater extent on the size of the resulting particles formed from the intergrowth of individual $CaSO_4 \cdot 2H_2O$ crystals and the exposure time of the resulting suspension of synthetic gypsum. Systematic studies have established that at the initial stage, the size of the resulting particles of synthetic $CaSO_4 \cdot 2H_2O$ lies in the range of 20-100 microns; and according to the established optimal parameters, 95% of the obtained particles lies in the range of 100-500 microns. The obtained granulograms are presented in the figure.

Larger particles determine the best filtration of the resulting suspension, as well as higher strength characteristics of gypsum binders obtained on their basis.

Further, studies were conducted on the production of high-strength gypsum binder from synthetic gypsum by the autoclave method [3]. The method includes the following technological operations: briquetting of powdered gypsum; autoclave treatment; dehydration of briquettes after autoclaving; grinding of briquettes; storage of finished products.

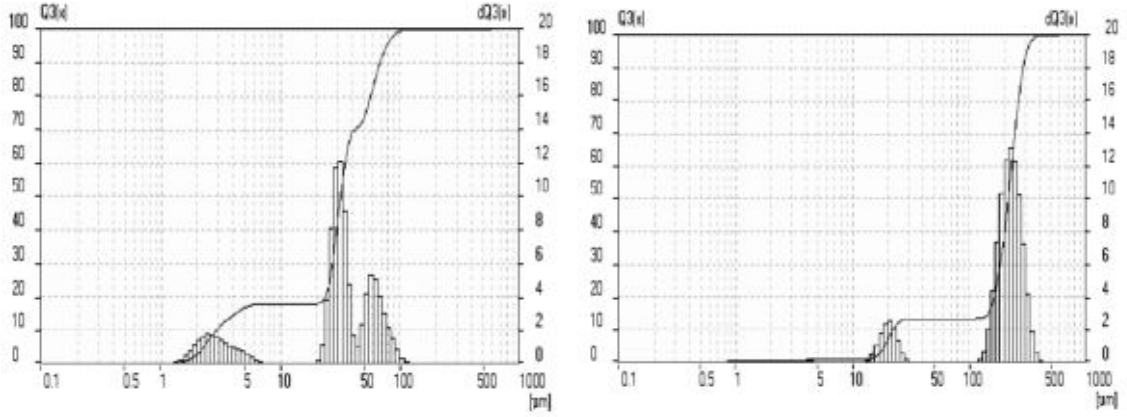

Figure 1 – granulograms of synthetic gypsum obtained at the first stage and according to optimal parameters

The studies found that the properties of the obtained high-strength gypsum binder according to the developed technology depend on the size of the initial particles of the original synthetic calcium sulfate dihydrate and are at the level of foreign analogues used in the production of dry building mixes and as part of self-levels. The brand of the obtained high-strength gypsum binder lies in the range of G10-G28. The obtained high-strength gypsum binder based on synthetic calcium sulfate dihydrate can be used in injection technology and also to create composite materials for construction, technical and medical purposes.

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WATER SCARCITY FOOTPRINT ASSESSMENT FOR CHINA'S SHALE GAS DEVELOPMENT

As the largest holder for shale gas resources, China is actively promoting its shale gas development to help itself realize a transition to a low carbon energy system. The development of shale gas usually needs a large amount of water, which could have a serious impact on local human and ecosystem water consumption since China is a country with scarce and unevenly

distributed water resource. Water scarcity footprint (WSF) of shale gas development in Chinese provinces is assessed to understand the impacts of shale gas development on local water consumption for other sectors. The water scarcity footprint (WSF) can better reflect different impacts of the same product produced in various regions. It assesses the deprivation of other freshwater users by the amount of water consumed to produce a given product, in the ratio of the given region's water scarcity index to the global average water scarcity index rather than the amount of precipitation and evaporation used in traditional water resource assessment[1]. The academic literature on WSF mainly concentrates on agricultural or industrial products. To the best of our knowledge, only one study applied WSF in shale gas, that is Absar et al. (2018)[2]. However, Absar et al. (2018) only analyzed the water scarcity footprint of Texas, the U.S. Based on the above analyses, the novelty or the contributions of this paper are: 1) The WSF of shale gas development in China is focused and assessed in this paper to understand the impacts of shale gas development on other local water users or sectors. 2) As the input of WSF assessment, both direct and indirect water consumption in all stages of China's shale gas development are evaluated.

WSF of shale gas exploration and development in China is calculated by using AWARE method in this study. The WSF can be obtained by multiplying the water consumption amount and the corresponding factor CF_{AWARE}. The equation is as follows:

$$WSF_{TOTAL}=WSF_D+WSF_{ID}$$
$$= (W_D \times \text{PROVINCE } CF_{AWARE}) + (W_{ID} \times \text{CHINA } CF_{AWARE})$$

In this paper, a hybrid Life Cycle Inventory (LCI) Model is proposed, including the Process-based Life Cycle Inventory (P_LCI) for accounting direct water consumption and an Economic Input-Output-based Life Cycle Inventory (EIO_LCI) for estimating indirect water consumption.

There are three main results in this study:

1) Among direct water consumption, the fracturing and well completion stage consumes the largest amount of water, accounting for more than 90%. The main reason is that the fracturing process itself is a high water-intensity activity. However, for indirect water consumption, the largest water user is the drilling stage. The main reason is that during the drilling process, wells are usually reinforced with large amounts of multi-layer steel casing and cement and producing these materials need lots of water. As for the total net water consumption, the largest amount of water is consumed in the well drilling stage, accounting for about 60-70% of the total figure. Water consumption in the fracturing and well completion stage is the second largest, accounting for 30-40%.

2) Firstly, the total WSF of China's shale gas development is 8834-22791 m^3 world. $eq/10^6m^3$ gas (average value:16556 m^3 world. $eq/10^6m^3$ gas). Secondly, by comparing the WSF in each province and the national average, 18 of 31 provinces have lower WSF than the national average. In other words, more than half provinces producing shale gas have less water deprivation potential for other users than the national average. The good thing is that the three regions that have proved developed, Chongqing, Yunnan and Sichuan, are all located in these provinces with lower WSF rank. Meanwhile, seven provinces expect to achieve further capacity also belong to this rank, and with the exception of Henan province, each of them has a lower WSF rank. Thirdly, 13 of 31 provinces have higher WSFs than China's average, and all these 13 provinces are proved undeveloped or unproved regions. Besides, Xinjiang has the highest WSF in all provinces, which means that developing shale gas may have much higher potential deprivation for other sectors' water demand in Xinjiang than those in other provinces. Then, the results of WSF imply that provinces such as Xinjiang, Shanxi, Hebei, Tianjin, Beijing, Shandong and Ningxia should avoid large-scale water use activities such as shale gas development; otherwise it will cause great deprivation to other local water users. And at last, the results suggest that if shale gas resources are found in Tibet, Shanghai and Beijing, they may be not suitable for exploitation because their water pressure will lead to more water competition with other water users.

3) Most of the suitable regions are located south of the Huai River in southern China (with the exception of Heilongjiang province) and most of the unsuitable regions are located north of the Huai River. The low-WSF regions are concentrated in the central provinces of China and the high-WSF regions are concentrated in the North China Plain and Xinjiang province.

Two conclusions are summarized based on our analyses:

First, the total water use for shale gas development in China by fully considering both direct and indirect water use in all exploitation stages of shale gas is assessed. The results show that the total water consumption is about 42100-108700 m^3/well (average value:79000 m^3/well). Of them, the direct water consumption is about 9700-37600 m^3/well (average value:24500 m^3/well), while the indirect water consumption is about 32400-71100 m^3/well (average value:48100 m^3/well). By considering the total gas production from the well, the water intensity is calculated, i.e., producing every 10^6 m3 of shale gas needs 320-824 m^3 (average value:598 m^3) of water.

Second, WSF of shale gas development in China is assessed by using AWARE method. The results show that the average water pressure for shale gas development in China is relatively high, with a water scarcity footprint of 16556 m^3 world. eq/$10^6 m^3$ gas. The advances in hydraulic fracturing technology will lead to more water use and higher WSF. Furthermore, 13 of 31 provinces have even higher WSF than the national average, which means these provinces may be not suitable for extracting shale gas resources. Other 18 provinces have lower WSF compared to the national average. However, to avoid the significant influences on local water use from other sectors, the exploitation of shale gas in these 18 provinces should also consider the speed and scale of extraction, as well as the amount of local shale gas resources.

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REDUCTION OF AIRBORNE PARTICULATE MATTERS EMISSIONS REDUCTION ASSOCIATED WITH PETROLEUM COKE PRODUCTION

Today, the delayed coking process is one of the most rapidly developing and promising processes for crude oil deep conversion, since commissioning of a delayed coking unit at a refinery leads to an increase in the main indicator - oil conversion ratio up to 95%. To ensure safe conduct of the process, it is necessary to strictly comply with the requirements of industrial and fire safety, labor protection, in addition, the working conditions of the workers of the plant

are changing, as there is an additional harmful production factor - dust, due to the release of coke dust into the air of the working area, which has the ability to smouldering, spontaneous combustion and self-ignition. Exceedence of the maximum allowable concentrations for petroleum coke dust in the air of the working area of production facilities (MAC in the working area is 5 mg/m^3) can lead to development of occupational lung diseases [1-4].

Compounding of thickening additive with solvent was carried out, the selection was made and the optimal ratio of initial raw components was determined to obtain a dust suppression-antifreeze agent with a complex of required properties. Dust suppression and anti-freeze agent was obtained in a cylindrical mixer with a mechanical mixing device with adjustable heating of the entire outer surface, a thickening additive in the amount of 3 ... 5% wt. was heated in a cylindrical metal mixer to (85 ± 5)°C, 95 ... 97% wt. of solvent was added and the mixture was stirred for 10 minutes at (85 ± 5)°C to obtain a homogeneous mass, then the resulting mixture was subjected to isothermal aging for 60 min at (85 ± 5)°C. As thickening additives for dust-suppression and antifreeze preventive agents the following was used: - fuel oil from the AVT-6 Crude Distillation Unit of Naftan OJSC with density at 20°C according to GOST 3900 equal to 939 g/cm^3, open cup flash point according to GOST 4333 equal to 173°C; - tar from the VT-1 Unit of Naftan OJSC with density at 20°C according to GOST 3900 equal to 1002 g/cm^3, open cup flash point according to GOST 4333 equal to 275°C. Secondary process kerosene-gasoil fractions were used as solvents in dust suppression-antifreeze preventive agents – kerosene-gasoil fraction of the visbreaking process from the Visbreaking-Thermal Cracking Unit of Naftan OJSC with boiling point of 195-245°C.

The obtained dust-suppression anti-freezing agents were studied by standard methods to determine the pour point (GOST 20287-74), closed cup flash point (GOST 6356), assumed viscosity at 50^{o}C (GOST 6258), density 20°C (GOST 3900), mass content of mechanical impurities and water (GOST 6370 and GOST 2477, respectively). The obtained dust-suppression antifreeze agents are a thin dark brown oily liquid based on a solvent and a thickening additive of petroleum origin, and with a small thickening additive content they have good low-temperature properties, which allows their use in severe climatic conditions. In this case, 3 ... 5% wt. is the optimal concentration of a thickening additive (tar or fuel oil) to achieve the maximum depressant effect in kerosene-gasoil fractions.

Air pollution with coke dust was evaluated by the mass method. It was found that dust suppression and anti-freeze agents based on diesel fractions of secondary oil refining processes with the addition of 5% wt. fuel oil from AVT-6 Unit (sample 1) reduces dust content of air by 7.4 times, and 3% wt. tar (sample 2) from VT-1 Unit – by 3.5 times. The simulation of the dust loss process of petroleum coke was carried out to prevent blowing out during transportation by open method. The wind speed in the laboratory wind tunnel was determined using a mechanical cup anemometer. A dry and treated weighted sample of petroleum coke dust was placed in a wind tunnel for 30 minutes at the wind speed of 30 km/h. The weighed sample without treatment with a preventive agent showed that dust removal is 58%, while dust removal for weighed samples treated with a sample is 1 - 12%, thus, losses during the blowing process are reduced by 4.8 times.

The developed dust suppression-antifreeze agents do not show corrosiveness with respect to metal surfaces, do not contain mechanical impurities and water, have sufficiently high flash points that meet fire safety requirements, are characterized by low pour points, allowing them to be used at ambient temperatures below minus 30 ° C; have good wettability, adhesive ability and rheological properties; low consumption of about 1.5% wt. per the mass of the transported cargo. The proposed dust-suppression and anti-freeze agents from local raw materials can be recommended for use to combat dust formation and to prevent freezing and adhesion of rocks and bulk carbon-containing cargoes to metal surfaces and cavities of automobile and railway vehicles. The use of kerosene-gasoil fractions of secondary processes in optimal proportions with residual oil products (tar or fuel oil) will increase the raw material base for the production of preventive agents, as well as expand the scope of use of petroleum by- and co-products.

Industrial implementation of the proposed agents for preventing freezing, adhesion as well as for dust suppression of bulk carbon-containing materials will decrease the cost of their transportation and unloading and reduce the impact of the dust factor on personnel.

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UTILIZATION OF IRON TAILINGS TO PREPARE HIGH-SURFACE AREA MESOPOROUS SILICA MATERIALS

Iron tailings, one of the major mine solid wastes, are mainly produced in the iron and steel industry. Abundant of non-recycled iron tailings are mainly disposed in iron tailings dam, which is a waste of land resource and also a potential threat to the environment. Iron tailings are fine, stable and complex materials, which are mainly composed of silica and iron oxide [1]. Residual silicon in iron tailings can be used to prepare mesoporous silica materials applied to energy storage, environmental protection and other fields. The conventional synthesis methods for mesoporous silica materials is the hydrothermal method using tetramethyl orthosilicate, tetraethyl orthosilicate or sodium silicate as the silicon source, which has several problems, such as time and energy inefficiency, high raw material costs, and potential environmental consequences [2]. Recently, synthesis tactics with simple technological conditions, high efficiency and energy conservation have been developed [3]. Meanwhile, in order to explore a green strategy for synthesizing mesoporous material, researchers have attempted to use natural silicate minerals or industrial solid wastes to replace the potentially toxic organic silicon [4]. The obtained mesoporous silica materials have demonstrated excellent properties. It is revealed the potential of using natural silicate minerals or industrial solid wastes in wide-scope synthesis of mesoporous silica materials.

High-surface area mesoporous silica materials were synthesized using iron tailings through an innovative non-hydrothermal route at room temperature. The high content of silica in iron tailings serves as a source of raw material for the synthesis of mesoporous silica materials applied in energy storage, environmental protection and other fields. A new idea is provided for a more efficient use of iron tailings and the preparation for environmental materials.

A pretreatment process involving acid leaching and hydrothermal alkaline reaction was vital to the successful utilization of iron tailings. Chemical pretreatments (acid leaching) was used to remove iron oxides, increasing the silica content in iron tailings, and extracted silicon sources by the hydrothermal alkaline reaction, followed by the application of non-hydrothermal

gelation method with cetyltrimethyl ammonium bromide (CTAB) as a surfactant template. The mesoporous silica materials were synthesized by the non-hydrothermal gelation method, which was similar to the one was used [3]. The differences were that the inorganic silicon source extracted from tailings was used instead of the organic silicon source (TEOS) and NH_4OH was not needed in this work. The samples were detailedly assessed by XRD, TG-DSC, N_2-adsorption-desorption, SEM, TEM, FTIR and ^{29}Si solid-state NMR spectroscopy. Furthermore, the evolution of silicon phase from iron tailings to mesoporous silica materials was elucidated and a general synthesis mechanism was proposed.

Acid leaching removed about 96 % of iron oxide from iron tailings but did not destroy the crystalline structure of silica (quartz). About 95 % of silicon was extracted from iron tailings and converted into a silicon source via hydrothermal alkaline reaction. As a result, the content of Si in the silicon source solution was determined to be about 56.9 g/L. Well-ordered mesoporous silica materials with a BET surface area of 1915 m^2/g and pore volume of 1.32 cm^3/g were successfully synthesized from iron tailings using an innovative room-temperature synthesis method. The final mesoporous silica materials with a well-ordered hexagonal channel structure were composed of amorphous SiO_2, indicating that the general synthesis of mesoporous silica materials from iron tailings could offer products of the same quality or batter than those prepared by conventional methods from tetraethoxysilane. The synthesis approach could provide a new strategy for the high value utilization of iron tailings.

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INNOVATIVE WATER CLEANING METHODS. PRINCIPLES OF STRUCTURAL AND FUNCTIONAL DESIGN

The vast majority of modern industries are inextricably linked to the use of water in their technology. The final product, as well as the smooth operation of the equipment, largely depends on its quality. Currently, special attention is paid not only to the parameters of the water when it is supplied to the process, but also to the economic feasibility of the applied water treatment methods. These requirements apply not only to clean water, but also to wastewater. The regulatory and legal framework of the Russian Federation places high demands on the quality of wastewater from industrial enterprises for discharge into fishery bodies and centralized sewers.

The effectiveness of the functioning of any developed production system depends on the structural principles laid down at the stage of its engineering. First, these principles are based on the functional tasks of its individual elements. In addition, it is necessary to take into account the

materials, energy, labor, environmental and other characteristics and technological relationships between these elements. From this data, a range of equipment for water treatment has been created, which, along with the breadth of the range of customer requirements, provided the use of standard design solutions and the unification of structural and technological elements of systems.

Poultry farms are an example of enterprises with high water consumption. Their technological process includes the work of the slaughterhouse and the daily houses cleaning. The generated wastewater is complex in composition and poses a threat to the environment when discharged in its untreated form. The system of evaporator ponds existing in most poultry farms does not meet modern environmental requirements, and the introduction of new wastewater treatment methods is required.

The entire process of wastewater treatment after agricultural complexes can be divided into five traditional stages: wastewater treatment; physical and chemical cleaning; biological treatment; bringing to a normative indicator; collection and disposal of garbage and sludge.

At the first stage, the primary preparation of water takes place: the removal of large debris by hitting, collecting and separating the mass on drum sieves, then there is grinding of a smaller fraction (feather) with preliminary extraction on a separator. Subsequently, on sand traps, small heavy suspensions (sand) are removed from the liquid, and the process of sedimentation and accumulation of runoff in the tanks passes. This technology is standard; the equipment for it is selected based on the system performance.

At the second stage, the runoff enters the vortex layer apparatus (VLA), into which chemical agents (coagulants, flocculants, alkali) are pre-dosed. The device homogenizes the runoff, providing acceleration of physical and chemical reactions, and ensures the destruction of pathogenic microflora. Subsequently, the effluent enters the pressure flotation and is divided into previously purified water, foam and sludge. This technology is unique and allows you to use the resources rationally. During the flow treatment in the vortex layer apparatus, the costs of chemical reagents are significantly reduced. The levels of COD (chemical oxygen consumption) and BOD (biological oxygen consumption) are sharply reduced. That allows you to clean the runoff better in the next steps.

At the third stage, the runoff enters biotenes, in which it is purified due to the natural work of bacteria, organic impurities and biological contaminants. In the course of biotenes, the activated sludge is formed.

To bring the wastewater to norm, this water undergoes extra purification from color and turbidity by electroflotation. With a sufficient content of chlorine in the wastewater during the electrical treatment, sodium chlorine occurs, which contributes to the disinfection of the drain. At the final stage, final grinding takes place on the sand filtration unit and the ultraviolet sterilization module.

The final stage of work with wastewater involves the collection of generated waste during the treatment process. As a result water going through four stages we have: household waste, grease, sludge (including activated sludge), and purified water are formed. The disposal methods are: the removal of household garbage to landfills, the mandatory disposal of grease (due to impurities cannot be used in the process of further processing), the sludge is used as fertilizer and can be used for spreading to the fields, treated water is applicable for discharge into central sewers and water bodies for fishing purposes.

The presented practical solutions are based on the structuring of the source data using basic standard solutions and the maximum use of the unification of structural elements and technology. The decision-making is based on the created formalized model using the mathematical apparatus of cluster analysis, information support and software. The rational structural and functional framework makes it possible to ensure a significant reduction in time and material costs in the development and installation of systems, and also reduces the operating costs.

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NANO COATED MAGNETIC COMPOSITE-SYSTEM FOR THE REMOVAL OF HEAVY METALS FROM URBAN CONTAMINATED SITES

Urban environment has contaminated by heavy metals that has posing risks to human health and considered as a prominent cause to sustainable cities and societies [1]. The dust has settled in urban surface which includes roadsides, grounds, residential areas, commercial district, educational and theme park and other outdoor spaces where human has direct exposure to soil and atmosphere. The existing remediation methods has lack of infrastructure and feasibility to applicable in urban areas, they are designed for remote areas such as immobilization, soil washing, phytoremediation and others [2]. There is an urgency to introduce the simple and applicable strategy in diversified contaminated sites in urban areas.

Here, designed and experimented the magnetic composite-system to remediate heavy metals in urban contaminated sites [3]. It is simple mechanism which has functionalized nano carbon coated magnetic composite and external magnetic system. Composite is synthesized by hydrothermal treatment with sucrose and polyethylene glycol on the spherical magnetic ceramsite. Homemade external magnetic system is designed by ordinary magnetic piece on the conventional tiller. Magnetic composite can spread into heavy metals contaminated sites in aqueous phase and could mixed in case of soil by conventional rotary tiller. Afterwards, with specific time the magnetic composite can be separated from sites (or soil) using external magnetic system.

Lead and hexavalent chromium removal are investigated from the contaminated soil using magnetic composite-system. The physiochemical properties have shown that composite having microporous surface with hydroxyl and carboxyl functional groups. Magnetic composite has revealed over 98% removal efficiency of Pb(II) and Cr(VI) with coexistence of each other even at higher concentration of Pb(II) and Cr(VI). The equilibrium was established after 2-hour contact time of composite with polluted soil. Adsorption kinetics and isotherm model have shown monolayer and chemisorption of Pb(II) and Cr(VI). Composite could be effectively regenerated with the rapid and simple process and has high efficiency (≥95%) even after the sixth cycle of reusability. The potential application of magnetic composite-system could reduce the accumulation of heavy metals in plants and minimized the contamination to subsurface and groundwater. Nanotechnology could be promising strategy for in-situ remediation of heavy metals contaminated sites especially urban areas. The pilot study is needs to conduct prior to full implication.

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BIOREMEDIATION USING GOLD, SILVER AND COPPER NANOPARTICLES: AN ECOFRIENDLY APPROACH

Metal nanoparticles have fascinated scientists and are now extensively utilized in environmental remediation. Nanoparticles of gold, silver and copper have been continuously used and modified to enable their use as environment-oriented technologies. A variety of physical, chemical and biological synthetic approaches has substantially influenced the environmental remediation applications. Recently, hazardous environmental concerns on using toxic chemicals in these strategies are in contrary replaced by ecofriendly and biodegradable biological approaches. Promising approaches for the production of nontoxic metallic nanoparticles using microbes, plant extracts, and biomolecules are extensively studied. Thus, in this chapter we introduced gold, silver and copper nanoparticles along with their composites with method of development and recent examples which utilize their intrinsic properties as a potential tool to decontaminate air, water and soil in a greener approach. The new horizon of opportunities with these nanomaterials offers in situ treatment of groundwater, sensing to reach target destination, surface water disinfection- purification-desalination, contaminated soil treatment and more often air pollutant removal to reduce the contaminant level to standard limits.

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A REVIEW OF THE TREATMENT COPPER SILVER GOLD ORES AND CONCENTRATES

Globally both copper and gold orebody grades have been dropping, and the mineralogy has become more complex. As well, the cyanidation process for gold production has been dominant for over 130 years as a consequence of its feasibility in the mining industry. For this reason, the industry is adjusting its methods for extracting gold with more efficient processes and technologies. Often gold may be found in conjunction with copper and silver in ores and concentrates. Hence, there may be difficulty in the application of cyanide to these types of ores because of the diversity of minerals found in these ores may cause that the application of cyanidation become more complicated. This paper will outline the practices, processes, and reagents proposed for effective treatment of these.

The primary purpose of this review paper is to present the hydrometallurgical processes that currently exist in the mining industry for treatment of silver, copper and gold ore treatment. Also, to present the most important challenges that the industry has to face in order having efficient and feasible processes.

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ASSESSING THE INFLUENCE OF THE DEOXYGENATION COEFFICIENT ON THE SELF-DEPURATION MODEL THROUGH THE EFFLUENTS OF A DAIRY PLANT

KEYWORDS: Deoxygenation coefficient, BOD, Streeter-Phelps, Self-depuration, Water body.

The limitations of in-depth specific studies about industrial discharges have led more and more professionals to make use of parameters that clash with reality, due to the adoption of tabulated coefficients which do not always correspond to the real characteristics of the aforementioned effluents. This study aims above all to determine the deoxygenation coefficient of the water body that receives the discharges of a dairy plant in the interior of the state of Goiás. A self-depuration study was also conducted along the lines of the Streeter-Phelps method, thanks to which it was possible to analyze the differences between the theoretical and experimental coefficients. The theoretical deoxygenation coefficient used was that found in the literature of Von Sperling for secondary treatment wastewater, varying between 0,12 d^{-1} (minimum), 0,18 d^{-1} (medium) and 0,24 d^{-1} (maximum), in which each of these values was corrected on the basis of the temperature of the effluent, resulting in $K_1^{26°C}$ = 0,16 d-1, 0,24 d-1 e 0,32 d-1, respectively. As for the experimental coefficient, it was determined using the Thomas method. The figure found for coefficient K_1 corrected on the basis of the temperature resulted in $K_1^{26°C}$ = 0,46 d^{-1}. Thanks to the self-depuration data modeling, it was possible to establish that the industrial discharge had the major impact on the receiving water body, the experimental $K_1^{26°C}$ showed a smaller amount of critical concentration of dissolved oxygen and consequently, after the active decomposition zone, there was a gradual improvement in the levels of the dissolved oxygen by means of the experimental $K_1^{26°C}$, which in turn led to the restoration of the initial characteristics of the clean waters zone in an area smaller when compared with the theoretical $K_1^{26°C}$.

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Can Acidicthiobacillus ferrooxidands and other heterotrophic bacteria be applied in bioremediation of Mercury-contaminated abandoned mine sites?

(FeTSB) which is a solid medium was developed for isolating and enumerating the iron oxidising bacterium. Acidithiobacillus ferrooxidands and heterotrophic bacteria. This solid medium consisted of tryptone soya broth, basal salts, and ferrous sulphate, solidified with Agarose.

This medium has been used to isolate bacteria from the natural environment and also in laboratory studies.

A three solution system was used to culture the bacteria.

1. Tryptone soya Broth (TSB) 0.35 g/l. the pH was adjusted to 2.7, and was heat sterilised at 120ºC for 15 minutes.

2. Ferrous sulphate solution 20% (w/v) solution was prepared, acidified with sulphuric acid to pH 2.0 and sterilised

3. Agarose Type 1 gelling solution used in solidifying solution. The solution was sterilised at 120ºC for 15minutes.

We would like to analyse how many colonies of Acidithiobacillus ferrooxidands and heterotrophs bacteria are required to break down elementary and organic mercury and how many days does it take for the bioremediation to be successful.

Our research was initially focused on identifying microorganisms that could be used in gold extraction. However, we are now analysing bioremediation with strains of Acidithiobacillus ferrooxidands and heterotrophs bacteria on mercury-contaminated water and soil. KECBO analysed the mine water and soil samples within artisanal small-scale gold mining environments in Western Kenya. Samples were taken to the Institute of Biotechnology Research lab at the Jomo Kenyatta University of Agriculture and Technology for culturing.

It was found that colonies of both AT. Ferrooxidans and heterotrophic bacteria were able to develop on the solid media after two weeks.

Strains of bacteria Acidicthiobacillus ferrooxidands, Acidicthiobacillus thiooxidands and Leptospirilium ferroxidands were identified. These bacteria prove to be more efficient in gold sulphide mineral oxidation due to the synergistic mechanisms involved. With the right optimum conditions, the bacteria can be applied in gold extraction. However further research is on-going on whether the identified colonies can act as a bioremediation remedy for mercury-contaminated sites.

The increase in gold mining activities in Africa has resulted in the influx of mercury use and serious land management issues among communities and local government authorities. Land is rendered wasted and barren yet it can be reclaimed profitably. According to a study done on the assessment of borehole water quality in Kakamega County, Western Kenya, the study revealed that mercury (Hg) concentration ranged between 0.00256 and 0.0611 ± 0.00005 mg/L which is beyond the 0.001mg/L World Health Organisation (WHO) standards. On the 12th of December 2019, KECBO conducted a land rehabilitation activity on abandoned mine sites in Rosterman village Kakamega County, Western Kenya.200 bamboo seedlings were planted on mercury contaminated mine sites. The bamboo plants were meant to extract mercury from the contaminated soil. However, more is to be done with regard to this. KECBO aims to solve this problem by using bioremediation on the affected areas where mercury pollution levels are high.

Informal poorly unregulated mines are a threat to biodiversity and most ASGM don't have resources for post-mining. 7-8% deforestation is caused by mining activities. KECBO aims to undertake land rehabilitation in these affected sites. The organisation has applied for the IUCN NL programme Small grants for the Purchase of Nature (SPN). If our application is successful, land reclamation from this grant will be achieved from buying land long term or through leasing from affected communities. We aim to reclaim such land and use it to protect endangered red-listed. Furthermore, we may establish a green conservancy area from previous historical mine sites and perhaps convert abandoned shafts to gravity-powered electricity.

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DEVELOPMENT OF MOBILE TECHNOLOGY FOR THE DISPOSIAL OF OILY WASTE

Currently, one of the key sectors of the Russian Federation is the fuel industry. Oil and gas production is growing annually; in 2018, 555 million tons of oil and 733 billion m3 of gas were produced.

The problem of the oil and gas industry is the negative impact on the environment, namely, the activities of oil and gas companies produce dangerous environmental pollutants, one of which is oil sludge. At the same time, at the same time it is a valuable raw material (potential product) that can be used in various industries. Despite the fact that large amounts of oil sludge are formed in specialized facilities (barns), the volume of disposal and the degree of their use are low, which leads to the concentration of oily waste in sludge barns. These factors have an anthropogenic impact on the environment, thereby creating a threat to human health.

In this regard, the development of resource-saving technologies, based on the separation of waste into component fractions, with a view to their further use as secondary raw materials in the manufacture of the product, is relevant.

In the framework of this work, a technological solution was developed regarding the use of a mobile complex for the disposal of oily waste, which is based on the installation of cavitation action. The results of the proposed technological solution will be the effective processing of oil sludge with the further possibility of isolating a valuable product (oil product, water, inert material) and its use in production. The project aims to reduce the negative impact on the environment by reducing the amount of waste disposed of in an open environment, as well as reducing the financial costs of waste disposal with the possibility of additional profit from the sale of a valuable product.

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REMOVAL AND RECOVERY OF NITROGEN COMPOUNDS FROM WASTEWATER BY CAPACITIVE DEIONIZATION

Nitrogen compounds are commonly present in wastewater. Nitrate ions appear in wastewater after the biological treatment stage, where ammonium is oxidized to nitrate. Releasing excess of nitrate ions into the water bodies can cause eutrophication resulting in oxygen depletion and toxic effect [1]. Therefore, nitrate ions should be removed from the treated wastewater before the discharge. Additionally, nitrogen compounds, recovered from the wastewater could be further used for fertilizer production or microalgae cultivation [2]. Capacitive deionization (CDI) technology has drawn particular interest in recent times [3]. CDI, the electrochemical process, involves two alternating operational modes: electrosorption and regeneration of the system. Electrosorption allows the accumulation of the charged ions onto the surface of the carbon electrodes via applied potential difference. The regeneration of the system is enabled by changing the polarity of the cell or via short- circuiting, as a result of which the accumulated ions are released back or recovered. Thus, in the case of wastewater treatment, the enhancement of water treatment quality and simultaneous recovery of remained valuable components can be achieved using CDI. There is still a huge knowledge gap that exists in the domain of CDI, particularly in the recovery process of nitrogen compounds.

Activated carbon (AC) electrodes have been fabricated and tested for nitrate ions removal and recovery from the low strength solution i.e. simulated municipal wastewater. Material characterization, electrosorption, and electrochemical study of the fabricated electrodes were performed. Morphology, composition, and surface functional groups on the fabricated electrode material were characterized by scanning electron microscopy (SEM), Raman spectroscopy, Fourier- transform infrared spectroscopy (FTIR). BET surface area was calculated by N_2 adsorption-desorption isotherms obtained at $77^{\circ}K$ using surface area and porosity analyzer. The electrosorption study was performed using the laboratory scale CDI cell in the single-pass mode operated under the various tested conditions. The concentration of nitrate ions in the samples was measured with chromatography. An electrochemical study was conducted in the three-electrode electrochemical cell using NH_4NO_3 electrolyte of different concentrations.

Material characterization of the fabricated AC electrodes showed three times decrease of the BET specific surface area of the electrode material compared to the pristine AC because of the presence of polymeric binder (PVDF) in the electrode composition. The presence of PVDF particles was observed in the electrode material via SEM analysis. However, washing of the electrodes before the CDI test can eliminate the excess PVDF particles from the electrode surface. FTIR spectra confirmed that 10 wt.% of the polymeric binder did not introduce additional functional groups on the AC electrode surface. Further, it was understood that such PVDF content affected the atomic structure of the material via the increase of the graphitization degree, which was confirmed by Raman spectroscopy. The specific capacitance of the fabricated AC electrodes at 40 mV/s scan rate was 0.5 F/g and 19 F/g for 1 and 1000 mM electrolyte (NH_4NO_3), respectively. The optimal electrosorption conditions were obtained at 1.2 V applied potential and 2 mL/min flow rate. The CDI performance was detected during 5 subsequent

operational cycles. Therefore, the recovery efficiency was 21%, while the removal efficiency achieved 48%. The electrosorption capacity of the fabricated electrodes towards nitrate ions was calculated to be 5.5 mg/g and the presence of competitive ions in the tested solution resulted in a slight decrease in nitrate removal efficiency [4].

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ADVANCEMENT OF COAGULATIVE PURIFICATION TECHNOLOGY OF CIRCULATING WATER CONTAINING SAPONITE SUSPENSION WITH CALCIUM INCLUDING WEIGHTING MATERIALS

Diamond mining enterprise PJSC «Severalmaz» at deposit named after M. V. Lomonosov has a major problem of accumulation of saponite fine particles in circular water which form a stable colloid system. Without proper treatment these particles create a significant threat to ecological situation in the region and also reduce efficiency of diamond mining process [1].

Commonly used coagulants and flocculants show small efficiency in saponite coagulation and often require additional conditions for reaction [2], also after use of these compounds obtained sediment is much less usable as a secondary product. Also water processed by all reactives do not satisfy ecological requirements, however after calcium-aluminosilicate reagent processed water has much less excess of such elements as Mn^{2+}, Cu^{2+}, Pb^{2+}, Al^{3+} [2].

Developed by SPMI at department of chemical engineering and energy sources processing calcium-aluminosilicate reagent has in its structure 3 Ca atoms and by one Si and Al atom, and also some ferric oxide impurity [3]. Obtained sediment forms large agglomerates, which are not dense enough to fully precipitate by its natural mass (1.03 g/sm^3). Weighting materials application based on calcium silicates allows to strongly enhance process of purification and increase output of water by 50-100%, also increasing density up to 1.06 g/sm^3.

Obtained sediment contains large amount of Ca, Mg, Si, and it is potentially usable as fertilizer, drilling fluid, construction composite or raw material for calcium-aluminosilicate regeneration.

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PROFITABLE DESIGN OF A BIODIGESTOR ADAPTABLE TO DOMICILIARY AND INDUSTRIAL CAMPS

KEY WORDS: Prototype, Organic Solid Waste, Anaerobic Biodigestion, Biol, Biogas College.

Solid Organic Waste are part of a serious problem worldwide, they represent more than 50% of the total waste generated, which in Latin America is not recovered optimally, thus reducing the useful life of sanitary landfills and generating subsequent environmental problems. (EMASEO, 2012). Energy costs are increased due to the inaccessibility to mining, oil, rural communities and farms, due to transportation for LPG and wiring network in the use of electrical energy for each camp and / or rural community. In order to provide a sustainable and profitable alternative, this study was carried out optimizing anaerobic biodigestion processes in a prototype that is capable of managing all organic waste and rejections, generating usable products, including organic fertilizers and Biogas, supporting the change in the country's productive and energy matrix.

The anaerobic digester design incorporated the optimization of initial maceration and temperature control for the entire process, allowing the optimization of biogas generation within the process, being able to control it both for mesophilic and thermophilic temperatures, using a camera thermal insulation and a temperature sensor that activates a system self-heating process. Temperature control not only manages to increase biogas generation, but also intervenes directly in the stabilization retention time of the fertilizer called Biol, in terms of fecal coliforms and total coliforms, according to tests carried out on petrifilm plates at the Central University of Ecuador with the NMKL 147.1993 methodology and method number 14 NORDVAL. (3M, 2006).

Volumetric quantification was performed with a gasometer proposed in the theses "Low-cost methodology for the quantification of biogas in laboratory biodigesters (MBM + 07)" (Mena, 2007) modified to be used worldwide called MBM19XPC and a alternative method for gas measurement to check volumetric results called MMB19XPC.

The prototype was designed to manage the waste of 2 people, taking into account the per capita production and waste characterization of EMASEO (2012), which was capable of producing around 8,664 m3 of Biogas equivalent to 10.83 kg of Biogas monthly, widely covering the per capita consumption of natural gas registered for Ecuador in 2018 which according to Indexmundi magazine was 27m3 per person per year, taking into account that we would be producing 103.97 m3 per year we would have a save of 49.97 m3 for electrical generation, corresponding to virtual energy independence in rural areas or mining-oil camps. The annual savings of the two people in equivalent energy would be $ 77.98 US dollars, referring to the prices published in the magazine "El Telégrafo" on Thursday, May 28, 2020.

To these products are added 70 liters of organic fertilizer "Biol", the same that meets quality criteria as indicated in the ministerial agreement No. 97, tables 3 and 4; water quality

criteria for agricultural irrigation and water parameters for irrigation, respectively (MAE, 2013). Carrying out a survey on virtual sales platforms (olx, free market, among others) of the price per liter of the fertilizer, an average of around US

$ 1.50 per liter was obtained, leaving $ 105 as gross monthly income, taking into account that the investment in the prototype in its simple model only for reuse of gas as thermo energy is 500 US dollars and for a reuse system with thermo energy and conversion to electrical energy it costs $ 900- $ 1100 in any case the investment made would be recovered in less than a year, making this system a highly profitable project.

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THERMODYNAMIC ANALYSIS OF BRINE DESALINATION USING SPRAY DRYING PROCESS ASSISTED BY SOLAR ENERGY

Water and energy are fundamental needs for life on Earth. However, fresh water supply on the earth is limited. Global warming, water contamination and growth of the industry and human population have generated a shortage of drinking water. Many people live without that benefit, and they must move to other places to get it [1]. Among all the technologies used to obtain drinking water, desalination stands out. Desalination is distinguished by using water that contains a concentration of salt like raw material [2]. Said process solves the problem of shortage of quality water and it has become an important process that in the last decades has increased and developed considerably, but is important to analyze this process, because it has two characteristics that are necessary to improve: it consumes a large amount of energy and it produces a waste that can have negative effects on the environment.

Close to seawater, there are reverse osmosis desalination plants, in these plants, desalinated seawater obtains potable water as product, and brine as waste. The term brine is used for salinities greater than 50 g/L. Usually, when brine is discharged to seawater, it can have an effect on marine life, because, in the discharge area, the salinity of the brine affects the concentration in the area, and this concentration represents high levels that some marine species cannot support [3]. The use of this plants, will continue to grow and develop significantly around the world, that is why it is necessary to have an appropriate control and management of brine.

Currently, we must think using a more sustainable and less polluting technology. Effective water treatment is essential to reduce the possible adverse effects that the discharge of effluents may have on the marine environment. Spray drying consists on the transformation of a concentrated fluid into dried particles, this transformation is through contact with a hot gas. The main stages of the drying process are: atomization of a concentrated fluid, mixture of hot gas-concentrated fluid, and separation of the dry product [4]. In this work, a macroscopic study of the spray drying process to use brine from reverse osmosis plants as raw material is performed, to obtain solid salt and potable water. Moreover, to complete the process, we will use a condenser equipment after spray drying to transform steam water into potable water. In addition, a mathematical model that simulates the process under special conditions for the viability of this brine management method is established. Furthermore, transference of energy and mass are important points in the thermodynamic analysis. Also, general balances and single balances analyzing each component is necessary consider in this study.

On the other hand, there is the fact that many areas with water shortages have a good potential to develop renewable energy. Relating coastal areas with the use of energy, we can have a benefit in areas with brine discharges, to develop a great potential using renewable energy. In this form, we can promote and support sustainable development. Solar energy is

inexhaustible, renewable and when used it does not generate pollution. In our region, we have much potential to develop this renewable energy. Annual average solar irradiation in Mexico is around 5.3 kwh/m² per day, according National Water Commission (CONAGUA, by its Spanish acronym). The study is intended to improve and to be environmentally friendly, so we can ensure a zero impact in flora and fauna of the marine environment, as well as the use of renewable energy, using thermal solar systems to heat brine and atmospheric air, in the first stage of the brine desalination process.

This study was very important, because the total value of energy when working in different operating conditions was obtained, this total energy must be supplied with thermal solar system. In addition, different amounts of condensed water were obtained, these amounts are related to the relative humidity of the incoming atmospheric air, and the salinity of the brine. We recommend a study of an optimal material for use in the spray dry and in the heating of the brine, because brine have a chemical characteristics corrosive. Also is necessary a study that defines a suitable type of thermal solar system that covers the required energy obtained in this work. Spray drying will be our equipment to study, and brine that is a waste of reverse osmosis plants, will be raw material that will be used, so that it is not discharged into the sea and, therefore, avoids alterations in the coastal environment.

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TREATMENT OF ACID RESIDUALS FROM THE CUBAN NICKEL INDUSTRY USING ZEOLITIZED TUFFS

Every day, nickel-producing plants in Cuba generate large amounts of solid, gaseous and liquid residuals, which brings about an imbalance in the environment [1]. The WL is a liquid waste that is generated during the metallurgical process of high pressure acid leaching to obtain nickel and cobalt sulphides. This waste constitutes a source of water contamination, it is bluish in color and has an unpleasant odor due to its H_2S content, it contains suspended particles of Ni and Co sulfides, great acidity and various dissolved metals [2], which could be recovered with adequate treatment. Many researchers have studied various aspects of heavy metal removal by using zeolites as adsorbents or ion exchangers, taking into account their low cost [3, 4]. However, the largest number of reported works regarding the possibility of using zeolitized tuffs in acid leaching residuals is insignificant.

For the ion exchange experiment, a column filled with zeolitized tuffs of the clinoptiloliteheulandite type, plus mordenite with granulometry (-1.4 +0.85) mm was designed. A batch test was performed at a temperature between 50-60^{o}C where the selectivity of the tuffs was in the order: $Fe^{2+} > Mn^{2+} > Co^{2+} > Mg^{2+} > Fe^{3+} > Zn^{2+}$. In the case of Mg^{2+}, although it did

not show the highest percentage of removal, it showed the highest adsorption capacity with 2.17 mg (Mg)/g of zeolitized tuff as a consequence of a higher concentration of these metal ions in the WL liquor.

It was possible to reduce the acidity of the WL from 1.58 to pH=2.6 after treatment with zeolitized tuffs, which constitutes a favorable variant in relation to environmental indicators, since, at pH above 2, it is possible to reach minimum levels of sulfhydric acid and also decrease the concentration of free acid. The influence of the zeolitic material in the reduction of the color and the unpleasant odor of the WL was also demonstrated.

Furthermore, it was observed that zeolitized tuffs suffers 1.4% delumination, as a consequence of the loss of aluminum from the zeolitic structure to the liquor, product to the acidic medium in which the experiment was carried out. Regarding the mineralogical composition, the zeolitized tuffs after contact with the WL show diffractograms identical to the original samples, in which the same diffractometric reflections with equal intensities are obtained, so the treatment with the WL did not modify its composition phasic.

The ability of the zeolitized tuffs to adsorb heavy metals by ion exchange in contact with the WL in batch was evidenced, their neutralizing character and their property of acting as a filter with a deodorizing character.

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USE OF WASTE COOKING OIL AS A CONTINUOUS PHASE IN INVERT EMULSION DRILLING FLUID

One of the main causes of contamination in well drilling is the use of invert emulsion drilling fluid, but this type of mud is also beneficial for drilling efficiency. Generally, the oil used is diesel or mineral oils of hydrocarbon origin, even though they are polluting the environment. In recent decades, research has focused on vegetable oils that are biodegradable and reduce the pollution of the environment [1]. Product development from sustainable source which would otherwise considered waste have been getting momentum in oil and gas field applications. It has been demonstrated by Amanullah and other authors that the waste vegetable oil could be used for development of products with potential application in oil and gas industry such as lubricants and biodiesel [2]. The main purpose of this work is to investigate sustainable sources to formulate drilling fluids that provide more efficiency, less costs and, of course, less environmental impact.

An invert emulsion mud (ratio 75/25) was formulated using an ester as the continuous phase. This methyl ester was obtained by alkaline transesterification of waste cooking oil [3]. In turn an oil-based drilling mud was formulated with the same additives and ratio as the ester base

mud, this was done with the aim of evaluating the feasibility of replacing diesel with ester, which is biodegradable and therefore, more friendly with the environment.

The additives for revert emulsion drilling mud were individually placed in contact with the ester to observe its degree of compatibility. This test was carried out for two weeks through periodic observations. As a result, no incompatibility between the ester and the additives was observed, so the mud was formulated (Table 1).

Table 1 - Formulation of invert emulsion drilling fluid with OWR 75/25

Synthetic base: 280 mL		
Name	Function	Calculated value
Q-mul gel, g/0.4L	Viscosifier	11.452
Lime, g/0.4L	alkalinity buffer	8.589
Envamul, mL/0.4L	primary emulsifier	12.597
Envawet, mL/0.4L	wetting agent	1.612
Water: 92,8 mL		
Brine, g/0.0928L		47.825
Aditional additives		
Gilsonite, g/0.4L	filtration control additive	1.145
Calcium Carbonate 325, g/0.4L	rheology modifier	68.714
Barite, g/0.4L	heavyweight additive	141.47

The most important properties to determine the technical application of a reverse emulsion fluid are viscosity and thermal stability. These properties were evaluated and the following results were obtained (Table 2).

Table 2 - Properties of drilling fluids tested

Property	Invert emulsion ester based mud		Oil based mud	
	Before aging	After aging	Before aging	After aging
plastic viscosity, cP	49	66	49	54
yield point, lb/100ft^2	84	38	52	40
apparent viscosity, cP	91	85	75	70
gel strength	24	17	10	7
HPHT 300°F and 500 psi, mL/30 min	15	18	5	8

According to Table 2, the results of ester base mud before aging and after aging are favorable. The rheological properties of diesel base mud are very similar to that of ester base mud. Being a relaxed filtrate mud, the filtrate volume in the HTHP test is within the range (maximum 20 mL). This mud is stable at temperatures below 300°F (148°C).

From a technical point of view, it is feasible to use the ester as a continuous phase in invert emulsion drilling fluid.

The ester is compatible with all the additives used in muds of this type, because none presented precipitation.

Ester-based drilling mud is environmentally viable, creating an alternative for the industry for offshore use and land operations in environmentally sensitive areas.

It is recommended to modify the ester/water ratios in the mud formulation to determine how its rheological properties vary, in addition to using compatibility tests at high temperatures to further study the advantages and disadvantages of ester base muds.

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NEW COLLECTOR FOR FINE IRON ORE FLOTATION WITHOUT DEPRESSANT

Iron is the main component of the global steel production industry, which composes a considerable part of the world economy. Iron oxide minerals (hematite, magnetite) are a primary and only raw material, which can be used for metallic iron extraction for further steel production [1]. Considering the role of steel in the global economy and the continuous industrialization and modernization of less developed countries it is natural that demand for steel will continue to grow. This growth in demand can lead to significant challenges, which are mostly motivated with the rapid depletion of high-grade iron deposits [2]. As a result, the mining industry will have to tackle low-grade, finely disseminated complex ores. Another possible solution is to develop routes that could beneficiate certain sources of iron which until have not been successfully tackled. An example of this potential new sources of iron are the slimes and tailings that originate from the mining operations [3].

Reverse cationic flotation route is the most widely used process for upgrading of hematite/magnetite, it is mainly used to reduce the silica content [4]. Two main surfactants are used in this flotation route: amines as collectors and starch as iron minerals depressant. However, recent research with iron ore samples from different deposits showed that starch is not efficient when the silica content in the concentrate is controlled by the Fe-Mg bearing minerals. The most common way to solve this issue is the usage of new collector formulations [4, 5].

The purpose of this study is the comparison of a new collector with the conventionally used collectors such as amine and starch in pure minerals systems: kaolinite, quartz, hematite, and their mixtures. The main objective is the evaluation of this new type of collector and the development of an alternative route that would allow to concentrate fine iron ore/tailings by flotation without a depressant reagent.

In order to replicate the particle size distribution of real iron ore tailings, quartz and hematite were grinded down to a feasible flotation size (d_{90}=100 μm). Kinetic flotation tests were conducted in order to evaluate efficiency of the collectors (amine and new collector).

The flotation tests using single mineral flotation systems have been performed in order to provide an understanding of specific interactions with selected minerals. In addition, tests with minerals mixtures have been performed in order to understand the impact of quartz and kaolinite on hematite flotation.

The results of hematite flotation showed good recovery with amine (without starch). However, the new collector did not show any ability to float hematite. Results of quartz flotation indicated that starch does not have a depressing effect on quartz. High recovery was obtained with amine as a collector. The new collector also showed a high ability to float quartz. Results of the kaolinite flotation showed that amine floated approximately 50% of the kaolinite, as well as in the case of quartz starch does not have an influence on the kaolinite recovery. The new collector did not show ability to float kaolinite.

The results of mineral recovery in the mixture system are shown in Figure 1. Results of the hematite recovery are very similar in both the hematite-quartz and hematite-kaolinite systems. Therefore, only results for hematite-quartz system are presented in the Figure 1.

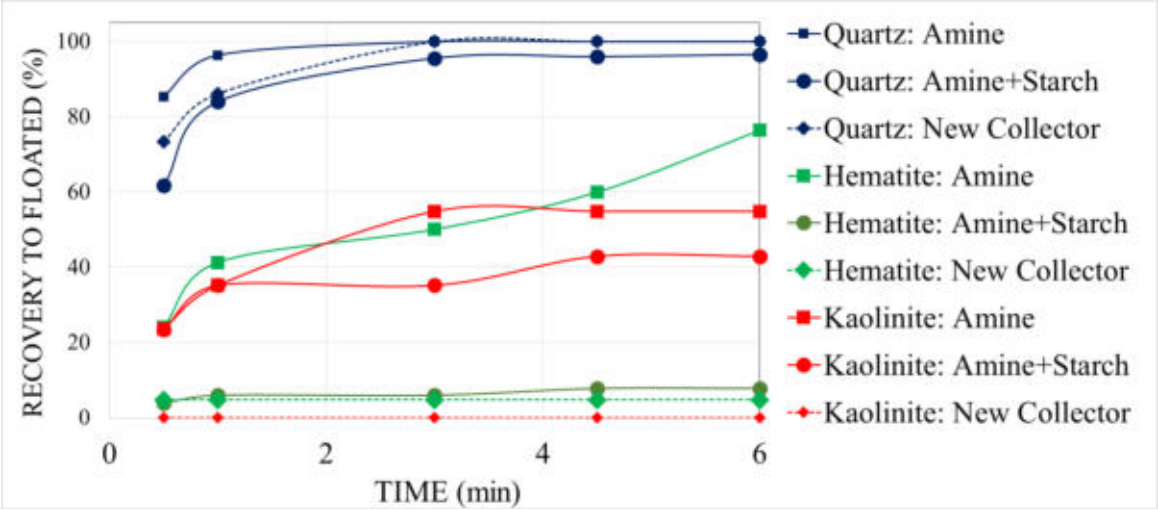

Figure 1 – Recovery of pure minerals mixture flotation tests.

Results of the hematite-quartz mixture proved that in case of flotation with amine a depressant reagent for the hematite is required in order to provide selectivity for the process. Depressant addition is essential due to the fact that with almost 100% of quartz recovery about 76% of hematite was floated. However, when floating with the new collector it was possible to achieve 100% of silica recovery with only 5% loss of hematite to the floated product. Results of the hematite-kaolinite flotation tests showed 55% of kaolinite recovery with amine without starch with 8% of hematite impurities (Figure 1).

From the conducted flotation tests, it can be seen that amine provided a high recovery for every mineral, explained by its low selectivity, which is depending on a depressant reagent. The new collector showed high selectivity towards quartz without floating hematite and this was achieved without necessity of an iron oxide depressor.

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RECYCLING OF WASTES FROM SEWAGE TREATMENT PLANTS AS A FULFILLMENT OF THEIR ECOLOGICAL AND ECONOMIC POTENTIAL

The existing system of waste management in Russia faces a number of critical issues. One of the most pressing problems in cities is the disposal of an ever-increasing amount of waste in conjunction with a limited capacity of facilities for their placement. Purpose of wastewater treatment plants (WWTP) is not limited solely to water purification. An important part is also the sewage sludge management. This waste is most often disposed at landfills and is not recycled [1]. The State Unitary Enterprise «Vodokanal of St. Petersburg», in particular, uses incineration of sewage sludge in fluidized bed furnaces to reduce waste generation. However, the total amount of sewage sludge ash (SSA) is still large, about 50 thousand tons per year. The Vodokanal of St. Petersburg is very interested in the decision on the ash utilization matter. The waste generated because of the three incineration plants activities is completely moved to the landfills. The Vodokanal of St. Petersburg runs «Volkhonka-2» (closed) and «Severny» landfills. The last one is filled with more than 90% of design capacity. Stopping of ash storing on the landfills and possible recycling of already disposed waste will not only free up space, but also reduce negative environmental impact in the future.

The study is devoted to finding a solution of the topical issue of SSA recycling with the prospect of the waste beneficial use in the natural economy. Firstly, the scientific novelty is a confirmation of SSA compliance with the requirements for lightweight concrete components. Secondly, it is a confirmation of the using SSA as a substitution of a cement part in concrete mix without significant deterioration of ash concrete strength. The practical significance of the study is the development of the SSA-based concrete taking into account the possibility of its further use for construction of buildings and roads, improvement of urban areas. The study was carried out using a set of research methods, including complex analysis of the issue based on studies by Russian and foreign scientists as well as laboratory methods for studying the structure and properties of wastes.

The negative impact of SSA on the environment consists of land taking to landfills as well as the associated air, water and soil pollution. Continuous increase in waste generation creates shortage of free space for its disposal and demonstrates need to find a SSA recycling solution. There are a number of studies on the use of waste in agriculture, reclamation of disturbed land and construction [4]. Increasing build materials demand needs alternative ways of their production including the use of sewage sludge and its processing products [2]. For environmental and sanitary safety, SSA can be recycled to receive a qualitative ash concrete [5]. Within this research, we used a way to concrete production with ash as a substitution of a cement part.

Externally SSA is a brown fine powder. It is necessary to identify a waste environmental safety to confirmation its beneficial using possibility. The main pollutants in the SSA composition are heavy metals. Exceedances of quality standards for Zn, Pb, Cu was documented on the basic of the X-ray fluorescence analysis and atomic absorption spectroscopy data. The IV

hazard class of waste was calculated and confirmed during the bioassay of aqueous extracts using chlorella algae culture according to the appropriate method.

As a component of concrete mix, SSA must meet requirements of quality standards [3]. It was established according to data received by series of tests. The waste completely satisfies all chemical structure requirements and is included in allow range of humidity, density etc. The use of SSA will be possible if the necessary physical and mechanical indicators of concrete are confirmed during the future tests. Concrete mix samples were made to clarify the strength indicator. SSA replaced part of cement in all samples, except the control one, in amount 5 to 50 percent of the mass. To determine volume of water for mixing, the normal consistency of the cement paste was calculated. After bending test, the samples were sent for compression testing. A density and strength class/grade assigned to the samples according to the test results. Eventually, the possibility of using SSA as a substitution up to 10% of a cement part in concrete mix (without significant deterioration of strength of the ash concrete) was confirmed.

SSA-based concrete can be successfully used for construction of buildings and roads, improvement of urban areas. These ways are especially relevant in cities. Firstly, using of SSA-based building material has a great resource saving effect. It is the recycling of waste and reducing the amount of cement required for concrete production. Secondly, it has an economic effect, since the cost of SSA-based concrete mix is significantly less than the market value of the ordinary concrete. The proposed approach to SSA recycling solves the following problems:

- waste utilization;
- reducing the load on the waste storage facility (landfills);
- minimize the negative impacts on the environment;
- producing lightweight ash concrete. It is promising for use in construction (manufacturing concrete blocks of industrial and energy buildings), repair of roads (production of asphalt concrete and road slabs, formation of road slopes) etc.

Reducing the generation of waste and its involvement in economic turnover are the main challenges facing modern technologies in the field of waste management. The study is realized on the basis of laboratory and experimental base of the accredited Center for the collective use of high-tech equipment of the Saint-Petersburg Mining University.

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DESIGN OF $Ti0_2$-UV REACTOR FOR DEGRADATION OF PHENOLIC COMPOUNDS IN INDUSTRIAL WASTEWATER

Having a clean environment is one of the main concerns for the past 6-7 decades as a result of the industry era. One of the industry types that produce significant amount of waste is the mining and the processing industries. As the roles of these companies is important in the economic and development sector of a country, it calls out for a solution with where the companies continue and the waste produced is reduced to the minimum level possible. The water used in mining is one medium to expose harmful materials that can cause serious problems as the water used is returned as wastewater to the environment [1]. The contaminants could be categorized in five groups such as the physical, chemical organic, chemical inorganic, biological and radiological.

In this paper, Advanced Oxidization Process (AOP) is presented as one of the solutions for the waste water treatment. It is a photo catalytic process in the presence of TiO_2 as a catalyst. This method is time tested and used across the industry since many years successfully. Recently advanced oxidization processes (AOP) based on Ultraviolet lamps (UV) and Titanium dioxide photo catalytic (TiO_2) has been widely studied, which use Photo catalytic Degradation principal to break and separate different contaminants from wastewater [2]. It is a process that takes place after the sludge, the oil and phenolic compounds is removed in which it is used to remove the chemicals at the last stage.

TiO_2 is an easily laboratorial product catalyst and inexpensive. It is a semiconductor with exceptional optical and electronic properties. The chemical stability of TiO_2 and the non- toxic characteristics make it suitable to be used as catalyst [2]. Many researches have been done regarding this method, and it was successful in the removal both the organic and inorganic (heavy metals) chemical contaminants. The factors that affect the efficiency are pH level, the emitted electron velocity and the band width of the UV light.

In this research the reactor's dimension is defined taking reference from ADNOC Company's wastewater production quantity [3]. There will be four tanks with a cross sectional area of $19.63m^2$ and 10m length which further will be 12 sections separated by UV light walls. The UV light will have 800watt with wavelength of 200-500nm. However this design is based on removing organic pollutants therefore the material balance and time needed is dependent in the organic contaminants.

The recovery of water in this process is very promising that the contaminants are either totally degraded or the toxicity of the elements (heavy metals) is reduced. In terms of the organic compounds the contaminants are converted in to CO_2 or H_2O while regarding heavy metals converting Cr (VI) to Cr (III) is such an example. The ability of TiO_2 captivity can be increased when grafted or coated with inorganic chemicals/ elements or hydro-oxide can also be recommended. The removal of TiO2 is still the dissatisfying factor however the nanoparticles separators or centrifugal circulation is can be used.

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PERSPECTIVE METHODS OF INCREASING QUALITY OF CRUSHED STONE BASED OT THE BLACT FURNACE SLAG

One of the wastes generated during the production of pig iron in blast furnaces is blast furnace slag. One of the most common ways of its recycling is the production of slag crushed stone to build the road bases [1-4]. However, such a material must meet high requirements regarding the uniformity of its composition in strength. At the same time, the strength of porous dump blast furnace slags varies in a very significant range - from 2 to 40 MPa. The average density of the individual elements of this material also differs significantly - from 400 to 1600 kg /m^3. The physicomechanical properties of slag crushed stone vary over a wider interval than crushed stone from rocks, which is caused by fluctuations in the quality of raw materials and technological parameters.

Many modern crushing and screening complexes are able to provide only washing, crushing and classification of bulk building materials by size. Such processing is quite sufficient to obtain fractionated crushed stone from rock, the strength of which is relatively constant. But it is not acceptable for slag crushed stone, since in the final product inevitably there is a large proportion of grains with low strength.

When using local mixed-strength stone materials, enrichment in strength is organized to improve their quality. Enrichment in strength is a set of production operations consisting of mechanical separation of those particles that reduce the strength of the stone material, or its separation into several grades, depending on the strength. The most common are gravitational (in particular, enrichment in heavy media, jigging, sorting on a concentration table, etc.), as well as special enrichment methods involving the use of mechanical classifiers.

Gravity methods for the enrichment of stone materials are based on the fact that grains with different bulk masses (and therefore with unequal strength) have different rates of fall in a particular medium (heavy liquids, suspensions, etc.). The rate of fall depends on the bulk mass, volume, shape of the grains, as well as on the properties of the medium where grains fall. The grains of the material in the corresponding medium are stratified according to its bulk masses: light grains float and heavy grains drown. The main condition for the application of this method is the presence of a fairly clear dependence of bulk density on strength.

Enrichment in heavy media is used on an industrial scale mainly to improve the gravel materials. To enrich material we can use a liquid with density that is intermediate (boundary) between the bulk masses of the separated differences. If we place the source material in this liquid, then the grains of the lighter material (weak) will float to the surface, and the heavier (strong) ones will sink to the bottom. As a medium for enrichment, we can use the suspensions consisting of a powdery substance (weighting agent) and water. To obtain a weighting agent, finely ground magnetite powder (Figure 2) and ferrosilicon or mixtures of these materials (60-75% magnetite and 25-40% ferrosilicon) are used.

The advantages of this method are:

1) the enrichment of raw materials with a particle size of up to 300 mm at high productivity with obtaining conditioned products;

2) the possibility of separation of grains slightly differing in density.

In turn, the disadvantages of the method considered are the impossibility of separating the thin material, the need for washing of the weighting agent from the enrichment products and weighting agent capture. Losses of the weighting agent, as a rule, are in the range from 300 to 600 g per 1 ton of enriched raw materials.

Considering the possibility of using this method for sorting of blast furnace slag by the strength, it should be noted that the first of these disadvantages does not matter, since grains of slag from 20 mm or more are subject to classification. However, significant losses of the weighting agent and the need for its washing increase the cost of the final product. For this reason, the use of this method in the enrichment of slag crushed stone is advisable only if the cost of the final product is lower than the cost of alternative stone material (economic effect is positive).

Special enrichment methods are those that are based on the use of other properties of the enriched materials. This group includes a method based on the presence of a certain relationship between the elastic properties and the strength of the particles of stone materials. This group includes a method based on the presence of a certain relationship between the elastic properties and the strength of the particles of stone materials. With this dependence in mind, special enrichment machines — mechanical classifiers — were designed [6].

The choice of the optimal technology for the enrichment of slag crushed stone largely depends on the quality of the raw materials received for recycling. With a low content of low-strength differences, it is possible to improve the material by selective crushing or by passing through mechanical classifiers. If there is a slight difference in the volumetric mass values, it is more rational to enrich the material by jigging. In cases of heterogeneous raw materials, when it becomes necessary not only to separate weak grains, but also to separate slag crushed stone into strength classes, a more complex enrichment scheme must be designed.

Based on the preliminary analysis, with the high cost of delivery of natural crushed stone (due to the remote location of the quarries) to the place of road building (we assume that the blast furnace slag dump is in close proximity to it, using the example of the Karaganda region), we consider it more rational to use slag crushed stone pre-sorted by strength, for example, by enrichment in heavy media as an alternative to natural crushed stone.

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REDUCING THE ENVIRONMENTAL IMPACT OF MINING BY INCREASING THE RECEIVING CAPACITY OF EXTERNAL DUMPS

Due to the specific nature of mining operations, the extraction of minerals inevitably leads to the formation of industrial waste, which must be removed from the working space to ensure access to minerals, creating dumps that consist mostly of empty and substandard rocks. At some mining enterprises while developing major minerals some associated minerals can be found. They include mineral complexes that do not have independent industrial significance, but extraction of which can be economically feasible during development of main minerals. In most cases, they also go into dumps, as well as the tailings of enrichment plants. According to 2007 data, Ukraine has accumulated 25 billion tons of solid waste, covering the area about 150 thousand hectares of fertile land [1]. During years of industrial coal mining and coal dressing in Donbass there has been stored an enormous amount of waste, according to the estimates in 2003, about 4000 tons of waste is accounted for every resident of the region [2].

Every year about 100 billion cubic meters of minerals are extracted in the world, while about 5-7 million hectares of fertile land are withdrawn from land use. Waste from mining and metallurgical production or technogenic mineral resources is accumulated in dumps and tailings of mining enterprises and enrichment plants. It is formed in the sludge and gold storage facilities of the fuel and energy complex. About 10% of the total world production of solid types of mineral raw materials is converted into finished products, and the remaining 90% is formed by various mining wastes. As a result, the dumps have accumulated tens of billions of tons of various rocks, billions of tons of metallurgical slag, hundreds of billions of tons of "tailings" of enriched minerals are accumulated in dumps [3]. These wastes change the landscape and negatively affect the environment; large areas of fertile land are taken out of the turnover of the national economy. Both territories directly allocated for dumps and the territories nearby are contaminated radioactively and chemically, which leads to soil degradation, plants and microorganisms inhibition. The quality of the land around deteriorates and the number of severe diseases among the population increases because microparticles of dust that get into the lungs are not removed naturally. All these problems are caused by dust drifting from dumps and tailings.

At the same time, the concept of "associated mineral" is quite conditional and depends on the market conditions of various minerals that vary unevenly over time, which is especially typical for many deposits of rare and non-ferrous metals. Methods of mineral development and dressing are constantly progressing, which makes it possible to obtain minerals that fit the conditions of the modern market by processing by - products from mining industry. As a rule dumps of mineral deposits development are valuable raw material for the production of a number of materials (mainly construction), as they contain sand and stone materials, various clays, chalk, crushed stone, and other components. Dumps of enrichment plants are regarded as more valuable due to high value components.

To reduce the negative impact of dumps before they are developed or recultivated, it is proposed to increase the receiving capacity of the dump spot by increasing the height of the layers and, accordingly, the height of the dump with a constant occupied area by increasing the coefficient of stability factor by creating a counterfort (Figure 1). A counterfort is bulk structures made of rock overburden to strengthen technogenic formations [5].It is important to note that the phenomenon of segregation has been known for a long time, but the impact of segregation processes in mining hasn’t been given enough consideration. As a result, these processes are

poorly studied and poorly used in creating of man-made formations in order to create technogenic deposits from them.

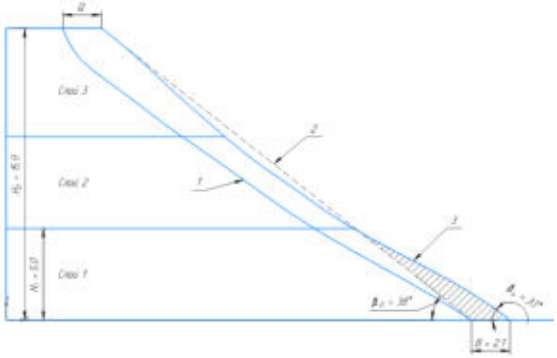

Figure 1 - The scheme of parameters for a natural counterfort to prevent surface and filtration deformations: 1-sliding surface, 2-straight slope, 3-actual slope line [5]

On the dumps of the mining enterprise Dokuchaevsky Flux-Dolomite Plant, the buttress is formed naturally along with the creation of dumps due to the features of independent segregation of rock pieces of different sizes when they are placed in the dump. Nevertheless, it is also possible to artificially increase the strength of the buttress by laying it in layers with subsequent rolling. It will create conditions for increasing the angle of gearing of the rock pieces and eliminate adverse layering during excavation. We also can fill the voids between the pieces with sand, which will improve their pinching and increase the shear resistance of the buttress material [5]. With the natural formation of a buttress on the dumps of the "Central" quarry branch № 14 "DFDK" of CJSC «Vneshtorgservice», with the area occupied by dumps unchanged, it became possible to place an additional 10% of the overburden rock volume. This allowed to save on paying rent for land by 7%, the savings amounted to 1 056 000 conventional units. With such huge volumes of dumping [3], the introduction of such a technology will bring invaluable benefits not only to the environment of Donbass but also of the whole world.

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ASSESSMENT OF SLUDGE STORAGE DESIGN STRENGTH

The issue of reducing the geoecological consequences of the operation of potash sludge storage facilities is very common in the Republic of Belarus [1]. Also, safety of operation of sludge storage facilities is an important issue [2].

The purpose of this study is to evaluate the technological scheme for the formation of a salt dump from halite waste using a hydraulic filling method.

Model studies of strength properties were performed to assess the effectiveness of the proposed technologies.

The geomechanical model of the applied problem is reduced to the study of the stress-stain state of the bulk structure on a deformable foundation. Bulk structure heterogeneity in terms of heights and the filling sequence in a large time interval are taken into account.

So, research consists of examining the model of a sludge storage on an elastic foundation and the free surface of the sludge storage on which halite wastes are layer-by-layer filled. Boundary condition in this case is a limitation along the contour of the sludge storage in the form of dams.

Halitic wastes are filled with the layers of 1.5 meters at an angle 1.5 degrees with respect to one of the limiting dams.

The elevations of the plate were taken into account when considering this model problem.

The bottom of the sludge storage is at an absolute mark of 153.5 m before the start of the filling. Filling of the storage occurs to an absolute mark of 207.5 m.

It is taken into account that by the time the next batch (stage) is filled the previous batch (stage) is hardened (transition from the freshly filled waste phase to hardened waste phase) when modeling.

Mechanical properties such as the angle of inner friction, structural adhesion, compressive strength and density were obtained as a result of the study of samples taken from the solid structural elements taken during the drilling of research wells.

The model problem is solved in a three-dimensional formulation. The problem is solved in a nonlinear quasistatic formulation due to the fact that real technological processes arise in a relatively long time interval.

All these objects (elements) of the general system (salt dump, dam, sludge storage, etc.) are considered as linearly deformable homogeneous isotropic bodies.

It was assumed that after hardening there is a complete adhesion of stages over all contact surfaces when solving the problem. The areas of adhesion of the filled sludge with hardened waste and the dam were also considered under the assumption of hard contact.

The model geomechanical problem corresponds to the following technical scheme: the bulk structure is located on a layer with properties obtained as it was mentioned above which in turn is located on an elastic foundation. The elastic foundation is assumed to be fixed at its lower boundary (condition for fixed support). The problem is solved in the gravity field.

The mathematical model describing the stress-strain state (SSS) of the studied geomechanical problem includes equilibrium equations, strain compatibility equations, equations of state of the medium and boundary conditions.

As criteria for assessing the strength of the elements of the general system the Coulomb-Mohr strength criterion and energy strength criterion were used [3].

It can be concluded that the design of the sludge storage meets the required strength standards and has a safety factor of 1.3 under the considered conditions for the filling of the dump at each stage.

Mathematical modeling shows that the maximum vertical displacement in the elements of the sludge storage is 30 cm.

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THE CHANGING BUSINESS ENVIRONMENT IN THE WAKE OF THE CORONAVIRUS PANDEMIC: A STUDY INTO INTERNATIONAL CONFLICT RESOLUTION

Throughout history, society has faced hundreds of crises. Crises are deemed to be negative changes in economic, political, societal, environmental and/or security affairs, especially when they occur abruptly, with little or no warning. More loosely, it is a term meaning "a testing time". The United States seems to have an economic crisis approximately every 10 years. They are difficult to eradicate because their causes are different: technology shocks, expectations, monetary and fiscal shocks, wars, or pandemics. In the 20th century, the most disastrous economic crises in terms of consumption expenditure were the First World War, the Second World War, the Great Depression, and the 1918 flu pandemic (the Spanish flu) [1].

The 2020 crisis is different. The difference lies in the fact that the economic recession now is a direct result of governments around the world making conscious efforts and doing everything possible to slow the economy down, whereas during other crises, governments made efforts to revive the economy. Moreover, it is unclear how long this crisis will last and how serious it is and will be, the reason being that the epidemiological data is not yet in (rate of transmission, mortality, immune response, among others). The economic and other consequences of governmental measures are also not yet clear, because of a lack of data and a lack of reliable sources of data. Another characteristic feature of this crisis is that costs are distributed unevenly. In other words, some industries are shutting down completely (restaurants and gyms, for example) while other industries are doing much better than before. The necessity of lockdowns is disputed, but we believe that they are essential. But not all countries introduced strict measures in containing the COVID-19 virus. For example, the Swedish authorities opted to give recommendations, not bans. In terms of the mortality rate per capita from COVID-19, Sweden is not doing as well as the other countries in nearby Scandinavia that are similar, but have approached the pandemic differently. Sweden and Iceland have experienced similar levels of economic disruption as those with tighter restrictions. Iceland has used extraordinary testing and quarantine measures to keep deaths down despite keeping businesses and schools open [2]. There is one country that has been successful in combating the spread of the virus: New Zealand. The lockdown rules were vital as they suppressed the spread of the virus early and bought precious time that other countries wasted. In the US, riots are making the situation more difficult, and because of the upcoming presidential elections authorities are being much less strict. This may result in a second wave of infections, and this wave could be even more disastrous. The question is not about the US economy, but the human lives involved. We believe that strict travel bans, 14 day quarantines for citizens returning from other countries, strict self-isolation and social distancing, along with widespread testing are the measures that have shown their efficacy.

The OECD predicts that there may be two equally possible scenarios: the single-hit scenario (a second wave is avoided) and the double-hit scenario (a second wave of infections hits before the end of the year) [3]. We have conducted a survey with 423 participants from 54 regions in Russia, 4 participants from the US, 2 participants from the Ukraine, and 1 participant from Germany and 1 from Belarus. The conducted survey has shown that the measures taken to

stimulate the economy of the Russian Federation are inefficient. It is obvious that the set of measures taken must be improved. Many experts have suggested distributing money by using the federal reserves of the Russian National Wealth Fund. However, we believe that it is not enough to improve the set of measures and to distribute "helicopter money" without controlling the distribution of this money. We believe that now, in the wake of this coronavirus pandemic, is the perfect time to combat this problem by using digital solutions. In this regard, Russia can channel China's previous experience with the ZeroTrust AI system that has been used in several cities and regions of China since 2012. Even though some cities have, as a result, refused to continue using this system, it has proven to be quite efficient at finding corrupt officials, having found 8721 officials so far. This technology could be a perfect opportunity for Russia and China to unite their efforts and develop new innovative solutions. It could lead to a significant development of the technological landscape and infrastructure, as well as a decrease in corruption in the country and better relations with China. The most important thing about this kind of relationship would be that there would be a confidence that the distributed money had reached the population of people that really needed it.

Although many experts have asserted that COVID-19 would be a blow to globalization, we believe the contrary: this crisis could provide the momentum needed to globalize the labour and education market. Working from home is now a popular new trend and many companies have realized the advantages of this kind of work, especially in Russia. This is important for many reasons. In the search for new employees many companies will start looking towards the global market, which will increase competition and facilitate the development of educational systems, in particular. And educational institutions, which have been forced to quickly adapt new educational infrastructure to continue their operations online, now have more possibilities and experience in online education, and this will increase the competition between them and will improve education on a global scale.

The pandemic could result in the increased cooperation among countries, because, as we have witnessed, problems in one country can grow into a global catastrophe. In the future, governments will have to take these kinds of issues much more seriously. It is necessary, in our opinion, to construct a series of immediate response strategies to such situations in countries all over the world, so that this situation would not repeat itself in the future as a result of a delayed response time. Refusing to cooperate in times of crisis should not be tolerated. We believe that this attitude can only result in the deterioration of mutual relations between China and the USA and the delay of trade agreements. But the US will not be the only country hostile towards China. China's silence will persuade many other countries into believing that China is directly responsible for their problems. These attitudes will be a blow to the global economy, where China is a major player. Moreover, significant financial aid provided to countries suffering from the consequences of the coronavirus will lead to another kind of crisis: a debt crisis. The only solution to these problems is cooperation among countries. We hope that this crisis will be the beginning of a new world order, where countries cooperate to solve a wide range of global problems together, instead of creating new ones.

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SOCIO-POLITICAL DISPUTES AMONG THE YOUTH IN MONGOLIA

Before we start to talk about socio-political conflicts among young people, I'd like to review the past and evaluate the present of Mongolia. We've had difficult times, times of triumph, times of loss, but at the same time our present is the result of the past. So where are we now in terms of our development in comparison to other countries? According to the human development index (HDI), we are located at the 92nd place among other 189 countries, and in terms of the business doing ease we are at the position № 74 [1]. These indicators show that we're right in the middle and if we don't go up, we can very easily slip down or we can climb up to be one of the greatest nations in the world.

We have faced some difficult times and young people generation argue about some problems. Today, for instance, such things as the environmental pollution, corruption, unemployment, poverty – the issues that we inherited from the past – are rather rampant today. Probably these problems will happen and happen in future. But if we don't unite and work on these issues right now, probably in 10 or 20 years young people will talk the same things accusing us of inaction, indifference.

Very often young Mongolian people compare Mongolia to other countries, especially to the post-undustrial ones (the USA, Japan, South Korea). And the classic answer is "Why we are not like they?". Of course, every country – even the most industrially and economically developed – has its own these or that problems. They came to this good result thanks to years of hard work. We have to realize finally that nobody else can help us get into the group of high rank economical countries. Only we can help ourselves. The majority of people believe that current issues will be resolved by somebody in future: by politicians, by the government, probably by the IMF and then somehow Mongolia will become a better country. Unfortunately, the history shows that it happens rarely.

So, in my opinion, there's no need to blame somebody in our problems and no need to split out. Nowadays Mongolian young people get some inspirations from some celebrities or millionaires who dropped out of their university, they no longer valued academic education. Instead of paying a lot of money for getting the university education and then get low salaries, young people launch their own start-ups [2]. But in reality, they need some theoretical and practical academic knowledge. On the other hand, a big number of our young Mongolian people try to study abroad and then settle down there. I even sometimes hear people saying that as soon as Mongolian government resolve all the problems and the country gets better, they will immediately go back in Mongolia. But actually you have to be involved in the process today to make things better. We should be sure that we are really involved in but not simply draw the picture of our future. Just make a bigger contribution back at home in Mongolia. I urge especially those of you who are studying abroad, who have dreams and aspirations this is the place to be. Thats why the young generation have to be responsible citizens.

We have a lot of opportunities.

- Sometimes we don't take into consideration how much opportunity we have living near the largest economies in the world.
- We're the one of youngest nation in the Asia. 30% of our population is under the age of 18. Around 60% of our population is under the age of 35. That means that our future is in our hands [3].
- We have a very good natural resources basis.
- The message that I want to give to everybody is what we can do for our country.

All of us we should believe that our future is bright.

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RESEARCH ON THE APPLICATION OF NEW TECHNOLOGY IN RIVER AND LAKE MANAGEMENT AREA DEMARCATION

The demarcation of rivers and lakes has such problems as wide range of river and Lake Management, Complex Topography, and rivers involving many management areas, etc.,Compared with the traditional all-field survey method, the low-altitude Unmanned Aerial Vehicle (UAV) photogrammetry technology is used to acquire the base map data, which has higher current situation, accuracy and comprehensiveness, and this method has less manpower and shorter construction period.In this paper, taking a river course in Mianyang as an example, the management scope of the river course is demarcated comprehensively by using the low-altitude photogrammetry technology of UAV, combined with cross-section survey data and Hydrologic Analysis results, it provides the decision-making basis for the river and Lake area management of the Water Conservancy Management Department.

The protection and construction of water ecological civilization is an arduous task,due to the special water conditions in China, water ecological problems such as water shortage, water environment deterioration, water pollution and flood disaster aggravate each other, it's also a long-lasting job. It is of great significance to define the scope of river management and protection in order to avoid disputes caused by the unclear boundary of river ownership.The construction of "river-lake Park" , put forward by Sichuan Province of China,organized the effective protection of the shorelines of rivers and lakes, which is of great significance for the comprehensive utilization of ecological resources.As the main carrier of water resources, rivers and lakes are natural channels for flood control and flood discharge, carrying important natural resources and ecological environment functions. Various water conservancy projects built on rivers and lakes play a role in flood control and disaster reduction, agricultural irrigation, and water ecological improvement. To play an important role, the delineation of the scope of river and lake management can give full play to the functions of rivers and lakes and the benefits of water conservancy projects.The management of rivers and lakes in Mianyang City, Sichuan Province is delineated using low-altitude drone aerial photography technology, which combines low-altitude drone photogrammetry with a small amount of field work to form basic data for the delineation of river and lake management. Based on the basic data, combined with the river flood level Historical data, data of artificially measured temporary water level stations, cross-section measurement data, internal management demarcate the management scope of rivers and lakes, and stake out of the external industry and internal industry construction of the management area to achieve integrated management of the internal and external linkage of the river channel.

The accuracy of the basic control data of river and lake demarcation plays a key role in the accuracy of the demarcation results.This type of project control network is divided into the first-level control network and the root control network. The layout of each level of control network should follow the principle of "from overall to local, hierarchical distribution".

The basic data source of the survey area is obtained through the low-altitude drone photogrammetry technology, which has become increasingly mature and widely used. This type of project uses this technology to enable decision makers to manage rivers more efficiently and comprehensively.The basic data acquisition technical route of the base map of the survey area is as follows:

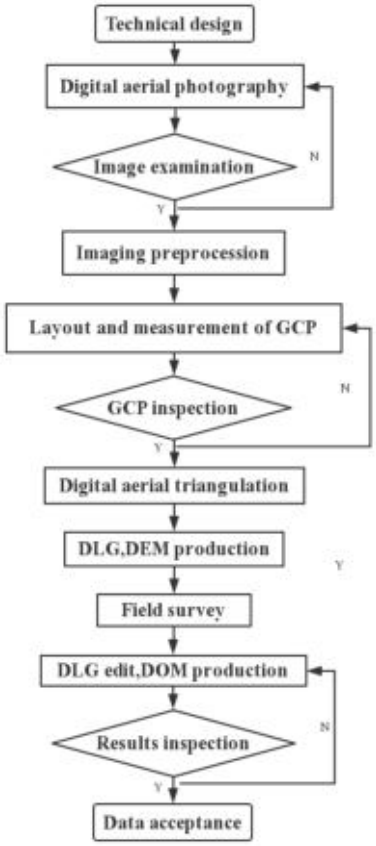

Figure 1 - Basic data acquisition technology flow chart

The drone is used to shoot images in the river range, and the professional mapping software is used to encrypt the images, restore the stereo pairs, and collect DEM, DOM, and DLG based on the stereo pairs.

Large section surveying and mapping of river channel includes vertical section and cross section surveying. In general, large section surveying and mapping is along the center line of the river channel, with one section survey point arranged every 300-500m, and wooden piles driven on the river bank as a sign. In principle, the section is orthogonal to the river channel.For large section survey, aerial survey and full field combined underwater survey can be used, and turning points of terrain and river water surface line can be controlled. Underwater topographic survey is used for the part below the water surface, and aerial survey or full field survey is used for the rest part.The section survey on the water surface shall be carried out to the inner foot of the embankment on both banks or 1 m above the maximum flood level. If the maximum flood level is too far from the shore, it shall be measured to 600 m behind the wooden pile.

The limit error of depth measurement (95% confidence) shall be executed according to Table 1:

Table 1 - Limit error of depth measurement

Sounding range	Limit error (m)
$0<Z\leq20$	±0.2
$20<Z\leq30$	±0.3
$30<Z\leq100$	±Z×1%
Note 1: Z is the depth of sounding (m). Note 2: When the operation is difficult, the error can be doubled.	

The underwater terrain measurement of the river cross section depends on the water depth and flow rate, and can be flexibly used in three measurement methods: sounding rod, sounding hammer and sounding instrument.The distance between sounding positioning points is 15 meters. Encryption surveying should be carried out when abnormal water depth is found.

In order to accurately obtain the elevation of the leveling point at the cross section, a temporary water level station is installed at the cross section, and the leveling point mark of the temporary water level station is prepared to obtain the elevation of the leveling point.

The water level observation of each water level station should be performed at the same time 30 minutes before the start of the water depth measurement and 30 minutes after the end of the water depth measurement to ensure the synchronization of the water depth measurement and water level observation.

The management scope of rivers and lakes shall be delineated in principle in accordance with the design flood water surface line meeting the river flood control standards and the boundary line of the bank.The design flood surface line can be determined in different areas according to local actual conditions.

The flood analysis and calculation includes design flood peak flow calculation and design flood water level calculation;Based on the characteristics of the river basin, geological conditions, and data, each region considers the impact of existing water conservancy and hydropower projects on the flood, and selects appropriate flood calculation methods and calculation parameters for analysis and calculation.

Calculate flood peak flow based on measured flood data.

Calculate the measured flood data on the upper and lower reaches of the river, and use the mathematical statistics method to calculate the design flood peak discharge.

1. The difference in the catchment area of the upper (lower) travel section is less than 5%, and the results of the design peak flow in the upper (lower) travel section should be directly used.

2. The difference in the catchment area of the upper (lower) travel section is between 5% and 20%. The area analogy method is used to transfer the results of the design of the peak flow of the upper (lower) travel section.

The adjacent basin is similar to the basin where the calculated river section is located. The area comparison method can be used to transfer the design flood peak discharge results of the adjacent basin, and the difference in area transferred is as mentioned above.

Calculate flood peak flow based on storm data

1. Design storm calculation

The design rainstorm can be inferred based on the measured rainstorm data of the basin where the calculated river section is located and the adjacent basin, and combined with the results of the calculation of the contour map collection of the local rainstorm statistical parameters.

2. Design flood peak flow calculation

According to the design rainstorm, the design flood peak discharge can be calculated by the inference formula method or the integrated instantaneous unit line method.

3. The flood empirical method (formula) for deriving rain from other areas is used to calculate the peak flood discharge, but it needs to be approved by the relevant departments.

Calculate flood peak flow based on flood survey data.

1. According to the distribution of flood marks obtained by the survey and the hydraulic characteristics of the surveyed river section, an appropriate calculation method is used to calculate the flood peak discharge.

2. Investigate the relative magnitude of floods and their rank in historical floods to determine the design peak flow.

(1)The river section with the relationship curve of water level and discharge can directly use the design flood peak flow to estimate the design flood level.

(2)Use the survey flood level as the design flood level; for the river section where the flood survey cannot be carried out, the annual flood level plus a certain super-high can be used as the design flood level according to the actual situation.

Calculate the measured flood water level data in the upper and lower reaches of the river, and use the mathematical statistics method to calculate the design flood water level.

If the design water level of the river section cannot be obtained from the above, a certain number of large sections of the river shall be measured according to the demand. According to the calculated peak discharge, the design flood level of each section and the flood water surface profile of the river section shall be calculated by Manning formula, Bernoulli equation and other hydraulic methods.In the hydraulic formula, the method for determining the gradient and roughness is as follows:

1. Gradient

The investigation flood trace gradient is taken as the calculation method, and the non investigation flood trace gradient is taken as the calculation method.

2. Roughness

For the river reach with measured hydrological data, the roughness shall be calculated with hydrological data; for the river reach without measured hydrological data, the roughness shall be determined according to the relevant technical manual of riverbed quality, bank slope vegetation, river regime, etc.

For lakes with flood control requirements, the design flood level of the lake is directly adopted; for general lakes without flood control requirements, a certain water level between the annual water level of the lake and the highest historical water level can be selected as the design flood level according to the actual situation.

The calculation formula of water level and flow of measurement control section is as follows:

$$Q = A \times \mathrm{v} = A \times \frac{1}{n} R^{2/3} J^{1/2} \qquad [1]$$

In the formula 1, Q is the flow rate, A is the cross-sectional area of flow, v is the flow rate, n is the roughness, R is the hydraulic radius, and J is the Gradient. The cross-sectional area A and hydraulic radius R at the corresponding water level are obtained from the control section, the channel Gradient J is obtained from the longitudinal section, and the roughness value n is determined by the conditions of the underlying surface of the small watershed.Use the above formula to calculate the water level and flow relationship curve corresponding to this section.

Design flood water level calculation formula:

$$Q = Q_R \times FF_R n \qquad [2]$$

In formula 2: Q is the flood peak flow value of the design station; Q_R is the flood peak flow value of the reference station; F_R is the control catchment area of the design station.

The river water level line is determined by collecting the river flood level analysis data, and the basic data of the superimposed base map is used as the basis for the delineation of the river management range.The demarcation of the management scope of the river channel is based on whether there are embankments. The management scope of the river channel with embankments is the water area between the embankments on both banks, sandbanks, beaches (including arable land), flood area, and embankments and embankments on both banks.For mountain-type rivers without embankments, the management scope is the waters, beaches (including arable land), flood areas, etc. between the design flood level (or the highest historical flood level) and the hills that meet the flood control standards of the river.

The management and use of achievements in demarcation of rivers and lakes must ultimately have the basic functions of loading, symbolizing, browsing, layer management, and data query of achievement data, so as to realize the achievement data management and visual display.The storage of achievements is mainly based on the achievement information of the delimitation of rivers and lakes, the measurement information of river cross-sections, and the

information of flood analysis. Finally, the achievements are summarized, converted into data and checked.

Establish a special database for water conservancy, combine spatial geographic information data and flood analysis results, form a special database for river and lake demarcation, and plan and organize multiple elements along points and lines along the river.

The demarcation of rivers and lakes is very important for the water conservancy rights determination.The clear ownership of rivers and lakes plays a decisive role in water conservancy management and the development of rivers and lakes. The current situation and accuracy of the demarcation work can provide efficient and comprehensive decision-making basis for the water conservancy management department from the root cause.This article uses low-altitude drone photogrammetry technology to obtain DEM, DOM, DLG within the river range, manually collect channel cross-section measurement data, collect hydrological analysis data, comprehensively understand and investigate the river management range, and provide a solid foundation for unified determination of natural resources basis.

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SOCIO-POLITICAL CONFLICTS IN THE YOUTH ENVIRONMENT OF MODERN EUROPEAN SOCIETY IN THE CONTEXT OF MASS MIGRATION CAUSED BY THE MIDDLE EASTERN CONFRONTATIONS

Youth has always been the most unstable social group which provides multiple contradictions because of their rebellious core. Their other problem is a high level of receptivity to the outer influence. Even though modern European population is rapidly aging, young people have remained their position as the engine of most social upheavals.

Meanwhile, numerous military and political conflicts across the Middle East have caused huge waves of migration from the region to “rich” European countries. The situation provokes even more problems in the youth environment because from this moment socio-political conflict becomes surrounded by cultural contradictions.

For many years and to this day liberal-democratic populists have been dictating their will to the people of Europe. Their ideology is based on the “oppressive” culture of the past. They claim white people (especially men) are responsible for systematic deprivation of the minorities’ rights which was caused either by colonial system or by patriarchal structure.

That is why it is reasonable to claim that nowadays there are two newly privileged groups: the first one is gender/sexual minorities[1] which fight for more rights in social sphere and mostly represent the younger generation. The second group is a product of western neo-imperialistic policies in the Middle East. The so-called Arab spring literally destroyed homes of hundreds of thousands of young people who rushed to the borders of Europe driven by the desire for a good life. [2]

As a result, Europe possess both ultra-traditionalistic nonintegrable group of Muslims from middle East and radical liberal leftists. It is how a polarized society was gained; governments try to support two opposing sides at a time. Thus, it is obvious that inconsistency of such policy may result in direct political clash.

Visible increase in percentage of the carriers of foreign culture to natives has resulted in activization of various conservative parties. Playing on the social demand they try to counteract the liberals.

Their ideology is based on the European union. Various alt-rights and conservatives claim that migrants steal jobs of the locals, parasitize on their social programs while not paying

taxes etc. It is worth highlighting that for more people the problem of race mixing is extremely acute. That is why their reaction frequently driven by populistic motives of the politicans turns into hatred, chauvinism and anti-globalist discourse. The youth influenced by the ideology form near-Nazi groups. All these leads to more socio-political problems and even open confrontation in youth environment.

The critical situation in the Europe nowadays attracts foreign countries. They try to influence decisions by controlling migrant waves. The brilliant example is the recent occasion with Turkey. Recep Tayyip Erdogan tried to manipulate Germany and the EU in early March 2020 which resulted in migrant crisis all over the Balkan border. It was a threatening precedent of the new form of hard power. [4]

To sum up, we think that nowadays because of the wrong decisions of the ruling parties and attempts of the populist politicians to attract wider electorate socio-political climate is harsh. Ideology has always played a colossal role in the youth environment; it can both unite and disunite various social groups. Modern socio-political conditions in Europe considering this massive intrusion of foreign culture stimulates division and polarization of the youth which may lead to severe negative effect on the whole society.

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PSYCHOLOGICAL ASPECTS OF EMOTIONAL BURNOUT AND COPING STRATEGIES OF STUDENTS IN TECHNICAL SPECIALTIES

The rapid changes taking place in modern society associated with global, political, socio-economic processes, a tendency to urbanization, the intensification of personal life and work, have led to an increase of the number of people of different age, sex, social status, areas of professional and studying activities to be prone to the damaging effects of stress. The term "burnout" introduced into the scientific circulation by the American psychiatrist H. J. Freidenberger in 1974 to describe the demoralization, frustration and extreme fatigue. Numerous studies, publications and analytical reviews of Western (E. Aronson, V. Burisch, P. Brill, C. Cherniss, C. Maslach, A. Pines, S. Jackson, and others) and Russian authors (V.V. Boyko, N.E. Vodopyanova, O.I. Muravyova, V.E. Orel, A.A. Rukavishnikov and others) highlight this complex and important problem. In psychology, there is no single understanding and approach to the problems of stress and emotional burnout. Almost all authors dealing with this issue note the general negative consequences of "burnout" [3]. In modern conditions of higher education in which, as if in a mirror, reflects the contradictions and changes taking place in society, the problem of students' emotional burnout is associated with a high risk of its occurrence. It is

known that student activities are associated with a high level of uncertainty, associated with systematic preparation for classes, passing exams, tests, intensive social contacts, etc. The relevance of the topic lies in the existence of a high risk of the development of a syndrome of emotional burnout, as well as the need to obtain psychological knowledge about the relationship between overcoming human behavior and the occurrence of emotional burnout, as well as finding ways to effectively manage stressful situations.

The main goal of our exploration was to examine the relationships between the risk of burnout and coping strategies of students. The study covered 87 1-2-course students of full-time technical studies in universities of St. Petersburg. We selected the following research methods: 1) Questionnaire "Emotional burnout" (author V.V. Boyko); 2) The technique of “coping behavior in stressful situations” (authors S. Norman, D. Endler, D. James, M. Parker), adapted by T. A. Kryukova.

Diagnosis of the level of emotional burnout of students was carried out using the questionnaire "Emotional burnout" V.V. Boyko. This technique gives detailed information about the “burnout” syndrome as a dynamic process that occurs in stages as the “phases” (ie, levels) of the “burnout” form, each of which has its own specific symptoms [1]. The first phase - the phase of “tension” - “triggers the mechanism” of the formation of the symptom complex of emotional burnout, is distinguished by its dynamics, constancy and increased impact of psycho-traumatic factors. The second phase is “resistance”, i.e. resistance to the growing effects of psycho-traumatic factors. The third phase - the phase of "exhaustion" - is the final link in the formation of burnout syndrome. This phase is associated with a decline in the student’s physical and moral strength, as well as a weakening of the nervous system [2].

Using the questionnaire "Emotional burnout" of V.V. Boyko the levels of emotional burnout were calculated in points. In accordance with the key of the questionnaire, the total score was determined, from which the indicator of each of the symptoms of burnout is added up, corresponding (or not corresponding) to one of the three "burnout phases". By the number of points scored, students were assigned (or not assigned) to one of the “phases” of burnout.

According to the results of the analysis, it turned out that the phase of "stress", which is accompanied by an anxious state and is a harbinger of the formation of emotional burnout, was formed in 27% of students. In 24.3% of students, the stage of “stress” is already in the stage of formation. And only 48.6% of students do not show a single symptom of emotional burnout, as well as a tendency to it. The “resistance” phase with its corresponding symptoms was formed in 16.2% of students. This phase was at the stage of formation in 18.9% of the students surveyed and not formed in 64.8% of students. The final phase - the phase of "exhaustion" - with a characteristic symptom complex was found in 10.8% of students, which indicates the formation of burnout syndrome in them. The phase at the formation stage was found in 16.2% of students. In 72.9% of students, symptoms of this phase are not detected.

The term “coping” is relatively new in the scientific literature, first used in the scientific works of L. Murphy (1962). The main provisions of the concept of coping behavior were developed by R. Lazarus (1966). Obviously, coping with stress is a key mechanism for a person to adapt to changing social conditions and require active, flexible, effective ways of coping. The psychological sig-nificance of coping (overcoming mechanism) is to adapt the individual as much as possible to difficult situations for him through mastering, weakening or mitigating the requirements of the situation, thereby reducing the stressful impact of the situation [3]. Using the methodology for exploring coping behavior in stressful situations (authors S. Norman, D. Endler, D. James, M. Parker), data of the student’s coping strategies were obtained.

Using the Pearson correlation coefficient, we analyzed the relationships between the level of emotional burnout and copying strategies of students. Students with the formed burnout syndrome are dominated by coping strategies focused on avoidance ($r=0,42$, at $p\leq0.05$) and distraction ($r=0,65$, at $p\leq0.03$). Negative correlations of a high level of emotional burnout with coping strategies aimed at finding social support ($r=-0,42$, with $p\leq0.01$) were identified. Students who do not have symptoms of emotional burnout are dominated by problem-oriented coping

strategies (r=0,45, with p≤0.05), as well as coping strategies of finding social support (r=0,43, with p≤0,04).

In this way, it was revealed that coping strategies of "distraction" and "avoidance" are characteristic of students with a formed burnout syndrome. Students who do not have symptoms of emotional burnout are dominated by problem-oriented coping strategies, as well as copings of the search for social support. It can be argued that the coping strategies of the individual are interconnected with the adaptive potential of the individual. It can be argued that personality and stress resistance are associated with the adaptive potential of the individual. All they need is the use of problem-oriented search strategies and support for social support. However, further studies are needed to obtain more detailed information about the reasons for the high level of students' burnout, the relationship between the tendency to burnout and the effectiveness of using coping strategies.

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ABOUT UNDERGROUND RESOURCES IN THE SOUTHEAST ASIA SEA AND RELATED DISPUTE ISSUES

KEYWORDS: Oil and gas, hydrocarbon, Southeast Asia sea.

The underground resources in the Southeast Asia Sea area are one of the main causes of the disputes here (Southeast Asia Sea is another name for the South China Sea). These disputes, if not well-orchestrated, not only lead to regional conflicts but also threaten to spread to the global conflict bar. In this paper we cover the following key issues.

1. Disputes over islands in Southeast Asia Sea area. In this section we refer to the historical facts of states' possession of major islands in the Southeast Asia Sea. At the same time, the reasons why the dispute was raised and the major milestones of the dispute process over islands in the Southeast Asia Sea.

2. The trend of militarization of Southeast Asia Sea. From the invasion of islands led to the establishment of military bases on these islands. It has even happened to build up artificial islands and build military bases on the artificial islands. All of this has led to full control of the Southeast Asia Sea, including the skies of the Southeast Asia Sea. One of the manifestations of Southeast Asia's control over the sea is its fishing rights.

3. Disputes over oil and gas exploitation areas in Southeast Asia Sea. In the ground of the Southeast Asia Sea lies a huge amount of oil and gas reserves. Oil and gas is one of the core causes of conflicts in the Southeast Asia Sea. Conflict not only occurred between countries with maritime areas and continental shelf in Southeast Asia Sea but also dragged the countries involved outside the region.

4. Disputes hydrocarbon resoures. Other underground resources in Southeast Asia's ocean are of tremendous value in hydrocarbon resources. This estimated $ 2.5 trillion hydrocarbon resource is another important cause of China's extremely aggressive expansion ambitions in the Southeast Asia Sea. China is the number one cause of conflict and tension in the Southeast Asia Sea. The important goal of China is to own all of this unexploited hydrocarbon resource.

5. Vietnam's approach to problems. Vietnam is a country that owns large seas and continental shelf in Southeast Asia sea. Therefore, Vietnam plays a very important role in ensuring peace and stability in Southeast Asia. Vietnam is also an important factor in ensuring

maritime trade in the Southeast Asia sea. Vietnam's approach to Southeast Asia's every issue is based on international law and through peaceful negotiations. Vietnam opposes all unilateral measures to use force to resolve conflicts. Vietnam welcomes the contributions of other countries (in and outside the Southeast Asian maritime area) in resolving the conflicts that arise in the Southeast Asia Sea.

Underground resources must be used for human beings and in peace. Underground resources cannot be the cause of war. In order to do this, it is absolutely necessary to comply with international law, through the path of peace negotiations and with the goodwill assistance of all stakeholders.

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A RESEARCH OF ECOLOGICAL CULTURE OF STUDENTS OF REDBRICK UNIVERSITIES

Environmental-oriented specialists are becoming necessary due to the increase in environmental problems. Such specialists will be able to treat the environment responsibly and make environmentally-oriented decisions for nature conservation. Human culture plays a huge role in such situations. The study of ecological culture was conducted to examine this factor in more depth among students because they are future specialists, whose actions affect the quality of the environment. In the literature on environmental aspects, much attention has been paid to the technological and economic nature of the human impact on nature. For example, research has focused on introducing green innovations in the industry [1], managing sustainable development in an industrial enterprise [2], and reducing carbon dioxide emissions by designing green chains [3]. However, while studying the data, almost no attention was paid to the cultural aspects, namely the development of ecological culture. In turn, culture is the main factor in the formation of human thinking, Linton understood culture as the total sum of knowledge, attitudes and habitual behaviors that are transmitted between members of a certain group of people [4]. Therefore, culture is the main aspect that shapes human thinking and behavior. Gagarin in his research talks about the need to train environmental-oriented specialists. He positions the ecocentric worldview as an ideal quality of the individual, which determines its place as a subject in the developing space of life.

The survey conducted in the course of the study became a practical method for obtaining data on the state of the ecological culture of students. It identified the main problems in the development of ecological culture among respondents. For getting more detailed information, the results of the survey were divided by gender and the course of the student's study. Thus, data were obtained on the dynamics of environmental responsibility and awareness development depending on the gender and age of the respondents. The results of the data analysis revealed the following problems:

1. Consumer attitude to nature and resources;
2. A low level of the knowledge base about conscious consuming;
3. Ignorance of the basic standard documents in the ecological sphere;

These problems were caused by insufficient development of three components which form the ecological culture of a man:

- Ecological consciousness;
- Ecological education;
- Ecological behavior;

These components were used to develop theoretical and practical methods for solving problems of ecological culture development. They consist of the introduction of environmental education in the learning process, using infographics to increase environmental awareness and media space for the formation of ecological culture. Other ways of developing this type of culture have also been studied. They are based on the gradual and easy development of ecological culture, considering each problem separately.

Motivating is the main factor that drives a person to develop certain qualities. This factor was taken into account and the study found that many students are willing to develop an ecological culture and study environmental issues in the course of training. These results indicate a positive trend in the further study of this issue, so the next stage of the study will be the introduction of the proposed methods and determining the level of ecological culture after applying these techniques. The methods given for the development of ecological culture can be supplemented and changed depending on the level of environmental education received by students. As noted above, the training of environmental-oriented specialists who can responsibly treat nature and apply their environmental knowledge in practice is a necessity in the era of industrial and technological progress, since the future of the planet depends on their decisions and actions.

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MEDIATION AS AN EFFECTIVE TOOL OF ALTERNATIVE DISPUTE AND CONFLICT RESOLUTION

The importance of the selected research topic is due to the dynamically developing trends in alternative systems for resolving disputes and conflicts in the Russian society completing the transition to the new digital reality.

Mediation, as a toolkit for the harmonization of social relations through the resolution of conflicts and disputes with the participation of an independent mediator, has been established in the Russian Federation law only ten years ago, since the publication of the Federal Law № 193-

FZ. Despite the considerable interest of the scientific community to this problem, there are still significant methodological gaps. in this research area.

The literature review has shown that throughout the history of the institute of mediation in Russia, there have been more than 50 PhD theses on this topic, and in general, there are more than 7,000 publications indexed in the information-analytical system SCIENCE INDEX of the information-analytical portal in the field of science, technology, medicine and education ELIBRARY.ru (as at April 2020.

The purpose of the study, the results of which are presented in this article, is studying mediation from the standpoint of evaluation of this procedure as a tool for alternative dispute and conflict resolution arising from civil, administrative, labor, family and other public legal relations.

The object of the study is the principles and methods of mediation procedure, which determine its effectiveness, and the subject is scientific research in the field of alternative jurisdiction, covering the development of mediation in Russia.

The choice of the object and subject of research has led to the determination of an algorithm for achieving the purpose by consistently addressing a number of tasks:

historical and bibliographic research of the literature sources on the problem under study;

identification of the mediation essence as an effective toolkit for alternative conflict and dispute resolution in Russia;

identification of the current level of regulation of the peremptory norms of the mediation procedure as applied to the Russian legal reality on the basis of the judicial practice.

studying the phenomenon of mediative dialogue as one of the key factors initiating the transformation of social being.

The research methodology includes three large groups of methods: general scientific methods, general ones and specific ones, which are all clearly presented in Figure 1.

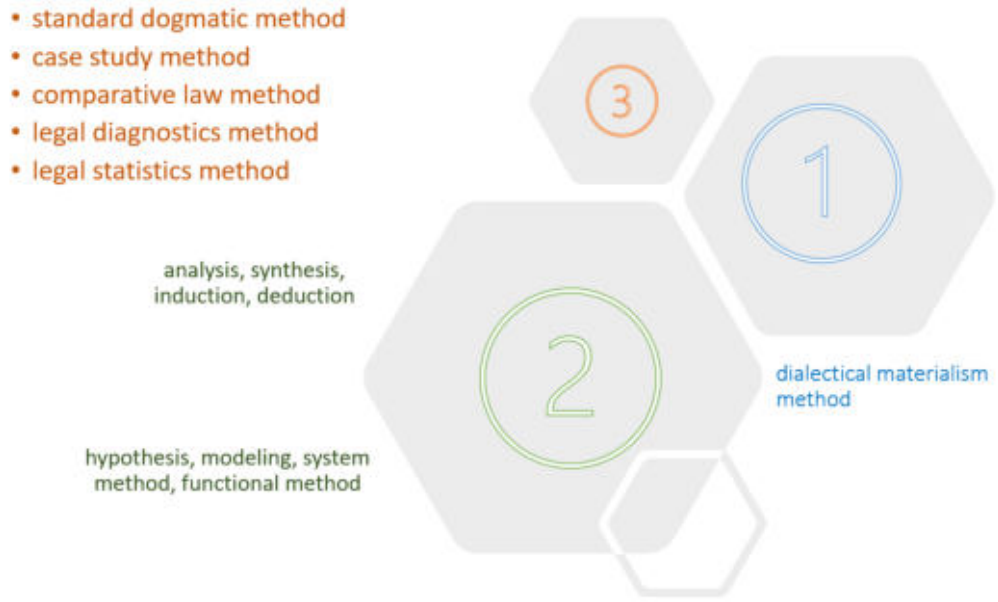

Figure 1 - Methods used to achieve the study purpose and sequence of tasks to be solved

The mediation procedure is aimed at settling disputes with the assistance of the mediator on the basis of voluntary consent of the parties in order to achieve a mutually acceptable solution [1]. The mediator, unlike a judge, does not have the authority and rights to make a specific decision on the conflict, and this refers to the category of exclusive rights of the parties to a dispute. Three forms of agreements are integral to the mediation procedure: on the application and conduct of the mediation procedure, and a mediator agreement. The mediative dialogue can be considered as one of the basic factors influencing changes in social being [2].

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EXAMINING THE SOCIO-CULTURAL FACTORS CAUSING THE LACK OF AUTOMATION IN INDIAN MINES AND PROPOSING SOLUTIONS

Mining is an age-old industry which has propelled human progress and development. As a consequence, large proportions of easily extractable minerals are exhausted and it is imperative to drill deeper in more remote areas while processing ores of lower concentrations. This significantly increases the risks associated and wastes generated [1]. Against this backdrop, espousing automation and control is a viable option being implemented in mines across the world [2,3]. Despite its richness in minerals and economic prowess, India is plagued with inefficient mines and lags in the implementation of automation in its mines [4,5]. This paper discusses reasons for the same and proposes solutions to accelerate modernisation of India's mining sector.

The success of automation in mining is exemplified by the Australian mining industry. The Longwall Automation system developed by the Commonwealth Scientific and Industrial Research Organisation is now used by over 70% of mines in Australia and is being adopted in global mines [2]. The Rio Tinto group pioneers the use of automation in mining and ascertains increased efficiency and safety [3]. Australia's successful mining industry contributed 6.99% of its GDP in 2016-17. In stark contrast, in the same year, Indian mining industry contributed a meagre 1.54% to its GDP.

Upon examining the current state of the Indian mining industry, it lags behind in optimal resource utilization due to sub-optimal technology penetration in the planning and operation stage. The industry realises the benefits of automation yet it is plagued by socio-cultural problems which need attention [4]. One of the significant hurdles is the community resistance to automated mines. Automation entails a conversion from a large quantity of low-skilled labour to a small quantity of high-skilled labour. The main fear among the mining labourers and the community around is association of automation to job loss [6]. Changing this perception requires the provision of job-security. The loss of jobs in the mining industry needs to be appropriately transferred to other sectors.

The structure of Indian mining primarily comprises a large number of small mines and corporations. Whereas large corporations with sufficient scientific, technical and financial resources have begun experimenting with and implementing advanced and environment-friendly practices, smaller counterparts are unable to do so [4]. Smaller corporations continue using

labour intensive methods owing to the abundance of cheap manpower in India. Moreover, several illegal mining operations run in the mineral rich parts of India. This further accentuates the problem of motivating an industry wide technological shift. To remedy this unfavourable scenario, it is imperative to implement strong regulatory mechanisms backed up with competent institutions which oversee mining operations in the nation. The existing small scale mining operations must be empowered with technical and scientific advisory services to impel technological advancement not limited to automation.

The industry is currently on the brink of adapting automation. At this stage, the study provides a clear insight into the existing socio-cultural challenges and solutions so that they can be tackled to ensure a smooth and quick transition. In conclusion, it is established that the aforementioned socio-cultural aspects are significantly hindering the adoption of automation in the Indian mining industry despite its plentiful benefits and measures to ameliorate the same have been suggested.

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SOME URGENT PROBLEMS OF THE INTERDEPENDENCE OF TRADE AND INDUSTRIAL POLICIES OF MINING ENTERPRISES

Industry is the driving force behind economic development, and the creation of new and modernization of existing enterprises is a prerequisite for improving the quality of the population.

Today, one of the most significant reasons for the decline in industrial production of mining enterprises may be the imposition of sanctions and trade restrictions due to the complication of political relations between states. Sanctions affect the interests of not only domestic business, but also the interests of state structures. They affect the activities of banking and other financial organizations, limit the ability to obtain cheap foreign loans, and limit the export of high-tech products. The restrictions introduced by the state demonstrate the dependence of the economy on existing trade relations and the need for cooperation with other developed countries, as well as the need to change the current model of economic development based on the country's specialization in low-processed products. Although high-tech products in the mining industry in significant quantities are purchased abroad [1].

The problem in the import dependence of the economy is manifested in the unwillingness to refuse to import raw materials at any price increase. The main obstacle to import substitution is the lack of production of the necessary equipment, components and raw materials in the country. Another significant obstacle is the low quality products of domestic enterprises.

Regulation of economic relations in the mining industry is an important task for the development of the national economy. The means of development of the mining industry is the formation and implementation of state industrial policy, which acts as the main tool of developed

economies for adapting the activities of mining enterprises to the ongoing global changes. The introduction of sanctions poses threats and the need to eliminate them. This requires the state to respond with strategic measures and decisions. An example of such actions is changes in industrial policy and the proclamation of an import substitution course, which involves the priority development of industries aimed at meeting the needs of the domestic market. Import substitution means ensuring the production of goods previously imported from abroad in the country: creating analogues of products that are superior to foreign in quality [2].

Currently, much attention is paid to the issues of the need for improving industrial policies, as a tool to bring national production forces to leading world positions, as well as ensuring the economic security of the state. For example, the adopted Federal Law of December 31, 2014 “On Industrial Policy in the Russian Federation” and its effectiveness are criticized: there are contradictions in the law and it does not solve the urgent problems facing the economy. Article 4 of Chapter 1 contains two contradictory principles: providing resources to priority industries and at the same time there is equal state support for the subjects. An effective industrial policy should be aimed at supporting individual, most promising and priority sectors. The law on industrial policy lacks a mechanism for determining priority sectors of industrial development. Thus, the accelerated development of certain areas of industry is not expected, but an equal and slow growth of the entire industrial production as a whole is planned. Sanctions and trade restrictions are a significant challenge for the mining industry [3]. Industrial policies and legislative acts need to be finalized and prioritized for development in order to counter the challenges and emerging threats. World experience shows that a systematic, well-thought-out and long-term industrial policy not only ensures national security and the state's independence of the state, but also allows creating new growth points in the economy.

In modern conditions of competition for national interests, the importance of trade policy is very pronounced. The trade policy of mining enterprises is a policy of state influence on international trade through the regulation of foreign trade. In trade policy, two opposing lines of economic behavior are embodied in interaction: liberalization and protectionism. The liberalization policy aims to increase competition, open the domestic market to foreign goods and capital. Protectionism is a policy aimed at protecting (closing) the domestic market from foreign goods and seizing foreign markets.

Industrial and trade policies in the mining environment should be meaningfully balanced according to the principles of formation and functions performed, according to priority goals and objectives, aimed at establishing a balance between the modes of functioning and development of mining enterprises by achieving a proportional and balanced structure and resources. Since the industrial and commercial aspect is inherent in all areas of the enterprise, within the framework of strategic management, industrial and trade policies should ensure coordination and interconnection of all functional policies of the enterprise.

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HOW TO MANAGE SOCIAL ACCEPTANCE OF OIL SANDS DEVELOPMENT

In general, the problem of social acceptance of a mining project is one of the great challenges for the entire mining and oil industry facing local, national or international public opinion. These challenges are for the most part related to the environment. In recent decades, the question of the environment has become almost everyone's concern. This is why it is of utmost importance for companies to act responsibly in order to have a good reputation and maintain their credibility and specially to influence public opinion. This work studied three relevant approaches or theories that deal with the issues of key aspects of the environment: the scientific bases of sustainable development, the theory of stakeholders and the socio-constructionist linkage of the sustainable development and stakeholder theory.

The notion of sustainable development requires that we meet the needs of consumers while respecting the environment. It can be defined as the process of developing land, businesses and communities to meet current needs without compromising the ability of future generations to meet their own needs. According to Jean Pasquero, this notion is slowly emerging as a new horizon for regulated capitalism [1]. The sustainable development approach is essential in this context as it can enable good management of environmental indicators. However, it is vague and can be one of the major challenges of today's companies especially its implementation. It contains some form of sociotechnical uncertainty. Its success may be facilitated by the development of collective action strategies in which relevant stakeholders arrive at common definitions of the problems to be solved and the solutions to be applied.

The socio-centric stakeholder theory complements and corrects the sustainable development approach. It recognizes the socialization of the organization in its environment is within the networks of stakeholders in interaction. The company becomes a social actor. It seeks to create not only economic value, for its shareholders and wages, but also social or socio-economic, for all stakeholders. This approach contains several strengths to respond to the new challenges of sustainable development. It is relational, realistic, pluralistic and pragmatic. The relationship component is very relevant if the oil company really wants to influence public opinion. However, it should be noted that the stakeholder theory, more precisely its firm-centered version, is limited by some weaknesses. Business leaders remain the masters of analysis and relationship management between the company and the stakeholders that they consider relevant.

Socio-constructionist linkage of sustainable development and stakeholder theory is a logical extension of the socio-centric version of stakeholder theory. It is based on the principle of Bachelard “Nothing goes without saying. Nothing is given. Everything is built”. It states that, in order to fully understand human behavior, two things must be considered: ends and means. These parameters are co-constructed in a relevant interaction process. This constructionism is said to be social when each stakeholder adjusts its goals and strategies to those of other stakeholders. The epistemology of the socio-constructionist approach can be defined based on three elements: social construction, the "interests-actions-knowledge" table, and the conception of relations between stakeholders as a negotiation process. Note that this approach also recognizes the major role that the relational component can play in the particular challenges of sustainable development that the oil and gas or any other industry faces. This is a very important element to remember.

It is difficult to change public opinion based on scientific results. It is often sentimental. It relies on points where scientific agreements are not clearly established and uses reason as a means to justify its objectives. Managers are better positioned to achieve sustainable

development and social responsibility benefits if they manage it collaboratively. It is by changing the relationships between stakeholders and managers that the goal of social acceptance of oil sands development would be achieved. Finally, there are some recommendations that can help managers and executives of oil companies to improve their credibility and the social acceptability of their projects. It is necessary that recognize that social acceptability is a necessary criterion, admit that social acceptability is a construction of the mind, consider that recognizing social acceptability is costly in time, money and thinking, consult with stakeholders and involve them in the relevant decision-making process, consider situations, claims and interests, and place them in order of priority according to they represent, disseminate, through the media, information on progress made, empower stakeholders to use this information in the decision-making process.

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INDIVIDUAL EDUCATIONAL PATHS

Innovations in education lead to changes of future specialist training. Higher education is considered as a key factor and essential for the future success of people in modern society [2]. Nowadays the question of education process individualization is still current. Individual educational paths allow students to choose their own courses and direction of study. The training process requires the formation of not only professional skills, but also such skills and qualities as flexibility, mobility, and decision-making.

Getting of a high qualified specialist is a problem of an enterprise, the problem of the specialist is to find a good job [1]. Nowadays professions appear and disappear very fast. Sometimes a traditional higher school does not get on these changes and a graduate can be expendable on a job market. That is why big quantity of graduates do not work according to their speciality.

Individual educational paths is a professional-educational program which provides actualization of an educa-tional standard and gives a man an opportunity to project one's own educational path with the assistance and help of a teacher (tutor). These learning methodologies consist in letting the students play an active role in their learning process rather than just receiving it directly from the teacher [3].

Individual educational paths have been partially introduced in Russian Universities since 2019. The idea of individual educational paths was taken into service from experience of Western countries. For example, in the United States, training takes place according to individual plans. The student is offered a list of subjects, some of which are mandatory, and the rest can be selected independently. To get a bachelor's degree, you need to take a certain number of lectures and seminars, called "credits". The paper gives results of students survey with the purpose of determination of problem of students individual educational path actualization.

In the future individualization will be applied to all educational system. Students will not be attached to universities and will be able to organize the program as constructor: for example, during several terms students will study at one place, then they will be transferred to another. They will be able to study a part of this program online abroad or on educational web-platforms.

Individual educational paths is a new phenomenon for Russian higher school. That is why it can help Russian universities to individualize the educational process in the higher school, and

also minimize complexities in organization of IEP for students. When correcting their educational path, as a result student become unique specialists, i.e. that they will not have an absolutly similar set of subjects. This becomes an advantage when looking for a job and increases the prestige of the educational institution.

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DIRECTIONS AND CONDITIONS FOR THE STRYCTURE OF FUEL AND ENERGY COMPLEX

The complexity of the socio-economic system of the region is determined by the existence of economic, social, environmental subsystems and mutual influence, as well as the influence of various levels.One of the most important components of the Russian economy is considered to be the fuel and energy complex, which ensures the vital activity of the main sectors of the national economy. The fuel and energy complex is a system of interconnected elements that combines the receipt, transportation, use and conversion of various fuel and energy resources. The peculiarity of the fuel and energy complex lies in the systematic nature of its functioning and development, which is due to the interchangeability of various types of energy carriers and energy resources. The degree of knowledge of the topic is insufficient, but many authors have made a significant contribution to the theoretical development of forecasting and planning the fuel and energy balance. Methodological issues of accounting for unconventional sources of hydrocarbons in the prospective fuel and energy balance are considered in the work of Alymova SV, Ilyinsky AA The fuel and energy balance as a tool for analysis, forecasting and indicative planning of energy development is considered in the works of I.A. Bashmakova. O.V. Belovoi, V.V. Litvak [1].

Today, in the future, an important aspect of the development of the fuel and energy complex is the creation of the possibility of switching to energy saving and increasing the energy efficiency of the use of resources. When reducing the negative impact on the environment and minimizing costs, the use of energy saving potential affects the improvement of energy security in Russia. In the development of the fuel and energy complex, an increase in negative factors related to energy security is currently taking place [2]. Therefore, it is necessary to carry out activities aimed at: changing tax and pricing policies, stimulating investment activity in the fuel and energy complex, improving the structure of the fuel and energy balance. Let us dwell in more detail on the latter, to improve the structure it is necessary:

- apply alternative energy sources (solar, geothermal, solar energy, etc.);
- reduce energy consumption by increasing the efficiency of consumption, distribution, production, use of energy resources;
- create systems to prevent downtime, emergencies and accidents;
- switch to more environmentally friendly fuels with the least amount of atmospheric emissions, for example, replace heating oil with gas (the World Energy Council predicts an

increase in gas demand in the next 20-25 years by 5-6% in developing countries, and in already developed countries by 1.5-2.5%.

- maximize the potential of energy conservation, which helps to reduce losses during the technological cycle, increase the use of raw materials [3].

Thus, since the fuel and energy complex and the fuel and energy balance have an inextricable link, it is therefore necessary to activate the above areas of improving the fuel and energy balance in order to improve the state of the economy and politics in the country.

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THE ANALYSIS OF CONDITIONS AND RISK FACTORS INVOLVED IN THE LONG-TERM DEVELOPMENT OF THE MINERAL RESOURCES SECTOR OF THE REPUBLIC OF BELARUS

Mining is one of the main factors of stable economic growth and social development in a number of resource-rich countries, such as Russia, Ukraine, Mongolia and the Kyrgyz Republic, where the local population often receives significant benefits from mining. Due to the fact that Belarus is not rich in natural resources, the presence of certain types of natural resources determines the specialisation of the country's mining industry. The direction of the republic is to derive potential benefits from the intensive development of available resources through a long-term, responsible approach to the development of the mining industry, its management, and the income provided by the industry.

This article analyzes the features of the development of the mining industry and its role in the economy of the Republic of Belarus. It defines the conditions for the development of this industry in the long term, and assesses the consequences of projected changes for the regional development of the country and their possible risks.

The Belarusian mining industry is mainly represented by oil production (about 1.5 million tons per year) and the development of mineral deposits for the production of building materials (chalk, stone, sand, etc.). The location of enterprises is also determined by the location of natural resources. The share of the mining industry in the total industrial output is small, for instance, in 2018 it amounted to only 1.3%. Also, the share of mining industry is rather small in the country's GDP, constituting only 0.8 %. Mining products occupy the largest share in Belarusian imports, since in 2018 this figure amounted to 27.5% ($ 9.84 billion) exceeding the export by about 9 times. The mining industry of Belarus consists of 28 organisations, about 20% of them are small enterprises and 82.5% of organisations are in state ownership. The net profit of

the mining industry has been declining over the past few years (the average annual growth rate is 14%). In 2018, 8 companies, 27% of the mining industry was unprofitable. The number of innovation-active organisations increased by 3 from 2016 to 2018. The share of innovative products in the total volume of shipped products decreased in 2018 by 0.3% compared to 2016. 10.2 thousand people work in the industry, which accounts for 1.2% of the total number of employees. In 2013-2014 the nominal salary reached 950 dollars. At the moment, salaries have decreased to the level of 830 dollars [1].

The development of the mining industry in the Republic of Belarus is limited by the following factors: low quality of mineral resources, a lack of modern mining and processing technologies, a lack of own financial resources, and a weak inflow of foreign direct investment. Consequently, the growth of the mining industry in the context of the development and distribution of productive forces is to be based on the coordination of regional factors such as social, economic, environmental, and investment levels, and includes: analysis and assessment of all types of mineral resources available in the region, technical and economic assessment of the industrial development of mineral sources, the availability and rationality of the use of resources assuming their uniqueness and demand within the economy, and investment issues [2]. In the long term, the Republic of Belarus is expected to meet a number of conditions: to develop the Sitnitsky deposit, and the construction of a mining and processing plant on its base (currently, the building stone reserves in the exploration field of the deposit are about 540 million m^3, which will ensure the operation of the enterprise with an annual production of crushed stone of 9 million tons for approximately 58 years); to explore on the basis of a concession agreement (in accordance with the Decree of the President of the Republic of Belarus dated January 28, 2008 No. 44) of the Turovskoye oil shale deposits (Stolin and Zhitkovichi districts) with estimated reserves of about 2.7 billion tons, as well as the Lyubanskoye field (Luban district) with forecasted reserves of 1.5 billion tons. In the same agreement, there was also a consideration of brown coal in the Zhitkovichsky, Brinevsky and Tonezhsky (the Gomel region) deposits and Nezhinsky (FLLC Slavkali) potash salts with a fertilizer capacity of up to 5 million tons [3]. In turn, these forecasted changes will lead to an increase in the production of crushed stone, the organisation of the production of shale oil and products created from it, the organisation of the production of stove and motor fuel from brown coal, the increase in the production of potassium salt of JSC Belaruskali and IOOO Slavkali, and the production of potash and complex fertilizers.

The conditions above will undoubtedly have beneficial effects on the development of the regions, such as greater contribution of the mining industry to the GRP of the Brest, Gomel and Minsk regions, better economic base for the development of Luninets, Stolinsky, Petrikovsky, Lyubansky, Zhitkovichsky and Soligorsk regions, ensured economic security of the country in terms of the availability of its own mineral fertilizers, protected labour potential of these territories. On the other hand, these measures can result in a number of risks appeared. First of all, the negative impact is associated with an increase in the level of pollution of air and water resources in the territories of Brest, Gomel and Minsk, as well as the allocation of large areas of land for quarries and landfills for ash and slag waste in Gomel region.

In summing up the analysis, the effective solution of the issues of providing the industrial complex of Belarus with its own mineral raw material base greatly depends on the geological exploration of the territory. Comprehensive research in the field of earth's interior structure will lead to an expansion in the mineral resource base. Therefore, the examination of subsurface resources and the prediction of its results require a modern geological information base that implies the careful design and execution of a unified state strategy for the scientific and technical exploration industry and mining complex, both in the preparation of strategic mineral reserves, and in the reproduction of the country's mineral resource base.

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MANIFESTATION OF DIGITAL TRANSFORMATION RISKS – MARGINALITY OR INSIGHT?

The relevance of the research topic is defined by both the active spreading of digital technologies in all spheres of the life of modern society and the changes that these technologies make in everyday life. In fact, the current digital era permeates our lives so much that modern technology not only defines society, but also in many ways creates a society where risks and conflicts take place. Digital transformation is the result of a number of socio-economic and technological developments. This transformation process makes certain adjustments to the social structure, essentially transforming it. The era of digital technologists is characterized by ambiguity and duality: on the one hand, a huge number of opportunities and certain freedom opens up for a person, and on the other, new forms and types of dependencies, risks and conflicts appear. [1] This transformation is most noticeable in the oil and gas industry, where digitalization is seen as the main way to increase the competitiveness and profitability of a business. The scientific novelty of the research is determined by the fact that despite experts in mining industry note that the benefits digital technology has some risks: low network bandwidth, lack of necessary qualification, organizational barriers; cybersecurity in the country, financial constraints, there are some risks of conflicts as well. Based on the idea of the similarity of risk and conflict, we can say that the conflict activity of individuals manifests itself as a response to the risks actualized for them. According to A. Giddens, “risk is a dynamic mobilizing force in a society striving for change, wishing to independently determine its future, and not leave it at the mercy of religion, traditions or the vagaries of nature.”[2]Thus, many individuals, in response to the threat of digital transformation, in an attempt to change the situation and confront those who disagree with it, produce conflicts. As a part of the means of adapting to risks and protecting against dangers, people begin to exhibit deviant behavior. A pronounced intolerant, one can even say, hostile attitude, towards those who are attributed to risk sources and blame for changes in the usual way of life, as well as division into “friends” and “foes” appear. So, who are those, who are against digital transformation? Are they marginalized or visionaries? Anyway, there is no doubt that the use of digital technologies, such as artificial intelligence, puts enormous pressure on workers because of changing work standards and efficiency, and therefore, they increase stress and anxiety, which leads to a deterioration in both physical and mental health and jeopardizes workplace safety. [3] In this work we use the conflict-management approach based on research programs by Kriesberg L., Beck U, Giddens A, Luhmann N., Bonfur A.

The conflict approach allows to examine the conflict with regard to digitalization. Furthermore, it makes it possible to identify the needs and interests of the parties, to determine the degree of their organization and the scope of support. On the other hand, the risk theory allows us to study the existing risk- reflection on digitalization, as it is really manifested in the minds of people. As we can see, this conflict is not generally recognized as legitimate currently and it is asymmetric.

In order to avoid social conflicts due to digital transformation risks it is necessary to carry out theoretical and empirical analysis of the impact of risk in different social and cultural

conditions on the dynamic and structural indicators of the conflict and its management (forecasting, prevention, stimulation, mitigation, settlement and resolution). Also, should be found out universal mechanisms of risk-reflection and the development of discursive strategies in the projection of everyday practices within conflict interactions actualized in the face of risks and threats of different nature. Moreover, it is necessary to identify the role of risks in the emergence of conflict moods in society, to identify realistic and unrealistic risks, the prerequisites for escalating conflicts, and to identify the main interests regulating social relations in conditions of uncertainty. Finally, to analyze the social interactions of stakeholders to achieve an acceptable level of risk, to identify the microstructures of social relations that determine the conflict of interests in a risk situation and the choice of risk communication norms, which is an important factor for managerial impact on the conflict. Without the strategic management of conflicts as a complex system of interactions at various levels, it is impossible to identify risks, rank and assess their strength.

Summing up, it should be said that such methodological guidelines allow not only to identify risks and dangers, but to devise a mechanism of prevention of threats and risks. Moreover, a broad discussion is necessary, since the absence of discussion leads to the radicalization of the conflict. It must be admitted that we can give an answer to the question in the title only with a conflict study of the positions of the sides, an assessment of their needs and interests, and realistic actions. In the meantime, the side opposed is not at all present in social discourse yet.

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EMOTIONAL AND PSYCHOLOGICAL COMPONENT OF THE NEGOTIATION PROCESS

All the spheres of our modern society are riddled with conflicts. In recent years there have been a lot of conferences, published works dedicated to problem solving of conflict situations. The concept of negotiation is understood ambiguously. G. Kennedy thinks that negotiation is a process of searching conditions for getting something that we want from someone, who wants something from us. According to I.N. Kuznetsov, negotiation is a resource, relation between people, for achieving an agreement, and also when sides have similar or different interests. Negotiation is a conscious communication with people for achieving certain goals in the M.G.Yatmanova's works. However, the T.V.Hudoikina's and E.A. Mirinova's concept is the most interesting. They think that negotiation is a purposeful and conscious communication between people for solving disagreement that is been interested by participants of conversation.

The main index of mastering the program of discipline 'Psychology' in Mining University is some knowledge and skills, particularly the ability to prevent conflicts and to

choose adequate strategies for overcoming them. The most effective method of solving the conflict situation is negotiation. What is the role of it in our life? It is said that during negotiation, conversations, one of the sides has to give so many arguments, so that the other side will be able to agree with indiit. But the reason why negation is been held is to achieve the result that is not possible without negotiation. Actually, the most important element of negotiation technique is negotiation itself and today there are a lot of similar techniques that help to get the essence of some individual activities, also how to get out of the most difficult or conflict situations. A lot of techniques are shown in the work 'Getting to yes' by William Ury, that holds negotiation is different countries, and he teaches people some methods of holding negotiation. One of the most interesting aspects is emotions. They play a great role as they can muddle our mind and lead not to good decision, but to conflict situation. Emotions of the one side can lead to intensity of emotions from the other side. Fear can lead to anger, anger can lead to fear. Emotions can lead to the quick end of negotiation. What should we do to handle these situations? Firstly, emotions have to be analyzed. They must be zoned out, and negotiator has to find out what emotions he feels at the moment and maybe write down them on a sheet of paper. Then he should compare them with things that he must feel: sureness and calm. Participating in negotiation it is important to understand that the other side has its strong point and can make a mistake. His career can be on the edge. The other person has his point of view. At least, he sits on the other side. It is obvious that build – up affects on how we will feel during negotiation, how we will feel our control on situation. If we distinguish all issues, that other side might ask, before negotiation if we understand what acquiescence we can do, then we will shorten risk of unpredictable ending of our conversation. According to Huthwaite, company, that analysis negotiation and prepare people to it, good negotiators use some phrases:

- "I am glad that we have a result …";
- "I am worried, that it might not work …".

There are some reasons that explain the effectivity of these phrases. Firstly, they replace establishment of agreement of disagreement. Secondly, they show your interests in this situation, and it cases more confidence to you. Finally, it is difficult to argue with people's emotions. If somebody says: I am worried, that it might not work» you can't contradict «No, you are not worried». In other words, this expression of feelings helps to save understanding during conversations. It is important to note that this type of behavior is called feelings expression according to Huthwaite. It is the demonstration of understanding and controlling our emotions via showing our thought and feeling. It does not mean expression of feelings via hysteria, crying or aggressive attack on the other side. Very often there is a moment during negotiation, when opponents lose control of their nerves and situation gets hotter. There is a good phrase in William Ury's book: 'The first step is not to control the other person's behavior. It is to control your own'. Instead of being rude to rude, or scream it is really important to concentrate on things, that you need, and what your goals are. There is also great technique called BATNA that can help to make a right decision. It is known that conflict situations should be avoided, since they are ineffective way of solving issues. The last and maybe the most important piece of advice is you have to relax. This method is called 'Go to the balcony'. If somebody is beginning to shout, toughly react on your words, think of the idea: do you need to answer your opponent in the same way? The most important lesson, that negotiation can give you, is not to react, but relax and remember why this conversation started.

All in all, there are a lot of techniques of successful holding negotiation that are the ways of successful agreement. Negotiation can be compared with sport: some people are able to negotiate and easily achieve their goals in negotiations and like for the best athletes they can achieve it with trainings and practice. But other people have to train a lot and make a lot of effort. It does not matter who you are, everyone has to practice and only hard work will pay off. John Kennedy once said: 'Let us never negotiate out of fear. But let us never fear to negotiate'.

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SOCIO – CULTURAL PROBLEM ITEMS OF P. BAZHOV'S TALES: NAMES OF STONES AND METALS

An important element in the study of the tales of Pavel Petrovich Bazhov - the "Ural wizard" according to the figurative definition of L. Kassil — is a linguistic analysis of lexemes belonging to the thematic group of "minerals", including the names of stones and metals that represent the culture and nature of the Urals.

Stones and metals in the works of P.P. Bazhov fulfill not only artistic functions, but also become "the basis of the life and existence of the Ural worker, who since childhood has perceived a stone as a fabricating material, wonderfully transformed in the skillful hands of a person with a delicate taste and rich imagination" [4]. Therefore, the writer depicts stones and metals from both sides: practical as well aesthetic value.

To the minerals that are described by P.P. Bazhov, first of all, refers to malachite - "a bright green mineral stone has black veinlets, and is used for various crafts" [2]. Indeed, the miraculous box that was gifted by the Mistress of the Copper Mountain was made of malachite. Copper is "widely used in the industry" [2], that is why the mountain is named after this metal. At the beginning of the tale "The Mistress of the Copper Mountain", there is an indication of the extraction of various minerals: "Malachite - ore were mined" [1].

The word "orlets" - "the old Russian name of rhodonite", a mineral of "pink color, which is used as an ornamental stone" [2] - is presented in the tale "A Fragile Twig": "For roots and leaves, there was also a certain order: some of the orlets and from some other stone" [1]. In the same tale, agate is being mentioned, "a solid mineral consisting of layers of various colors" [2]. Jasper is a nontransparent ornamental stone of variegated coloration, often having veinlets of red, gray or green" [2].

In the tale "Silver Hoof", chrysolite is mentioned, the name of which in Greek means "golden stone", but in Russian language this word is used to describe "a green color mineral with a golden hue" [2].

Thus, we observe the practical role of stone in the life of fairy tale heroes, considering the fact that stone is a common natural material that is actively mined in the Urals and constitutes an important part of the region's economy.

In the works of P. Bazhov, some widely known metals have been also described. Thus, in the tale "The Dancing Fire Maid" gold is mentioned: "Where such a Jump appears, there is gold. Not strong gold, but breast gold, and not lying in a layer, but like a radish planted"[1]. And the diamond helps the narrator to describe the outfit of the Mistress of the Copper Mountain: "And the dress on her - on the Mistress — is changing. First it glitters, like a glass, then it suddenly sheds, or then it flashes with a diamond scree" [1].

It is interesting to note that the reader may find widely known minerals that are used in the production: copper ("The Mistress of the Copper Mountain"), tin ("A Fragile Twig"), asbestos ("The Silk Hill").

In the tales of Pavel Petrovich Bazhov, many different stones and minerals are mentioned. They are extracted and processed by the mining workers of the Urals. Here, there is another important hero that should not go unspoken about. It is the "master", who is considered to be a professional in any craft, so, in his opinion, one cannot do without an ethical, moral criterion (the tale "The Mountain Craftsman"), especially if ... a model is created, an ideal "[3].

In this respect, difficulties in understanding the phrase "stone power" arise, which P.P. Bazhov used in the tale "Dikes of Gold" to describe the condition of Old Believer prospector Erofei Markov, the discoverer of gold in the Urals. It is stone power that forces him to release the "golden serpent from the earth" [1]. However, it can be said that this "stone power" also belonged to Bazhov himself, forcing him to write more and more stories about the Ural Mountains, the Stone Belt of Russia.

The stone in Bazhov's tales is the main symbol and at the same time the everyday reality of the Urals, which is known to be a stone kingdom compared to the Central Russia. The ideal embodiment of the stone kingdom is the mountains, representing the spiritual center of the world as a symbol of excellence, eternity, purity, eternity, ascent, aspiration and challenge. It is no coincidence that in the overwhelming majority of Bazhov's tales, particularly mountains are depicted as the ideal scene.

As the result of the study of linguistic material, we come to the following conclusions. Images of stone and metals in the works of P.P. Bazhov are presented, first of all, in practical implementation as the backbone material of works of art created by "skilful fingers" and the talent of masters. The stone turns out to be closely related to the problem of aesthetic perception of both works of art and stone jewelry. Analysis of the thematic group "minerals" introduces you to the nature, culture, and labor activities of the Urals.

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CRISIS MANAGEMENT IN COMMUNICATION WITH LOCAL MINING COMPANY STAKEHOLDERS

We talk about crisis management when we are dealing with a crisis that is destroying the organisation and the attempts to repair it so far have failed. This occurs when the short reaction time prevents the use of normal process card procedures. In the event of an emergency, preventive and remedial work should be planned, arranged in an algorithm of extraordinary but nevertheless structured action. They also include communication activities. This speech presents the approach

to crisis management by a mining company in the event of mining damage caused in the process of its exploitation. One of the most important objectives of the presented tool has become to arrange the communication process with local stakeholders reporting such damages.

The paper will present an original scheme of conduct by a mining company in the case of reporting mining damage by a stakeholder. The algorithm was built according to the Servqual methodology, taking into account in parallel, in accordance with the project management triangle, elements of scope, finances, time and quality. The algorithm is fully functional and comprehensive. Not only does it guide you through the next steps, indicating times and personal responsibility for them, but it also includes draft input and output documents. Therefore, in the opinion of the authors, it constitutes an effective guide for the conduct of each notification, describing the course of action and indicating the necessary action to be taken.

The tool presented here may constitute a basic element of a universal system for crisis management in the process of mining damage management.

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FOREIGN ACCENT SYNDROME AS A PROBLEM OF CLINICAL LINGUISTICS

Speech and language are important factors of social and cultural identification. People acquire communicative and speech features of the environment. However, there are unique cases when the native language undergoes tremendous phonetic, morphological, syntactic changes that are inherent in a foreign/non-native language. Some already studied and reviewed cases of patients with the foreign accent syndrome show that people lose their environment, social status, work and even trust. Thereby, they become the subject of discussion, sometimes they may not be understood, and they lose their national identity [3]. All these factors create depression, insecurity, helplessness and other psychological problems that are often not taken seriously.

Foreign accent syndrome (FAS) is an uncommon disease in which individuals develop a sudden change to speech that are perceived as a foreign accent that is distinct from their native accent. The first reported case, a patient with a stroke in the left hemisphere, was published in 1907 by the French neurologist Pierre Marie. The patient whose was a speaker of Parisian French accent, which he had changed into Alsatian French after recovery from anarthria following the stroke. Since then other reports of foreign accent syndrome have been recorded all around the world and included accent changing from Japanese to Korean, from American English to British English, from English to Russian, from French to the Dutch and etc [1;4].

The neurolinguist Harry Whitaker was the first to propose the term “foreign accent syndrome” in 1982, and attributed four characteristics of the FAS: 1) The accent is considered by the patient, by acquaintance and by the investigator, to sound foreign. 2) It is unlike the patient’s native dialect before insult. 3) It can be related to the central nervous system damage. 4) There is no evidence in the patient’s background of being a speaker of a foreign language. In neurolinguistics the main causes of the syndrome are distinguished such as traumatic brain injury, migraines, brain hemorrhage, multiple sclerosis, brain tumor. Symptoms of foreign accent syndrome may vary from patient to patient, but the most common can still be noted: distorted rhythm, troubles of pronouncing some consonant clusters, changes in sound quality by moving

the tongue or jaw differently while speaking, substitution of words/syllables/sounds, usage of inappropriate words to describe something, deletion of syllables/sounds and etc [2].

Verhoeven and Mariën proposed three types of foreign accent syndrome: neurogenic, psychogenic, mixed variant.

Neurogenic FAS is the most frequent syndrome, which is directly connected with the damage to the central nervous system. Lesions locations may affect basal ganglia, frontal lobe, parietal lobe, insular region, temporal region, pons, frontal operculum, cerebellum or corpus callosum.

The accent change is generally linked with a combination of segmental and suprasegmental pronunciation characteristics. At the segmental level, the most common problems are articulation errors pertaining to the degree of articulatory constriction in consonants and vowels with overshoot being more common than undershoot. The suprasegmental level consists of fundamental change of speech rhythm which is described as slow, different, isosyllabic, scanning [5].

Psychogenic FAS is associated with psychological/psychiatric problems such as depression, familial history, suicidal ideation, psychosis, conversion disorder, bipolar disorder or schizophrenia. Influenced by this type of syndrome patients make irregular morphological mistakes occurring in a short sample of spontaneous speech. Besides, here language often shows code switching and language mixing [1].

Mixed variant consists of characteristics of both neurogenic and psychogenic FAS. the cause of this syndrome may primarily be neurogenic and later on be developed in psychogenic. Loss of identity affects patients so profoundly that they further develop the accent in order to create the impression of a more authentic personality. At the linguistic level patients suffer from word-finding difficulties and morphological problems [2;5].

Diagnostics and therapy. Since this condition is difficult and rare, only a team of professionals (speech-language pathologist, neurologist, neuropsychologist, psychologist) can conduct the following case and prescribe the therapy. Firstly, language skills must be assessed, which can be done with reading and writing tests and tests of language comprehension. Besides, spontaneous speech must be recorded to analyze speech patterns and fluency, determine language disorders and serve as evidence of a change in speech. Many patients face difficulties accepting their foreign accent since they do not even realize or hear that their speech has changed. Thus, recordings of their own speech help patients to understand the whole problem of their diagnosis and compare their speech before and after the tram/stroke. In order to determine which part of the brain is affected and interpret the connection between brain's electrical activity and speech, brain images must be taken, using magnetic resonance imaging (MRI), computed tomography (CT), single-photon emission computed tomography (SPECT), positron emission tomography (PET) and electroencephalogram (EEG). Therapy prescription should be based on reliable information, test' results and a case history, including medical history, language acquisition, language exposure, education and work history.

In conclusion, a theoretical review of the scientific literature on the problems of the foreign accent syndrome shows that this problem is at the initial stage of development of science, requires an in-depth study of the causes of occurrence, patterns and subsequent therapy. Linguistic studies of the phenomenon of "foreign accent syndrome" may expand the understanding of speech disorders, clinical phonetics, aspects of psychotherapy, speech therapy and may ease social and psychological adaptation and verbal communication.

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THE PLACE OF MEDIATION IN THE SYSTEM OF ALTERNATIVE DISPUTE AND CONFLICT RESOLUTION

Conflicts are an integral part of any society. The in emergence of conflict situations in any sphere of society proceeds differently and is resolved accordance with the situation. There are many ways out of conflict such as arbitration, reconciliation with the participation of the ombudsman and conciliation commission. The correct technique for getting out of conflict leads to the progress in any area, correcting mistakes and minimizing charges.

A group of scientists suppose that mediation is a relatively new phenomenon in Russian legal reality which in its modern development from the first theoretical development to special legislative regulation has approximately 20 years.[1] After all, the legislative consolidation took place only in the 21th century. For instance, Uniform Mediation Act was accepted in 2001, law

«About alternative dispute resolution procedure with the participation of intermediaries (mediation procedure)» in Russia in 2010 and «Mediationsgesetz» in Germany only in 2012. However, mediation of disputes has deep historical roots. And the first stage of mediation development was the process of conflict resolution in tribes, communities and later in states. At that time, the term «mediation» did`t yet exists in our understanding. This stage was characteristic for Primitive and Antiquity society. The direct development of mediation took place in the second stage. The starting point for it was «The act of mediation» which was the first legal act in the field of mediation in the history. Active development of mediation occurred during the second half of the 20th century in the countries of Anglo-Saxon law and later in continental Europe. Currently, mediation is being developed in such countries as Ukraine, Moldova, Armenia, Azerbaijan, Poland, Romania, Uzbekistan, Lithuania, Estonia and others. Thus, mediation exists in the countries of the former Soviet Union and in the countries of Eastern Europe. Regarding the Russian Federation it would be pointless to deny that the mediation procedure is new and unknown way to resolve conflicts. Only 1,115 court cases out of 15, 81942 were settled through mediation, of which 916 cases were settled through the mediation agreement.[2]

In the modern sense mediation is a special type of activity that involves optimization with the participation of a third party in the process of finding a solution to the conflict that would allow the conflict to end. [3] But we shouldn`t assume that the terms «intercession» and

«mediation» are equivalent. Intercession can recommend and persuade the party to make a decision, the mediator doesn't have the right to do so according to the basic principles. But then the question is: What are the main principles of the mediator`s activity? The law contains such principles as voluntariness, confederacy, equality of the parties, impartiality and independence of the mediator. We should pay attention to the principle of confidentiality because Russian legislative doesn`t clearly state the prohibition of confidentiality but there is a reference rule to law. While this position presents in the United States Uniform Mediation Act and there are certain conditions when the use of confidentiality is unacceptable. The principles of

mediation require their compliance unconditionally, without reasoning and without doubt. This is the moral maxim that extends to all facets and stages of mediation without exception.[4] Having considered the main points of support in the activities of the mediator, namely, the principles, they are the basis on which all activities of the mediator are built. It is worth briefly describing the mediation procedure. It includes three aspects. First of all, it is an out-of-court procedure. It happens when disputants have intention to go to the court but the conflict situation has already occurred. Secondly, it is a pre-judicial order. In cases when they are stipulated by a contact or agreement concluded between the parties to the dispute. Thirdly, in the framework of the judicial process. This method is used when the parties have the right to interrupt the process at any stage of the trial and apply to the mediation procedure. The stages of mediation procedure are: organization of negotiation processes, presentation of the parties' positions; search for the true interests of the parties; development of a joint solution ; reaching a pre-agreement and signing a settlement agreement. However, the process is not typical for every cases which allows us to note that mediation is not limited to any framework.

To sum up, we can conclude that the mediation plays a key role in the conflict resolution process. It helps people with different opinions but the same interests come to a mutual decision at least with someone else`s help. Mediation gives the right to avoid an incorrect decision of the judge and subsequent appeal proceedings. After all, in the process of mediation the mediator is only an assistant and the «judge» is a person to himself. The mediator doesn`t take responsibility for your decision but balances it in the interests of both parties.

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DISTANT EDUCATION: ONLINE-UTOPIA 2020

The transition of all Russian universities to a distant educational format in connection with the spread of the new COVID-19 coronavirus infection has become a real challenge for Russian universities. The discussion of online-education did not leave any teacher or student indifferent. Unfortunately, most academic discussions about online-education are negative [1]. On the one hand, distant education really plays an important role in the current epidemiological situation, as well as in connection with the introduction of a regime of self-isolation, because it makes it possible not to stop the educational process. This provision was noted by UNESCO Director General Audrey Azoulay in her speech: "We are entering uncharted territory and

working with countries to find high-tech, low-tech, or non-technological solutions that ensure continuous education." [2] It is also worth noting that distant education allows university teachers to create and include in the educational process new practical and theoretical tasks that could have a different impact on students, more and more developing their abilities and revealing their talents. On the other hand, online-education is perceived by most representatives of the academic environment as a negative phenomenon, because it excludes the possibility of personal contact between the student and the university teacher, which can be a significant reason for reducing the level of understanding of the material by the student [3]. Also, distant education excludes the possibility of proper control of the student's activities by the university teacher, which is why the student often shirks from studying, shows an unfair attitude to the delivery of cut-off works. Thus, the quality of education is significantly reduced.

Due to the ambivalent attitude of representatives of the academic environment to the distant educational format, it was decided to conduct a survey among students of higher educational institutions, the purpose of which was to identify the personal attitude of students to the new educational format for them. The survey was attended by 120 people, 68% of respondents – young women, 32% – young men. The average age of respondents is 20 years, most of them are students of Saint Petersburg universities. The survey helped to identify the attitude of students of Russian universities to the distant educational format, to identify the level of understanding of educational material in the absence of full-time classes, as well as to determine the moral well-being of students during the general self-isolation and remote educational format. The survey also made it possible to estimate the level of increased manifestation of students ' feelings such as aggression, nervousness, depression and boredom during distant education, as well as to determine the causes of intensification of these feelings.

As a result of the research, the following conclusions were obtained:

1. Distant education is ambivalent, because both university teachers and students do not have a common opinion and a common estimation of this tool of the internal form of knowledge purchasing.

2. The majority of students noted that they experience increased nervousness, boredom, and an increased sense of depression and anxiety due to being in a new for them remote environment. It is also noted that the educational material that is given on distant education for a third of students is unclear and uninteresting, which directly causes annoyance, depression and boredom.

3. Nowadays not all university teachers and students are ready to work remotely, but this does not mean that in the future they will not be able to adapt to this.

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BENEFITS AND DRAW-BACKS OF NATIVE AND FOREIGN EDUCATION. DEVELOPMENT TRENDS

Higher education is considered as a key factor and essential for the future success of people in modern society [1]. Nowadays enterprises search for skilled workforce oriented towards intellectual work and able to embrace high technologies and who will also de-velop these technologies and implement them in industries. That is why training of highly trained professionals for enterprises and development of engineering education are policy chal-lenge and priority growth area for a country development.

In this paper we presented differences between native and foreign education patterns and also global requirements applied to quality of engineering education nowadays.

In order to understand differences between native and foreign education patterns we picked out benefits and draw-backs of each model and also broached the following questions:

1. What is the level of engineering education nowadays?
2. Who is the main requestor of qualified specialists-engineers?
3. What personal qualities and professional strengths should an engineer have to be on-fire?

Answering these questions we picked out several necessary reconstructions of engineering education in several directions: internationalization of science and creation of international departments, enhancement of mobility, language proficiency and also creation of conditions to solve non-routine tasks and teamwork.

Having analyzed native education system we made a conclusion that USSR created one of the best education systems and due to that soviet education pattern rated high not only at home but also abroad.

At the end of the last millennium, European ministers in charge of higher education initial-ized a set of far-reaching reforms that are known as the Bologna Process. Today, 48 countries participate in this endeavor, which has harmonized higher education systems across Europe, to enhance the competitiveness, mobility and employability of their students [2].

Development of modern society resulted in a situation where since 2003 Russia started trans-fer to Bolognese education system. As a result of it Russia reached a new level and continued competition on educational services market.

One of tendencies of engineering development is education by means of real projects. But ac-cording to Klochkov Yuriy Sergeevich «It is not possible to develop a single strategy for all universities; however, having analysed the programs of universities, we can outline major de-velopment directions» [3].

Education through real projects will allow to concentrate student's attention not only on an analysis of some problem but also to research and find solutions that will be an initial position the process of further education. During the research of the problem which exists in industries students will gain knowledge consciously. Also by means of inter- and multi disciplinary ap-proach students will not only gain knowledge independently but will also use and concentrate them during solution of a specific problem.

Also education by means of real projects will promote creation of a whole chain "research – design – technology – production – bringing to a consumer – provision of operation" which a modern graduate should not only use but create it singly.

Engineering education by means of real projects can be considered as an upcoming trend of education because it promotes conduction not only of a problem research, but gives means to solve it. This approach to education will promote development not only of students but also of

industries and also it will sharpen the “gap” between requirements of employers and abilities of graduates, because each enterprise will study and train future workers by means of projects which exist in industries.

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CHINA-RUSSIA ENERGY COOPERATE UNDER THE PERSPECTIVES OF DECLINING EROI, INCREASING ENTROPY AND THE LIMITED TO ECONOMY GROWTH

The human would fall into a double collapse - a socio collapse (due to the sharp gap between the rich and the poor) and the ecological crisis (biosphere and environmental disaster). From the physical perspective, entropy increases are inevitable in nature. Economy Crisis is one performance of the increasing entropy. The global economy faced a downward trend and China's economic development entered a maintaining medium-low growth rate. Unfortunately, global coronavirus is raging since the end in 2019. People’s all walks of life, hit the pause button during the outbreak.

At the micro level, the necessity and feasibility of diversified cooperation between China and Russia are expounded, especially in oil and natural gas cooperation. China has a big consumer of oil and natural gas, and China fossil fuel production is far from meeting the needs of the domestic consumption market. Meanwhile Russia is a big producer of oil and gas. Although the risks and uncertainties in the energy sector between China and Russia, win-win cooperation is still the general trend of energy development of the two countries.

This paper focus on Energy Return on investment (EROI) of oil and gas analysis in China and Russia from macro-national level and micro-company level[1-4]. The results show that the value of national net energy is going down. That is the main reason that both Russian and China economy paced into a mid-low growth recent years. There is a fact to feedback what Meadows said in the book “Limited to growth”. the cost of energy production is ignored or underestimated in the economic process standing on the point of micro economic perspective. Government of both side should strengthen the cooperation especially energy strategy to sufficiently merge the European-Asian Union and One-belt One Road proposal.

On the other side, authors cited Ulanowicz ecological complexity network analysis model into the world macro-economic system, and try to explore the economic efficiency (X) and resilience (Ψ) under the information entropy methodology based on WIOD input-output table from the year 2000 to 2014[5-6]. The result shows that USA has the biggest values of X and Ψ, and China is the second largest country X and Ψ,compared with other countries. Only China is the uptrend of X and Ψ from 2000-2004, other countries are the downtrend. Countries should work together to protest the globally crisis such as the epidemic.

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BUILDING GIS DATA & SUSTAINABLE MASTER PLAN FOR HADDATHA VILLAGE

Places are built and expand as society grows. Nowadays, it is essential to use a sustainable approach to the use of natural resources. It must be created a more sustainable environment to enjoy and live for decades to come and should be applied to urban planning, architecture, and land use. Everything must be considered from water, infrastructure, waste, and transportation to energy, stainable materials from natural resources, to create a place environmentally-friendly and economically viable. To achieve sustainable development in the master plan, the sustainable architecture should locate in the urban planning sequence; this is due to that the construction subsequent use of buildings has great environmental impacts,buildings should be constructed using non-hazardious and use less energy, renewable materials.

To facilitate the development of plans and their amendment at any time, a digital template must be created, archived, and villages and cities built using digital information. Accordingly, the objective of this project is to build Geodatabase and create a sustainable master plan for Haddatha. Haddatha is a village on the border with southern Lebanon, which to this day, suffers from a lack of proper urban planning because of the several wars that led to the destruction of most Lebanese villages. Using GIS software a master plan did create for the reconstruction of public utilities and daily amenities and its modernization. Before did create the urban master plan map, we did create the real state map, parcel size map, parcel specification map, road networks map, residential areas map. After that, according to these maps and the Lebanese laws used in the general directorate of urban planning, we did a zoning analysis and divided it into 10 zones according to the nature of each land. After that, a land classification map and master plan map has been created.

HADDATHA contains some ancient springs and ponds, internal roads still lack infrastructure(not paved and afforestation), there is a small football stadium that needs renovation and redesign, the village has a public garden that considered as reserved area but hasn't received any sufficient attention from decision-maker, it also exposed to a fire that burnt a large number of trees, and Haddatha relies on electric generators because of the partial absence of the general electricity that increases environmental pollution. Using some of the 17 SDGs‘[1]’We were able to create sustainable development solutions to the village with the rely on natural resources, subject to the rational use of natural resources, and conservation on the environment. these solutions took into consideration: high-quality health care, protection of water supplies and quality to get clean water and sanitation, affordable and clean energy, incorporated land-use planning, and management, reinforcement the forestation, promotion of the incorporation of sustainable development in the agricultural context, biodiversity conservation, and environmental-friendly way treatment of waste and wastewater.

We'll talk about how one of the most efficient responses we have to need to reduce the impact of the destruction of our environment and greenhouse effect through building materials and others is to apply sustainable development principles to the building. The sustainable development applied to architecture focuses on the construction and design of environmentally friendly buildings. architectural engineering seeks to improve building management and user health by reducing energy consumption and reducing environmental impact through the application of clean technologies. a building must be ecological which means that the building should rely on natural materials. Using the 3ds max a 3D model of the sustainable master plan

was created to show the future image of this village if we implement the SDG solutions (refurbished garden, small soccer field, pool, landscaping, environmentally friendly buildings).

After completing work on this project, it became possible to obtain digital data for the village through which this data can easily be used to obtain any required information about HADDATHA. The land of HADDATHA have a sustainable master plan, which facilitates and organizes the work of the municipality to carry out any new project and to facilitate the use of lands and data. If we implement these solutions to promote sustainable development in all context, we can start addressing challenges such as poverty, health, education, women's empowerment, growth, inequality, environmental protection, and we can provide ways to work for a better and more equal future for the Lebanese themselves and the future generation.

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URBAN CLIMATE AND REGISTRATION OF THERMAL ANOMALIES OF TERRITORIES USING SATELLITE IMAGERY

This paper describes a methodology for simplified mapping of urban surface temperatures in order to construct a map of thermal anomalies with subsequent long-term and multi-season analysis. The resulting temperature distribution maps can be used to determine the quantitative indicators of microclimate in cities, as well as the impact of various types of land tenure and vegetation cover parameters on the urban heat island (UHI - urban heat island).

To simplify the solution of such problems, methods that allow mapping UHI with adjacent territories in a sufficiently high spatial and temporal resolution are required. To solve problems of this kind, satellite multispectral images are currently being used, the special processing of which allows obtaining sufficiently high-quality maps of the Earth's surface temperature or LST-maps (land surface temperature) suitable for studies at regional scales.

The work describes all the stages of working with thermal images of the Earth in terms of maximizing the acceleration of the process of obtaining a finished temperature map of the city with high quality and maximum stability of the results for any territories and time periods.

As part of the article, the process of obtaining and processing several fragments of satellite images of the same section of the city territory at different times of the year with a difference of 18 years. Then we considered to compare a relative temperature in characteristic areas.

The work considers the fastest and most automated method for processing L1 level images for Landsat 7 (before 2003) and Landsat 8 (after 2003) satellites, including: atmospheric correction using the DOS method, calculation of the emissivity parameter based on surface classification. Image processing was carried out in the QGIS software package using the plug-in extension Semiautomatic Classification Plugin.

The techniques described in this work will be useful for research in the field of urban microclimate and urban planning, as they will greatly facilitate the search for a reliable algorithm for obtaining and processing satellite data to visually represent the thermal structure of the urban area.

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FROM THE INTEGRATION OF MEASURING TECHNIQUES TO THE MODEL IN HBIM TECHNOLOGY – THE STATE-OF-THE-ART APPROACH TO THE DOCUMENTATION OF CULTURAL HERITAGE OBJECTS

The process of collecting spatial data relating to the studied objects can be or even has to be optimized. One of the many ways to enable this is through the integration of different measurement methods. In recent decades, two of them became incredibly popular – these being terrestrial laser scanning as well as photogrammetry. Both techniques are successfully used in a broadly defined inventory of internal and external surface structures providing spatial data with a high level of detail. The mentioned measurement techniques differ from each other due to their advantages and limitations and that is why reducing their defects is crucial. We are also witnessing a very rapid development of broadly defined software and universal data formats that allow to apply various variants of integration. These elements allow, among others non-standard use of BIM (Building Information Modeling) technology - for the needs of inventorying of an existing historical object. In geodetic environments, both on the integration of the mentioned measurement methods as well as BIM and HBIM (Heritage Building Information Modeling) technologies, many interesting publications were created, based on specific examples. One of them concerns the automation of algorithms used in the integration process of the mentioned measurement techniques [1]. Another publication presents the achievements of a research project using HBIM technology in the field of archaeological research - on the example of the Antasa Temple colonnade [2]. As you can see, this topic is still being developed and improved, and the list of places where it is possible to apply these technologies is still open.

There is no doubt that the best approach to use BIM technology is to do it already at the conceptual stage of a construction investment. This approach undoubtedly saves time and costs incurred during the investment, while minimizing the possibility of human errors. However, its suitability for reproducing existing objects in 3D space should not be excluded. When we turn our attention to the historic objects, very often destroyed but significant for the culture and art, it is easy to find a very important application of new technologies in their documentation, visualization, rebuilding or even reconstruction. These activities are possible by using HBIM (Heritage Building Information Model) technology which is a standard method for historic sites, allowing not only storage of spatial information and metadata but also enables documentation of changes of the objects over time. The technology could be considered as a process, a database, software or even 3D model but in fact, it integrates all of these functions.

The effects of inventory provide the necessary technical documentation, views, cross sections along with quantitative and surface information and many others. On their basis, it is much easier to create, among others a reliable estimate of the planned renovation or reconstruction of the facility. In addition, the investor has almost unlimited possibilities of presenting such an object in 3D - visualizations, virtual walks, interactive animations [3], which positively affects the promotion of a given object. It is also a chance to interest the modern recipient, not only the virtual tour of the object, but also the importance of its protection.

This work is focused on implementing the integration of data acquired from terrestrial laser scanning and photogrammetry. It presents the applying of HBIM technology on the example of Palace Park Complex named after Ignacy Jan Paderewski in Kąśna Dolna (Poland). The effectiveness of HBIM technology in accurate spatial documentation of small objects of cultural heritage was evaluated in the paper. The question of the usefulness of mentioned methods has been also raised in the context of using them in the creation of 3D models of objects with different level of detail.

The conducted research proved that the integration of laser scanning and photogrammetry enables a comprehensive inventory of the external structures of objects, however, before measuring, it is necessary to determine the purpose of the final model, i.e. to determine the level of inventory detail. It is worth emphasizing that the right choice of measuring techniques and tools is crucial to achieve the objectives. In addition, it has been found that HBIM technology is successfully used for existing historical objects. An added value is also the fact that 3D models of cultural heritage objects, available e.g. on websites, allow to reach a wide audience. Promoting the historical object and important issues related to its protection is much easier, moreover, it can be successfully used for teaching purposes.

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THE REVERSE ENGINEERING AUTOMATION FOR THE OBJECTS OF THE URBAN DEVELOPMENT, BASED ON THE RESULTS OF AERIAL PHOTOGRAPHY

Currently, Russia is implementing the national program «Digital Economy of the Russian Federation», in which much attention is paid to the development of geographic information technologies and the use of spatial data. The Smart City section, included in this program, is aimed at creating an effective urban management system, creating safe and comfortable living conditions for people. The development of this section involves the use of spatial data to build digital models of buildings and structures, as well as for further operational management of urban areas [1]. Spatial data are the digital data of spatial objects, which including information about their shape, location and properties also presented by coordinates [2]. For the digital economy, spatial data are needed in the form of three-dimensional coordinates X, Y, Z, as well as information on the reliability and accuracy of their determination.

The digital three-dimensional model is a system of a number of elements: a three-dimensional model of the earth’s surface, land objects (real estate objects) and subsoil

(geological models) and etc. [3]. Spatial models are the basis of geographic information design. A three-dimensional model can be created either manually (using CAD or GIS technologies) or automatically. In many cases the initial data for building three-dimensional models are the data of geodetic and photogrammetric definitions.

Building a three-dimensional model from scratch is time consuming. For such cases, the software offers the best option: creating a mathematical three-dimensional model or surface (or set of surfaces) based on information obtained from a physical object. Currently, the term «reverse engineering» refers to the process of designing a digital model which describes an object and its technological properties by performing a comprehensive analysis of its structure. This process is aimed at creating a virtual three-dimensional model based on an existing physical object for its study, duplication or improvement [4].

Currently, the creation of a three-dimensional stereo model is carried out using the PHOTOMOD software product by using the «reverse engineering» method based on the results of aerial photography. Three-dimensional models are automatically created in special software products: Metashape and ContextCapture. The principle of operation of these programs is based on restoring the geometric shape of objects and building textures of building facades from their aerial photographs. The technological process of building a three-dimensional model involves the identification of characteristic points in the zone of mutual overlap of images, the formation of a point cloud which describes the earth's surface and objects towering above it. In the next step, the point cloud is triangulated to get the surface. In the resulting surface, a search is made for the planes that best express the walls and roofs of buildings. The final product is a three-dimensional terrain model, presented with varying degrees of detail.

The purpose of work is to confirm or refute the assumption that it is possible to use a three-dimensional model created automatically from aerial photographs in the case of the reverse engineering method. To achieve the goal, the following tasks were set and solved:

- the automatic process of creating a three-dimensional model from aerial photographs in the Metashape and ContextCapture programs was studied using a specific object was studied and a visual comparison of the results was performed;
- a comparison of the coordinates (X, Y and Z) of the characteristic points of the three-dimensional model which is obtained automatically, and with the 3D stereo model built in PHOTOMOD;
- based on statistical methods, conclusions are drawn about the accuracy of three-dimensional models created in the automatic mode with the requirements of Russian legislation in the field of spatial data.

This study was carried out in the following places: industrial enterprise; object of cultural heritage of regional significance «Outhouse from the Plotnikov's Manor».

A three-dimensional model created automatically based on the materials of planned aerial photography. In the case of the reverse engineering method, this model isn't suitable for performing measurements. If you combine planned aerial photography with an inclined one, then in this case, using the three-dimensional model, you can get fairly accurate values of X, Y and Z. This proves that the method of aerial photography directly affects the quality of a three-dimensional model. To create an accurate, geometrically correct three-dimensional model with high detail, it is necessary to additionally conduct inclined aerial photography, laser scanning, and ground-based photogrammetric photography. However, all these actions will lead to increasing the cost of aerial photography.

Currently, the process of creating a three-dimensional stereo model is more economical, affordable and familiar to the user than building a three-dimensional model. With the automatic creation of a three-dimensional model, it is currently quite difficult to achieve results close to a three-dimensional stereo model. The automatic construction of three-dimensional models requires further study, development and improvement through various experiments. For the widespread dissemination of the three-dimensional models, it's necessary to begin the development of a regulatory framework and provide enterprises with special software.

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TACTICAL URBANISM AS AN INSTRUMENT OF FLEXIBLE PLANNING UNDER CRISIS

In 2020, the world community faced the challenges of the economic crisis caused by COVID-19 pandemic. The epidemic-induced changes in citizens' everyday lives and the emergence of new rules for the use of public goods required rapid structural changes in open urban spaces, which in the context of the economic crisis also imply the budgetary nature of the decisions applied. However, standard methods for transforming the urban environment do not imply operational and especially budgetary changes, which necessitates the search for new methods that can adjust urban spaces to rapidly changing conditions quickly and inexpensively.

The modern city is a system of multi-layer and constantly changing requests, to which it has to respond promptly. At this stage of development, the city cannot just maintain the stability and integrity of the system. To meet the needs of citizens, a process of continuous data collection and adjustment of urban processes based on their analysis is set up. This leads to the fact that the modern city is becoming more interactive.

According to the international standard ISO 13407: 1999 "Human-centered design processes for interactive systems", the process of creating any product that interacts with a person consists of the following mandatory steps: planning the design process, determining the context of use, determining requirements, developing design solutions, evaluating and introducing product into operation [1]. Moreover, in the case of unsatisfactory results at the stage of evaluation, the process is repeated, starting from the stage at which the problem potentially arose. Thus, after the required number of iterations, a product that satisfies all the needs of users appears. In the process of designing urban spaces, it is the evaluation stage that causes the greatest difficulties. Even expert assessment is quite subjective, and the practice of prototyping and testing solutions on real users is not common. One of the solutions to this problem is the use of tactical urbanism as a tool to verify the decisions made in the design process.

Tactical urbanism is a set of tools for short-term scalable interventions that provoke long-term changes [2]. This approach pays particular attention to delineating and maintaining processes and user scenarios within the space, pushing the aesthetic component into the background. In the USA, where this movement appeared, tactical urbanism is a bottom-up activity tool that has earned its popularity among local communities as a budget way to adjust urban spaces independently. At the same time for the cities of Belarus and the post-Soviet context in general, where urban activism practices are just emerging and relations between activists and city administrations are still not strong enough, tactical urbanism has great potential as an advantageous low-cost way to test future large infrastructure projects initiated by city administration. It can be confirmed by such an example as the tactical project of reconfiguration

of the station square in the city of Saratov (Russia). Although experts from the field of urban consulting developed the project, still a lot of criticism from users was received after 4 months of the test mode and the project was revised, which did not allow the initial injection of large capital into a defective and erroneous project. Another example is the the Victory Square project in Vinnitsa (Ukraine). Insights collected during the 5-hour temporary implementation were included in the adjustment of the capital reconstruction project. Local grassroots projects in the post-Soviet context arise most often during the collaboration of local activists with business. In that case, tactical urbanism projects are implemented in private territories as a compromise between the monetary interests of entrepreneurs and the social interests of local communities. For example, within the framework of Street Food project in Molodechno (Belarus), activists created an inclusive public space on the territory of the private market using the tools of tactical urbanism.

During the COVID-19 pandemic, tactical urbanism tools got a new purpose. The new rules for the use of public spaces like social distancing and the increasing role of the bicycle in the structure of urban mobility because of the limitation of public passenger transport volumes have forced many cities to use tactical urbanism tools for quick and budget reprogramming of urban open areas. Those changes are mostly implemented as pedestrian and bicycle zones expanding, as well as a new zoning of public spaces. At this stage, the key characteristic for tactical urbanism is its ability to adjust the urban environment to a temporary deviation from the norm quickly and without using invasive tools to make retrieval of its original state possible, which makes the city's spaces more flexible and resilient. Zoning the park by marking on recreational areas, which allows you to maintain the proper distance between vacationers, as in the case of Domino Park in New York (USA), makes it possible to maintain park activity as a recreation zone, which at the same time meets the new needs of citizens in social distance. Or the following example, how the expansion and rapid improvement of pedestrian and bicycle spaces in London, Milan, Berlin, Vancouver and many other cities in the world allows us to maintain the transit and recreational functions of city streets, while satisfying the increased demand for physically active modes of transportation (walking, cycling, scooter) due to prolonged isolation and limited mobility.

Despite the fact that the tactical decisions during the pandemic were implemented as temporary ones, many city administrations decided to keep some of them for good. They are already developing programs for the overhaul of street profiles in favor of pedestrians and cyclists. This reveals the new role of tactical urbanism in urban planning as a 'research through experiment and observation' tool, which allows us to test not only verified and thought-out decisions based on existing requests, but also to experiment with the environment, in search of new unobvious solutions.

Thus, one can note low cost, non-invasiveness, efficiency as those properties of tactical urbanism tools that make it possible to search for new solutions for urban spaces and test verified solutions on real users even during the economic crisis. These tools give designers and the city administration the right to erroneous design decisions and make the urban planning process more flexible and adaptable to emergency crises.

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DYNAMIC ANALYSIS AND MONITORING OF THE PEDESTRIAN BRIDGE MODEL

During these last years there is a growing tendency to build light footbridges. Due to decreasing mass, slenderness of given objects and the increase of dynamic forces we should give special attention to dynamic phenomena of given objects. Increase in problems of modern footbridges associated with vibration caused by dynamic forces means that footbridges should no longer only be designed due to static impacts. Bridge designs characterized by: low slenderness, light weight such as ribbon bridges and suspension bridges may not meet the conditions set out in the design standards [1] [2], not only regarding to natural frequencies, but also regarding to damping properties and dynamic response related to pedestrians traffic. Modern design tools should take into account all negative factors that may affect the adverse dynamic effects of bridge structures. Structures characterized by negative parameters regarding to the possibility of resonance phenomena can be designed and made if appropriate calculations have been made taking into account external influencing factors and appropriate comfort requirements. If dynamic interactions do not meet individual design criteria, then appropriate design changes should be applied and system consisting of damping devices should be designed [3].

The project concerns dynamic analysis of a laboratory model of a pedestrian bridge. The subject of the analysis is a single-span beam, subjected to dynamic effects from the operation of the object. To the constructed laboratory model of the footbridge, a mass vibration damper was additionally designed and made. Parallel to the physical model of the composite footbridge, the "quadqa" software was created, which aims to provide a simple and extensible system for monitoring the structure. The software is designed to allow monitoring of construction objects using simple electronic sensors and the popular Raspberry Pi minicomputer. While making the laboratory model, we used the help of the calculation algorithm written in Matlab and the detailed numerical model created in ANSYS.

Vibration reduction with mass vibration dampers can only take place if they are correctly designed and placed in the most optimal place of the structure. It is important to first determine the form and frequency of natural vibrations to know to what frequency dampers are tuned and in which place damper achieves the highest efficiency. In the next stage, the maximum displacement of characteristic points depending on the frequency is checked to determine how much they affect the use of the structure. Then, when maneuvering during subsequent analyzes, the places of attaching the dampers to the structure and their parameters should find the optimal combination of dampers. In the case of a small difference between successive frequencies of natural vibrations, the mutual influence of the dampers on each other should be considered. The basis for this statement is a detailed analysis of dynamic response graphs of the structure.

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VISUALIZATION OF DATA OBTAINED FROM UAV IN A FIRST-PERSON PERSPECTIVE IN UNITY GAME ENGINE

This work is concerned with the current issue of visualization of spatial data collected from UAVs (Unmanned Aerial Vehicles) by surveyors as well as representatives of many other areas. The proposed method of presentation of collected research data is not only low-cost at preparation but is also distinguished by its simplicity of implementation. This issue is particularly important nowadays as many spheres of our life have been moved to the virtual reality and that is why representatives of areas such as industry, science, culture and art need to deal with the representation of the real world in a 3D reality. Accordingly, the transition of some elements of the real world to the 3D reality is becoming increasingly popular. A very good example of such activity is an initiative of Dr. Chris Fisher and Dr. Steve Leisz [2]. They suggested to carry out detailed 3D measurements of all the lands of the planet Earth in order to demonstrate to the future generations the current state that some of these areas are in. A modern recipients use Virtual Reality more and more often in order to learn about new areas they are interested in. Museums, popular tourist attractions, new technological developments – all of these can be accessed unlimitedly by a man in a 3D cyberworld [3]. This work answers questions concerned with the methods of presentation of archaeological sites and places in VR (Virtual Reality), as well as the ways of sharing it online. Another issue this paper deals with is an integration of data from the two most popular photogrametric measurement methods which are currently being used in many areas of research– speaking of digital photogrammetry and laser scanning [1]. Taking this issue into account is relevant in a context of suitability of these methods in 3D visualization made in one integrated environment.

The functionality of the proposed method will be presented by using an example of the Agora area located in the Archaeological Park of Kato Paphos in Cyprus. The mentioned area was created in order to protect and promote the archaeological sites as well as the artefacts from the former epoch which have been found in the area. Such historic places are very often not fully available to see by visitors and that is why the documentation and visualization of them in 3D reality might be incredibly helpful. This kind of activity not only contributes to the popularization of archaeological research but also meets the expectations of a modern recipient who uses virtual reality more and more often in order to learn about new places.

From a technical point of view, the presented work guides a recipient through the complete process of development of an advanced animation in the environment used in the creation of 3D computer games – the game engine Unity. In the first part of the article the suitability of the data results obtained in digital photogrammetry as well as laser scanning was estimated for purposes of applying the presented method. The work also brings up the issues of limitation of free software and raises a question of methods allowing to meet the requirements with minimized loss of quality and accuracy of the data.

The next step was to present the method of importing data (a mesh model and a high-resolution texture). Operating mechanism in Unity as well as a transfer of interactive visualization into the online browser Unity Connect were discussed in the further part of the article. It is worth mentioning that thanks to the FPP (First Person Perspective) technique the developed visualization allows a user to be transferred right into the centre of the archaeological sites where the admission for the third party is usually significantly restricted.

Presented research on the example of archaeological data could be successfully used, for example, in open-pit mines. More and more often UAVs raids are made over them in order to calculate the volume of excavated material. Without additional money and time spent on the field measurements, the suggested visualization could be helpful for checking work progress from the first person perspective. The whole can be finalized with a creation of an game (for

example arcade racing or riding on a motorcycle) on a professional level, however this would require an additional involvement of IT specialists. Apart from that, a visualization like this could be done also in a VR technology, which is becoming popular nowadays. Continuing on a path of visualization made by people not advanced in an IT area, there is a wide range of ways to expand it with subsequent interactive elements. Such an approach to the issue of online visualizations is a great opportunity to popularize research in almost every field among the community tended to a virtual perception of reality in 3D.

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THE INTERCONNECTION OF VKHUTEMAS AND BAUHAUS URBAN PLANNING SCHOOLS. THE INFLUENCE ON MODERN ARCHITECTURE

The beginning of the twentieth century is definitely a complicated period in architecture. Urbanization, industrialization, popularity increase, social system’s change and the ideas of the new just appeared flow of rationalism brought some significant changes into the modern city and its structure. The biggest development of architecture at that time was provided by two schools of Soviet VKhUTEMAS and German Bauhaus.

The main goal for both schools was to design living areas that would match with social needs, technological development and aesthetics of the new times. The idea to replace luxury with the accessibility of housing became especially popular in the twenties and thirties. The social aspect starts being number one priority in the architecture and city planning. And all of these factors contribute to the emergence of a new settlement type - a socialist city. Urban planner-theoretic Milyutin N.A. has written a book “Socialist city. The problem of building socialist cities. The main issues of rational planning and the construction of settlements of the USSR" describing this phenomenon and giving its certain characteristics.

One of the most outstanding architects-city planners of VKhUTEMAS who worked hard on designing non-existent earlier socialist cities, in my opinion, was Nikolai A. Ladovsky. He aspired not only to create a new type of the settlement but totally change the design approach. Ladovsky advocated work from the general to the specific – from a city to a building. Being a Soviet rationalism leader, he worked on city plans, which could get more complicated with time but still save the connection between the functional zones. Ladovsky considered the city with all components as a unified living organism. Besides that, he paid much attention to the perception of the city while moving down its main streets. Ladovsky’s mostly recognized urbanist projects are the industrial settlement Kostino (1927-1929) and Moscow redevelopment. None of them is realized but both perfectly show the impact of rationalistic ideas on the socialist cities’ structure.

One of the Bauhaus adherents - Hannes Meyer was ideologically close to the theories of Soviet architects-urban planners. After leaving the Bauhaus director post, he has also proposed a Moscow redevelopment project. Moreover, he has taken part in designing the Soviet cities of Magnitogorsk and Birobidzhan. Along with him Bauhaus teacher Ludwig Karl Hilberseimer influenced the urbanist theories with his research works and projects as well. His best-known project of High Rise City (1924) with time outgrown into the Decentralized City (1944), which almost cleared the border between the city and the country. In my view, they both can be called Socialist cities. And the Decentralized City project notably has a connection with the concepts of Ladovsky.

The relevance of the ideas developed by the VKhUTEMAS and Bauhaus members is obvious. The architectural and urban planning theories of metabolists can be mentioned in support of this. A post-war Japanese architectural movement continues speaking about a city as a unified living system, all components of which are connected. Kenzō Tange's reconstruction project for Skopje and unexecuted project «Tokyo-1960» are demonstrative examples of the unique metabolists' approach that has much in common with the Soviet and German schools' developments. Even today's cities with comfortable environment are following the ideas of that time as I think. The research in the area of the human's psychophysiological perception regularity of architectural forms, space and color has become even more popular than it was among the rationalists. Thus, the importance of the VKhUTEMAS and Bauhaus representatives' works is hardly deniable.

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APPLICATION OF FREE OF CHARGE GEOSPATIAL DATA FOR MONITORING OF LOOTING AT ARCHEOLOGICAL SITES

The problem of illegal archaeological looting, unfortunately is an increasingly common theme. It can be caused by the unstable political situation, as observed at the Apamea archaeological site in Syria [1]. Studies confirm that the war, which has been ongoing since 2011, contributes to the creation of new looting pits. Due to an unusual situation, archaeological sites, are not adequately protected, resulting in increased looting of archaeological artifacts located in their surroundings. This is a global problem, because monitoring archaeologically significant sites requires additional costs that most countries cannot afford. Being advised on existence as well as on the number of such looting pits and the time they were made is essential to the explorers, because archeological examination requiring major financial input. The area devastated too much, obviously lessens prospects of successful exploration, which in result may affect the decision whether to act in that very region.

This information would certainly facilitate the combat of looting and make the work of archeologists much more comfortable. The carried-out research aimed at determining whether application of free of charge geospatial data enables spotting of looting pits to monitor looting at archeological sites.

The area of research is the ancient city of Tuwaneh, located in Jordan. The participants of the XVII BARI "Buildings Archeology Inventory" Expedition taking place at the end of 2018, organized by AGH University of Science and Technology, in cooperation with archeologists of the Jagiellonian University, made an inventory of this archaeological site, during which numerous looting pits were discovered. For about 120 of them separate documentation was made, composed of their photographs and the coordinates of points located on their perimeters, which is referential data for studies made. During the measurements the Spectra Precision SP60 receiver in the RTX (Real Time eXtended) GNSS mode and with Geomax Zenith 25Pro in the RTK (Real Time Kinematic) GNSS mode were used. The analyzed area is about 7 ha. Further measurements were carried out in 2019, this time of selected newly created looting pits, amount of which unfortunately increased significantly. The same documentation as before has been prepared, covering over 60 looting pits.

Satellite imagery has the greatest potential to achieve the research objectives. They are gaining popularity and their possibilities are still being explored. Until recently, it was accessible to a narrow group of recipients and obtaining them was tantamount to incurring large charges. Nowadays, there are services which make them accessible absolutely free of chargé to any interested person. Examples are images from the Sentinel-2A and Sentinel-2B satellites, made available free of charge within the European Copernicus program. The satellites, launched by the European Space Agency in 2015 and 2017, provide multispectral imagery used for, among others, monitoring of seas and lands. In this research it was decided to examine the possibilities of their use in archaeological issues, specifically in the detection of looting pits. After checking the free satellite images available, it was found that those coming from Sentinel-2A and 2B had the best spatial resolution of 10 m maximum. So far, according to the knowledge gained, the potential of these images to detect damage at archaeological sites has been presented in only one article by Casana and Lauger [2]. Due to the small number of studies carried out, their possibilities were verified. Images that covered the area of the ancient city of Tuwaneh at the time of field measurements were obtained, both in 2018 and 2019.

The acquisition of images with a resolution higher than 10 m is possible at an appropriate fee, as they come mainly from commercial satellites. This research is aimed at obtaining data free of charge, so the focus is on a popular program providing good quality satellite images, which most of us had the opportunity to use. Google Earth is a 3D model of the globe, representing the whole world. For most places the spatial resolution is very high. Moreover, the use of desktop software gives access to archival photos. Unfortunately, their quantity for a particular region and quality is independent of us. Contreras claims that Google Earth made it possible to identify the looted area located in the Viru Valley in Peru [3]. In this case, the focus was on identifying each of the looting pits.

The research was carried out in a manual way comparing the location of looting pits from the measurements with the place of their occurrence in the picture. It was checked whether there are any new looting pits in the 2019 data. Imagery from the Sentinel-2 were found to be insufficient to detect them or to determine the devastated area. There were also no changes indicating looting activities between 2018 and 2019, which certainly took place. Google Earth, on the other hand, made it possible to detect most of the looting pits. In relation to the others, conclusions have been drawn as to why they may not be visible. The main factor was the topography or irregular shape of the trench. Certainly, images with even greater spatial resolution would eliminate some of the errors that have occurred, so if they are available free of charge in the future, they have a chance of great interest from archaeologists.

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ASSESSMENT OF ENVIRINMENTAL AND ANTHROPOGENIC RISKS FOR THE SUSTAINABLE DEVELOPMENT HERITAGE CITY

This work is dedicated to model formation and assessment of hydrological processes, which make developing risks of adverse situations, which can threaten by historic part of Nizhny Novgorod. Nizhny Novgorod was made on the right bank of Oka river, overtop more than 150 m. This place characterizes like unsustainable for landslides, ravin erosion and erosion of shoreline. The lower part of city characterizes like unsustainable for karsts and suffusion erosion, flooding risks for the reason of breakthrough of the Gorky hydroelectric dam. Increasing of the city area was made by connection of fabric settlements in 19 and 20 centuries, thereafter it made the modern structure of Nizhny Novgorod. This topic is relevant currently for reasons of regular erosion processes in a historic city. This problem has quite wide degree of study and international experience shows that erosion control measures have been developed for a long time. Also, unsustainable landscapes accumulate harmful substances in a soil and groundwaters. Their deposits observed near highways and fabrics. Accordingly, recorded a large number of heavy metals concentrations and oil lenses. Air pollution corrodes metal structures. The main idea of this abstract is the assessment of risks for all types of foresaid erosions, for the cultural heritage preservation.

Assessment of risks for sustainable development historic city, including the risk of adverse environmental and anthropogenic factors, risk of lack of protection against adverse events. This kind of risks describe using probabilities of occurrence of relevant events:

$$Risk = P_1 * (1-P_2) * P_3,$$

where: P_1 – is the probability of an unfavorable natural, natural-anthropogenic or anthropogenic factor; P_2 – is the probability of operation of the protection system from an adverse factor; P_3 – is the probability of damage to the object of natural or cultural heritage during an adverse event in the absence of protection. (When $P_1 = 1$, $P_2 = 1$).

The valuation of cultural heritage sites is based on the cadastral value. The calculations will be based on a 500-year risk assessment for cultural heritage sites. If there are reasons, then for each object it is possible to determine its own period of existence, based on its physical and technical features.

The approach of the research includes air pollution risks to heritage, soil pollution risks to environment, flooding risks, karst, slides and banks erosion [1, 2].

The risk of vulnerability of a residential area to destruction as a result of a karst failure in Avtozavodsky District which has a lot of heritage from industrialization time is 0.35 (P_3). The

calculation of vulnerability risk is based on building density in the area of cultural heritage sites and on a typical diameter of 10-meter karst failures [3].

An assessment of the risks for sustainable development of the city associated with karst-erosion measures showed that the probability of damage to an object = 1%; the frequency of occurrence of karst per year = 0,000003; the risks of occurrence of karst over 500 years = 0,0015; the risks of occurrence of karst per year = 0,0003%; the risks of karst occurring over 500 years = 0,15%. The potential damage, taking into account the risk of a one percent loss, is risk = 0,0015 * 0,4 = 0,006 and the total cadastral value of cultural heritage objects 256,468,405,501 rubles is 154 million rubles.

Flooding risks associated with accidents at hydraulic structures are based on the probability of a breakthrough of the Gorky Hydroelectric Power Station. The greatest threat to Nizhny Novgorod is the combined risk of a dam breaking and spring melting when landslides and erosion are activated [4].

Lack of storm sewer systems and landscape features of the upper part of the city create the risk of landslide and ravine erosion. As measures to protect against landslides, retaining walls are used, retaining soil layers, a system of tunnels for water drainage, stabilization of slopes with the help of vegetation. As for the ravines, the most common option is stabilization with vegetation using.

Oil lenses are formed as a result of the discharge of oil-containing products by city-forming factories of the last century. They are located mainly in the Sormovsky, Kanavinsky and Avtozavodsky districts of the lower part of Nizhny Novgorod. The mass emission of oil-containing products per year by 1992 was 27 thousand tons per year [5].

The concept of risk assessment for cultural heritage sites from natural and anthropogenic factors, taking into account the long life of cultural heritage sites, was proposed in this abstract. The concept is applied to assessing the risk of damage to cultural heritage sites during karst failures and floods as a result of the destruction of a large hydraulic structure – the dam of the Gorky Hydroelectric Power Station. The results of the calculation of potential damage allow us to found the cost of risk minimization measures. The proposed concept makes it possible to found events for protection historical and cultural heritage as the main tool to preserve cultural heritage sites and ensure the sustainable development of historical cities.

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ARCHITECTURAL ORGANIZATION OF BUILDINGS AND STRUCTURES MODERN SCIENTIFIC AND EDUCATIONAL CENTERS

To date, the processes of formation of modern scientific and educational centers have been studied extremely poorly. This is due to the fact that the typology of buildings of scientific and educational centers represents a new direction in the development of architectural and spatial solutions for public facilities. The main problem is that most of the existing scientific and educational centers and objects of similar purpose are at a stage of significant moral and physical deterioration. Current trends in the formation of buildings and structures of modern scientific and educational centers show that to determine the prevailing approaches to the formation of architectural and spatial solutions, it is necessary to consider the spatial and spatial organization of the main functional blocks, the compositional and artistic design of the exterior and interior of the object, as well as the formation of a scientific and educational Center at the level of architectural and urban organization.

Architecture combines art and science in an organized environment designed to create favorable conditions for the existence of man, as well as to reveal his creative potential.

Determining the position in the structure of the city plays a fundamental role in the formation of a modern scientific and educational center. It is preferable to locate the REC in the central part of the city. However, the modern urban planning environment of each city has individual characteristic features that do not always allow you to locate an object, bulky in size, in the center of the city. In this case, the necessary site is selected at some distance from the city center, but with the mandatory availability of high-quality transport accessibility. Also, the urban planning position will affect the architectural style of the scientific and educational center and the overall height of buildings and structures. Thus, an expressive architectural ensemble is formed, highlighting the projected object on the general silhouette of the city.

The organization of the master plan is an extremely important stage of the architectural and spatial organization of any architectural object and is being developed in parallel with the creation of the architectural form, since these two processes are closely interconnected. A competent distribution of the necessary functional zones is required, taking into account the identification of the interconnections of the main units [1]. High-quality development requires the improvement of the territory and the general stylistic coordination of the elements of the general plan with the architectural form of buildings and structures of the scientific and educational center.

Creating an architectural form is the main property of an architectural object that allows the viewer to understand and feel the scale of a particular idea. The form of a scientific and educational center is influenced by such factors as the associativity of the selected composition, functionality and constructive solution of the object. Any architectural form has a different effect on a person, on his feelings, on his perception. The world around us shows that the correct geometric shapes do not occur in nature, they are inherent only in the results of human activity. The most comfortable thing is to be in an architectural environment represented by bionic forms. However, in order to maximize the scientific orientation of the object under consideration, one should strictly adhere to the canons of geometric shaping, taking into account the competent selection of proportions. Also at the level of creating an architectural form, one should take into account such a property of architectural objects as chiaroscuro, which enhances the visual perception of the architectural form [2,3].

The formation of the architectural solution of the modern scientific and educational center directly depends on the internal space and urban conditions. In addition, this process must

be carried out in accordance with such modern trends as open educational spaces, an innovative environment, as well as transformable spaces.

The formation of a constructive solution has its own requirements and characteristic features for the design of buildings and structures and directly depends on the architectural form of the object. Since, modern trends in the design of scientific and educational centers are aimed at creating open transformative spaces, it is necessary to select the most suitable constructive solution. Rational will be the use of a post-beam system with the use of long-span structures. The presented constructive solution has a large number of advantages in organizing the internal space and shaping the architectural appearance of buildings and structures in general.

Composition and decoration is an important component of the architectural form, which includes the selection of colors, the use of a specific set of materials. The creation of the architectural environment of scientific and educational centers, which has overall integrity and completeness, requires an integrated approach to determining the goals of the use of color and materials. Color acts as a kind of reference point in space for a person, helps to reveal the functional and semantic significance of space [4]. With the help of color, you can modify the shape and even visually resize the structures. Materials in architecture have individual characteristic features, not only look different, but also impose different requirements, can contribute or, conversely, contradict the task. Modern trends in architecture are aimed at ensuring maximum expressiveness of the architectural environment with minimal impact on the environment. Thus, in the formation of a scientific and educational center, a calm color scheme using natural materials should be used. It is allowed to use bright accents to highlight any functional areas, input groups, etc.

Studies have shown that the main problem of the formation of scientific and educational centers is based on the degree of moral and physical wear and tear of existing objects of the type under study, which requires the creation of new ultramodern scientific and educational spaces.

Scientific understanding of the current problem made it possible to determine the main directions for the development of further design and research solutions in the field of the formation of modern scientific and educational centers, taking into account current trends.

The study identified conceptual approaches to the formation of architectural and spatial solutions of buildings and structures of scientific and educational centers, the basis of which is functional, urban planning and compositional and artistic conditions.

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THE OPTIMIZATION OF COLLECTING AND PROCESSING KITE AERIAL PHOTOGRAPHY IMAGERY WITH MODERN PHOTOGRAMMETRY TECHNIQUES IN ORDER TO DOCUMENT ARCHAEOLOGICAL SITE

This paper aims to present a technology which uses a kite as a carrier of a non-metric digital camera for close-range photogrammetry tasks. This inexpensive solution rivals the classical aerial photogrammetry tasks. The Kite Aerial Photography (KAP) technology is currently being used in archaeology, forestry and geomorphology. It is also useful in obtaining information about real estate as well as in monitoring tidal zones [3] or in the study of wetlands [1]. The application of KAP in archaeology is a topic often discussed in literature. The use of KAP in combination with other technologies, such as GPS RTK measurements, geophysical surveys and various types of GIS analysis, allow to obtain precise information on the distribution of artefacts at archaeological sites. These integrated measurement techniques significantly exceed the traditional methods, not only in terms of accuracy, but also in terms of time spent on collecting the necessary data [2]. In the research carried out at one of the sites in the ancient city of Petra, the accuracy of the final photogrammetric products has been obtained at the level of single centimeters [4]. The application of this technology is also an alternative source of data acquisition in areas where the use of drones is prohibited. An example of such zone is the Jordanian archaeological site Tuwaneh, in the region of At-Tafilah where the field data for research purposes was collected in 2019.

The aim of our work was not only to assess the accuracy of this measurement technology, but in particular to develop an optimal method of collecting and processing images leading to the most accurate results of image block alignment. Within 3 days of surveys, data was obtained by using a kite and a camera GoPro HERO 6 attached to it. The camera was fitted with a fish-eye lens and a GNSS receiver which registered an approximate coordinates of image projection centres. The presented setup for a kite aerial photography system is characterised by lightness, ease of transportation as well as low cost. In the process of optimizing the alignment of the block of images, different variants have been used. Authors have prepared 32 data sets which differ in the quantity of taken photos, Ground Control Points (GCP) as well as the size of the adopted area. The final results of the research are dense point clouds and other photogrammetric products such as Numerical Terrain Models (NMT) or orthomosaics, which are materials documenting the current state of preservation of the Tuwaneh archaeological site. The results were also compared with measurement data obtained for the area in 2018 using another measurement technology, i.e. ULAPh (Ultra Low Altitude Photogrammetry i.e. a technology of taking pictures with a GoPro camera mounted on a boom).

In the conducted research, the accuracy of KAP measurement technology has been obtained at a satisfactory level. The results of the analysis clearly show that it is possible to reduce the number of GCP even three times, and the number of obtained photos twice, without significant loss of accuracy. Such a procedure, significantly shortens the time of work in the field as well as the processing time afterwards. In addition, by reducing the number of images, the processing power required for their development is also reduced. To sum up, the KAP technology can be used to create archaeological documentation and can successfully replace aerial photographs from UAVs.

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ESTABLISHING A THREE-DIMENSIONAL MODEL AND DIGITAL DOCUMENTATION OF BEAUFORT CASTLE BY USING GPS, 3D LASER SCANNER, & DIGITAL PHOTOGRAMMETRY

Three-dimensional digital technology is important in the maintenance and monitoring of archeological sites. This study focuses on using a combination of terrestrial laser scanning and unmanned aerial vehicle (Phantom 4 pro) photogrammetry to establish a three-dimensional model and associated digital documentation of Beaufort castle (Arnoun, South Lebanon). Documenting archaeological sites and preserving all the information and details about them have always been considered important especially during natural disasters and wars. Nowadays, and with the rise of terrorist attacks in our area, as in Iraq, and Syria, it has become a national duty and urge to preserve the historic artifacts that remain, and, investigate contemporary methods that could revitalize the economy through tourism.

Surveys obtained by laser scanner allow quick scanning of the landscapes and structures [1]. Laser scanning is a cost-effective and labor-saving survey method [2]. Nowadays, laser scanning of buried archaeological elements provides an effective solution to their visualization and give a chance for communities to appreciate these findings, rather than keeping this experience exclusively with archaeologists that took part in the excavation [2]. Laser scanning, also, allows those archaeologists to proceed with their studies, formulate further hypotheses and elaborate their research, even when the excavation is closed [2]. Terrestrial 3D laser scanning is the future conventional tool for high-resolution 3D documentation of archaeological excavations and push forward to consider augmentation of archaeological stratigraphy theory [2].

This study demonstrates the integration of terrestrial laser scanning and photogrammetry in 3D digital documentation and spatial analysis of the Lebanese archeological sites. Integrating aerial photogrammetry helped in improving the 3D model by complementing the point cloud data for the upper parts of buildings which are difficult to get through laser scanning, thus increasing the accuracy of the overall topography as well as the shape of an individual building.

In our investigation, we set up GPS points around the castle, and joined them with a military point (High accuracy point X, Y, Z).We then set up a laser scanner based on those points (GPS Points). Next, we began to generate millions of point clouds, outside and inside the

castle. And, we merged these points using Software 3D-Reshaper. After that, we fixed Ground Control Points in the same place where we set up the laser scanner, and, where we were preparing for a Geo flight mission. The Geo Flight mission was carried out for 2 hours, at an elevation height of 40 meters above the castle. The overlapping was 80%. At the end of this flight mission, we generated a 3-D model using Agisoft-Software. At last, we were able to integrate these two models using cloud compare.

Ultimately, this study has established an accurate 3D model of Beaufort Castle using terrestrial laser scanning and Phantom 4 pro photogrammetry to get digital documentation of the place from different directions. Terrestrial laser scanning and photogrammetry were used to acquire the perpendicular geometry of the buildings and sites, where photogrammetry yielded higher planar data acquisition rate in upper zones, such as the roof of a building than, terrestrial laser scanning. On comparing the two technologies' accuracy based on their ground control points, laser scanning was observed to provide higher positional accuracy than photogrammetry [4]. Laser scanning showed a high data acquisition rate in the perpendicular direction, whereas, photogrammetry generated high-level planar point clouds [4]. Such tools have proved their efficiency in scanning archaeological sites since they can determine the layout conditions and topographical features based on an orthoimage [3]. Yet, such techniques could still be of limited application if precise survey drawings are required [3].

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THE ARCHITECTURAL HERITAGE OF A. N. VORONIKHIN IN THE HISTORIC CENTER OF SAINT PETERSBURG

In today's globalized world, the preservation and study of architectural heritage are particularly relevant. Cultural heritage sites (monuments, architectural complexes and landmarks) shape the architectural and spatial environment of the centers of old cities, defining its scale and style. In accordance with the Federal Law of 25 June 2002 No. 73-FZ About objects of cultural heritage (historical and cultural monuments) of the people of the Russian Federation (with amendments), cultural heritage sites are classified into the following categories:

- sites of federal importance (objects of historical, architectural, artistic, scientific, and memorial value that are of specific importance for the history and culture of the Russian Federation, as well as objects of archaeological heritage);
- sites of regional importance (objects of historical, architectural, artistic, scientific, and memorial value that are of specific importance for the history and culture of a particular Russian region);

- sites of local importance (objects of historical, architectural, artistic, scientific, and memorial value that are of specific importance for the history and culture of a municipal district).

In the fabric of Saint Petersburg, a special place belongs to buildings of the Empire style which were designed by the outstanding Russian architect Andrey Nikiforovich Voronikhin (1759 – 1814). He was born in the village of Novoe Usolye, Perm Governorate, and was from a family of serfs belonging to Count Alexander Sergeevich Stroganov [1]. A. N. Voronikhin was homeschooled together with Count Stroganov's son and studied in an icon-painting workshop since he was 6 until he became 13. In 1774, he moved to Moscow and starting from 1777, he studied perspective and miniature painting as well as architecture under the guidance of such famous Russian architects working in the classical style as Vasily Ivanovich Bazhenov and Matvey Fedorovich Kazakov [3]. Voronikhin proved himself as an artist in 1778 when he painted the refectory of the Trinity Lavra of St. Sergius. In 1779, he moved to Saint Petersburg. From 1781 to 1785, together with Pavel Alexandrovich Stroganov, he made numerous trips around Russia. In 1786 he was manumitted [1]. From 1786 to 1790, he lived in Geneva and Paris, where he and Pavel Alexandrovich Stroganov studied architecture, mechanics, mathematics, and natural sciences.

His first major work after returning to Saint Petersburg was the interior design of the Mineral Study in the Stroganov Palace (1793). While working on the project, Voronikhin developed his approach as an architect and his distinctive style was formed. During this period of creative activity, he worked on the Gorodnya manor house in Kaluga Governorate (1798) and the Stroganov's Dacha near the Chernaya River (1795-1796) [3]. In these works, A. N. Voronikhin continued to develop the best traditions and achievements of Russian architecture, creating a new style of a public building which both was simple and clear and reflected the power and glory of Russia. In 1797, A. N. Voronikhin was awarded the title of Academician of Perspective Painting for a picture of Stroganov's country house [3]. Thanks to Stroganov's influence, the architect began to be commissioned by the state. The first contract was for the creation of galleries and the main cascade in Peterhof. In 1800, he was appointed architect of Kazan Cathedral, which became the main project of his life. This monumental and majestic structure became an organic element of Nevskiy Prospect, the main street in St. Petersburg. Its wide semicircular colonnades are joined together by the central portico with a pediment and a delicate dome. The construction of Kazan Cathedral set the stage for building other major structures on Nevsky Prospect. Students at the St. Petersburg Academy of Arts did their internships at the construction site [2]. It can be said that a whole generation of architects was raised there. When Voronikhin started teaching at the St. Petersburg Academy of Arts, he made it mandatory for students to visit the construction site.

Another major work by Voronikhin was the construction of the Mining Cadet Corps building, which now belongs to St. Petersburg Mining University, and the design of the area around it. From 1806 to 1811, Voronikhin worked on the building and connected several old houses into an architectural complex. The main facade is decorated by a Doric dodecastyle portico with a wide staircase. The monumental colonnade facing the Neva River became a landmark for those entering the city from the Gulf of Finland [2]. To the left and the right of the portico, two sculptures were put (V. I. Demut-Malinovsky's The Abduction of Proserpina and S. S. Pimenov's Hercules Slaying Antaeus). Of all the rooms decorated by Voronikhin, only the grand staircase has been preserved. Simultaneously with the construction of the building, the Mining Museum was created. It contains the world's richest collection of minerals, rocks, fossils, and scale models of mining equipment. Both buildings have the status of sites of federal importance. They shape the image of the historical center of Saint Petersburg. Buildings designed by Voronikhin were created in the best traditions of the Russian Empire style with the use of new, lightweight structures and natural building materials. They are characterized by profound architectural and artistic expression, which is achieved by the clarity of spatial

composition, the contrast between the large smooth walls and the colonnades, classic ornaments, and a combination of visual arts including architecture and sculpture.

Voronikhin's art played an important role in the development of Russian architecture at the end of the 18th century and during the first three decades of the 19th century and had a direct impact on the development of the so-called Petersburg style which the modern generation of architects should not lose.

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GENTRIFICATION VERSUS STRUCTURE RELOCATION - HOW CAN WE PRESERVED THE CULTURAL HERITAGE OF THE CITY

The development patterns that lead to gentrification are shaped by a complex array of private and public actions at the local, regional and national levels. A number of cities now experience gentrification in its many stages and intensities. Gentrification is a powerful force for economic change in number of cities, but it is often accompanied by unnecessary historic building demolition which are not listed as a heritage building under conservation protection. In certain respects, a neighborhood that is gentrified can become a "victim of its own success". The upward spiral of desirability and increasing rents and property values often erodes the very qualities that began attracting new people in the first place [1]. Currently, many urban areas are under pressure of transformations or destruction. The unique character of a district comes very often from a beauty of its architecture. When success comes to a neighborhood, developers look for an opportunity of new investations and often demolished those beautiful examples of architectucture to build a new more profitable once. To preserve the urban heritage of the city, a structure relocation can be a solution in some cases [2].

The relocation of a building is a technical, financial, legal and social problem. The decision about moving a structure is by and large a result of a discussion about preserve the cultural heritage of a historical area in its original version and to save it from potential demolition or detrimental reconstruction. The relocation can be carried out in two ways. The first one involves the demolition and reconstruction of the building at the target site, the second one involves cutting the entire structure off at the foundation, and then moving it (after reinforcing it with a steel structure, bracing the building) as one element – either by crane or on special transport rollers [2]. Moving the whole structure, though difficult and risky, is much faster and retains its original character almost completely. In the case of historic buildings erected in brick technology, demoltion is usually ruled out.

The building of the historic Atelier, which was the subject of my relocation project, is located at 12 Łobzowska Street, in the very center of Piasek, one of Krakow's historic districts. The decision to relocate the structure was made because of the danger of it being demolished because of the development plans associated with the nearby tenement house, which is the private property of a third-party [3]. The developer needs to move the Atelier due to plans to expand the tenement houses located on the same plot. The block of buildings in which the Atelier inquestion is located also possesses high-value natural assets – the gardens located within

it [4]. This garden is to be a the target site for the translocated building. The main design principle is to move the building of the historic Atelier in a straight line by either 21 or 59 metres, depending on the site development option chosen by the developer at a later stage of the project. The approximate cost of both variants is € 100,000 [3]. Apart of the difficulties and costs, relocation of the building will bring a lot more profit on many levels than destroying it in the first place [5].

Figure 1 - Map of the project site, with the current placement of the Atelier building marked in red and a new target site of a relocated building in green, Source: own study, base map source: Google Maps

The analysis is based on a case study of the on-going urban transformation of the Krakow district of Piasek. The investigation was based on the text analysis of urban planning documents and own work of a structure relocation conceptual project. The aim of these measures is to prevent the demolition of this building, now over a century old, as a result of which a forgotten element of the cultural heritage of the city will be saved. The victims of gentrification are not only human beings, but also the city's urban heritage, such as no enough protected by the law historical buildings. The case of the Atelier building may provide an inspiration for discussion as well as raising awareness among citizens and city authorities. The Atelie case, being exceptional because has the potential to highlight the relation between single historic buildings and the integrity of an urban heritage site.

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SMART CITY: DEVELOPMENT PERSPECTIVES IN THE RUSSIAN FEDERATION

Because of the high level of urbanization solving the problem of intelligent and interlinked functioning of all city systems becomes relevant. For specialists, including of architectural and urban-planning industry, the problem of developing and realization of smart cities on principles of sustainable urban planning is important. This is the reaction on modern city′s requests for organizing seamless and integral spatial environment, supporting non-stop operation of its all components. In the foundation of the concept of smart cities lies effective usage of resources by all members [1]. First, smart city system is aimed at its citizens, providing them with comfortable, safe and sustainable living environment.

Smart City is the city that was built from scratch or had a huge transformation and reengineering of the classic city, in the infrastructure of which the newest intellectual and technical solutions were integrated for more high-quality living conditions for its citizens, for providing the most comfortable services and increasing the effectiveness of management of urban resources.

The types of common problems during creating smart cities are organizational, financial and technological. Also, social and psychological problems were mentioned. Technocratic project of Smart City that is not related to historic and cultural traditions and national preferences requires vast social adaptation in order to become attractive to citizens. At the same time during realization of the concept of Smart City the existing risks of the possible cyber-attacks (for example, informational risks like infection of shared online-platforms) must be considered and neutralized.

Currently, the Russian Federation has a tendency to develop individual components of a smart city, or, less commonly, its creation and formation. The Smart City project is aimed at improving the competitiveness of Russian cities, creating an effective urban management system and safe and comfortable living conditions for citizens. The goal of the Smart City is not only to digitally transform and automate processes, but also to comprehensively improve the efficiency of urban infrastructure. The elements of the Smart City concept are being introduced gradually. So far, there is no practice of creating a new city in which all the basic processes of life are automated. In this sense, we are seriously behind world achievements.

One of the directions of Smart City in Russia is the control of urban lighting on the street and in the premises. Replacing bulbs with LEDs gives significant energy savings, the installation of special sensors allows you to remotely control the operation of each lamp. The problems of overflowing garbage containers are being solved, however, the system has not been brought to full automatism. Sensors inform about the state of the container, in case of fullness, the operators send the car, building convenient routes. One of the most popular examples of the implementation of IoT ("Internet of things" – the Internet of things) in the housing sector is the installation of sensors on special equipment. The tracker on the machine allows you to monitor its movement online, control the work of employees and fuel consumption [2].

On March 3, 2020, the Ministry of Construction of the Russian Federation for the first time introduced the IQ Urban Digitalization Index [3]. Among the largest cities with a population of 1 million or more, the first places in the ranking were occupied by Moscow, Kazan and St. Petersburg. Of the large cities, with a population of 250 thousand to 1 million, the first three places were occupied by Khimki, Balashikha and Tyumen. categories of large cities with a population of 100 to 250 thousand people, the first three places were in Reutov, Serpukhov and Elektrostal. The cities of Dubna, Ivanteyevka and Naro-Fominsk have shown themselves to be the most developed administrative centers from the point of view of digitalization – settlements with a population of less than 100 thousand people.

Innopolis is rightfully considered the most advanced, modern and smart city in Russia at the moment. Innopolis city dwellers are young IT specialists who are employees of companies working inside the city. A whole technopark has been allocated for work here, one of the two largest in Russia (the second in Skolkovo). In Innopolis, there is a huge fund of rental housing, which already has everything you need. All buildings in the city were built with the introduction of a smart housing and communal services, which keeps track of utility costs using digital services and closely monitors them. It is planned to install smart electricity and water meters in all apartments to diagnose defects in communications [4]. You can get into the apartment using biometric sensors and hands.

The Skolkovo Innovation Center is a modern scientific and technological innovation complex for the development and commercialization of new technologies, in which special economic conditions are created for companies working in priority sectors of modernization of the Russian economy.

In modern conditions, it is necessary not only to answer the question of how to implement the concept of a Smart City in Russia, but also to understand how to prepare the population for living in such a city [4]. It is important to create an urban environment that will be comfortable, attractive, and, most importantly, safe for the vast majority of residents.

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ADVANCED FEATURES OF ARCHITECTURE WITH THE CONVERGENCE OF ADAPTIVE MORPHOLOGY

The innovative technology has introduced a dynamic, interactive as well as responsive approach into the architecture field along with adaptation to time, social and economic forms, occupant needs, and environmental responsibility. This constant progressive nature of architecture and multi-disciplinary developments have removed certain limitations among the notion of architecture, IT, and industrial sciences. The primary driver behind the building progression is the adaptability that has allowed the differentiation between the previous

generation of buildings. Adaptability enables to process the data that is gathered by different sources to prepare the building for the specific occasion before it has occurred [1]. The adaptive morphology obtains a broad spectrum by modifying a building to various occupant's perception of comfort to climate change. To meet the described resultant, the building has to pursue; information and communication technology, system integration, facility management systems and, superior energy management and sustainability.

Information and communication technology have presented an alternative perspective into system integration enabling to process the data unobtrusively and promoting an interaction between human-objects. The complex-adaptive buildings have networked with the sensing layer to originate inroads into real-time responsiveness. The sensing layer, tags and sensors, detect occupancy state, mobility and movement, and a number of technologies stated internally and externally. These sensors transmit the data to decision-making units to high-level responses through wired/wireless open protocols such as; BACnet, Zigbee, LonWorks, and etc. Building automation enables wide spectrum monitoring and control capabilities in the form of modular web services. Frequently, the occupant/building manager has access to the underlying data flow to providing an appropriate level of control to adapt the building accordingly [2]. The information and communication technology provide the required infrastructure to monitors and manage the buildings' electrical and mechanical equipment such as; HVAC, lighting, water, safety and security systems and, provides automated control to those building systems. Creating a durable and permanent building management system is the first step of sustainable responsibility, and it should pursue; open protocol and connectivity, globally accepted standards, software and hardware configuration, user-friendly interfaces, system reliability and quality [3].

Occupant behaviors and comfort parameters cause a significant effect on building energy management and sustainability. Achieving precisely the expected comfort index requires occupancy proximity and detection systems, like RFID, optical codes, smart cards, NFC, infrared sensors, as well as occupant control. These sophisticated sensors and new smart meters allow the understanding of space utilization and building energy use per effective occupancy. Energy monitoring, planning, and operating schedules with an adaptive approach allows being understanding of anticipated results. Through the user-friendly interfaces of operating systems or 3rd party platforms, occupants can be engaged with the data of energy and power consumption reports and building carbon footprints. To increase the use of green energy building management system also explore provisioning of renewable energy resources. In particular, it collects data on weather conditions and subsequence renewable energy generation together with the occupant activity in the building. The building management system uses big data analytics to determine how to schedule renewable energy from its sources [4]. In brief, through implementing smart building management systems, the building sector fulfil the purposes on; benefiting of user data, increased life quality and well-being, the efficiency of energy usage, decreased consumption, real-time response, fast maintenance and cost benefits.

The core of the new building concept is based upon the analysis and represent occupant state, mobility and movement along with the corresponding internal and external technological responses. In this research, it has been described the interlinked features of the most recent trends, which are more explanatory and pertinent in the long term; and illustrate a general outlook to building performance. While many systems potentially overlap with a various architectural stream, as well as with many fields, the framework has been presented with embracing the latest technological developments, instead of categorization. The foundation of the concept that has been presented in this paper is advanced features of building performance along with adaptive morphology.

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THE OPPORTUNITIES FOR ORGANIZING PEDESTRIAN ECOTOURISM ALONG THE HISTORICAL EMBANKMENTS OF SAINT PETERSBURG

This presentation discusses the possibilities of humanizing the urban environment for pedestrians on the historical embankments of St. Petersburg.

The creation of pedestrian area along the water space in the cities of the world cultural heritage is becoming a priority in the XXI century. However, the main transit highways of megacities are often embedded in the transport scheme of using inner-city embankments. In this regard, the main problem for creating a pedestrian zone along the embankments of the Neva river in the historical center of St. Petersburg is to eliminate the conflict of traffic and pedestrian flows.

The use of underground and underwater space could help solve this problem. There are lots of new technologies for performing underground and underwater works, although some projects are required to unite the efforts of specialists in different fields.To solve the problem of flow dilution, it is necessary to work out a number of aspects.

It is needed to identify historical features of the appearance of embankments [1], to analyze the existing functional purpose of the territory of historical embankments, as well as providing them with infrastructure. Also, it is necessary to clarify the legal regulations for the procedure for carrying out work near and on cultural heritage sites, because the embankments of St. Petersburg are considered to be world historical architectural monuments [2]. Historical embankments are under the jurisdiction of city and regional regulation, so for the development of projects, objects are needed to be granted special urban planning status. It is needed to develop the concept of using modern technologies for work in complex hydrogeological conditions. Also, it is necessary to find adequate planning solutions for placing bulky ramps for entering and exiting cars in historical buildings [3] and to add new functions to the embankment zone in order to get additional financing for high costs of constructions.

So far, projects have been carried out to move the traffic flow into tunnels, but have not been realized now. For example, the project "Kronverk transport corridor", "Orlovsky tunnel", "scheme of development of Nevsky Prospekt". It is worth paying attention to the proposal to build a deep tunnel along the Neva embankment from Liteyny bridge to Blagoveshchensk. The project was prepared in 2006 by the Stroyproekt Institute by the request Of the Committee for improvement and road management (the author of the idea of the Nevsky automobile tunnel, M. Y. Itskov) [4]. The disadvantages of this project include the violation of the historical appearance of the embankments, but the project has not been completed due to the loss of interest in it by the city authorities.

All the significant and large-scale projects for the reconstruction of coastal territories have to be carried out on the initiative or with the participation of the city authorities. This ensures a unified strategy for the development of the urban area, project management and the

need to ensure special urban planning requirements, as well as stimulating investments by providing incentives and preferences to the developers. We need the initiatives from the citizens and city authorities to adapt the legal framework and encourage investments.

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THE SPECIFICS OF THE INNOVATIVE ARCHITECTURE FORMATION DURING THE RECONSTRUCTION OF PUBLIC BUILDINGS AND STRUCTURES

Radical changes in the area of new construction and reconstruction of buildings and structures have caused the need for transformation of typical and historical buildings, in particular, those objects of public use, which subsequently underwent intensive use of physical and moral wear and tear. And also in reconsideration of the requirements shown to the general architectural and spatial organization of reconstructed objects taking into account their influence on the developed canvas of city building. The purpose of the research is to determine the peculiarities of innovative architecture formation at the reconstruction of public buildings and structures in accordance with current standards and modern trends. The analysis of publications and researches within the limits of the presented problem has shown, that many works of the faculty of architecture illuminate numerous aspects of process of the reconstruction directed on perfection of a housing stock [4], modernization of the industrial enterprises [2], and also transformation of typical and historical building as a whole [3], however, the question of reconstruction of public buildings from the point of view of formation of modern architecture of city remains poorly studied.

The basic feature of formation of innovative building at reconstruction of public buildings and constructions consists in opening of new possibilities, creation of unique and steady architecture. Necessity of application of the given process is caused by a number of reasons, the most important of which are:

1. Moral and physical wear and tear caused to many reconstruction sites in the post-Soviet territories, which can affect the aesthetic and structural-technical condition of the public building.
2. The value of the object of reconstruction from the point of view of integral architectural and town-planning perception of the building in interaction with a modern and/or historical city.
3. Social need to transform outdated urban development.
4. Potential for reuse of the object.

Within the limits of the given scientific research by the author some features of formation of innovative architecture in the conditions of reconstruction of public buildings, capable at their practical application to give already dilapidated objects the new architecturally-spatial and aesthetic decision, and also in some cases to prolong and multiply for some years their term of operation is allocated.

1. Functional transformation (or re-functionalization) can solve the problem of obsolescence of the existing filling of the object of reconstruction and give modern consumer qualities depending on the wishes of the population by means of: adaptation of the new functions with the re-use of the construction volume of the object of reconstruction; transformation of the functional filling, i.e. restoration of the lost functions of the object, and their adaptation to the modern operating conditions; restructuring with the replacement of the new functions, initially not with the new functions.

2. Achievement of architectural recognition and uniqueness which is capable to give modern look and will increase the useful area to objects of reconstruction at the expense of application of innovative approaches of form formation: introduction of additional block inserts (dynamic form formation), use of modern forms which will interact with the historical environment (integrated form formation), radical transformation of internal planning filling with preservation of former appearance (latent reconstruction) [1].

3. use of the latest materials and energy efficient technologies, taking into account the most important national economic issues of resource saving and recycling (reuse of materials), which within the framework of the problem under consideration will give new properties and, in some cases, additional strength to the structural characteristics of the reconstruction objects, as a result of which the conditions of human residence can be significantly improved.

The process of formation of innovative architecture of public buildings under reconstruction is considered as one of the most important directions of modern development. As a result of the research the conceptual provisions defining the features of innovative architecture formation from the point of view of transformation of architectural and spatial characteristics which in their practical application will allow to give architectural recognition and expressiveness to the objects of reconstruction are revealed.

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RAINWATER HARVESTING OPPORTUNITIES EXPLORED EAST SHORES STAGE 1B PROJECT

This consultancy report has been completed as a part of the fulfilment of a Bachelor of Civil Engineering Honours and a Diploma of Professional Practice at Central Queensland University.

East Shores Stage 1B Project includes a waterfront café, state of the art open air cinema, boot camp, cruise terminal plaza, multiple barbeque and picnic shelters, many iconic artefacts and artwork showcasing Gladstone's marine history and recreational parklands. This new development project also offers the very unique experience of having an unrestricted view within a couple of hundred meters of LNG gas ships moving up to 50 million dollars' worth of cargo and 200 thousand tonne coal ships berthing to be unloaded at the largest by volume port in the Southern hemisphere. East Shores Stage 1B Project is a 29 million dollar addition to the 40 million dollar East Shores Stage 1A facility that makes up the East Shores Precinct, provided free for public use by the Gladstone Ports Corporation.

This project was completed in conjunction with the Gladstone Ports Corporation and the East Shores Stage 1B Project. An opportunity to increase the sustainability of Stage 1B was identified through the upgrade of the current stormwater collection and drainage system by implementing a rainwater harvesting system to reduce the amount of polluted water entering the stormwater drainage system and eventually the Auckland Inlet. Gladstone, Queensland is a drought declared, coastal and humid region within Australia. Water sensitive urban design is critical. This consultancy report investigates innovative and sustainable ways to incorporate a rainwater harvesting system into the East Shores Project Stage 1B, that will have the capacity to contribute to the parklands irrigation demand and potentially provide water for other non-potable services and facilities. A weighted evaluation criterion was used to select the most suitable roof structure for the project which was found to be the café building. This consultancy report provides a long-term performance assessment of the RWH system using local daily rainfall data and a conceptual design of the system using MS Excel. This investigation displays results for five different design scenarios with varying demand volumes and end uses including irrigation of turf and gardens and toilet flushing. It was concluded that it is feasible to reduce the parklands reliance on municipal water to supply both localised irrigation and toilet flushing however, it is recommended that the RWH system be utilised to provide a water resource for a localised irrigation demand efficiently. The findings of this consultancy report showed that the most effective design scenario using the selected RWH system arrangement was found to be Combined Gardens 1 due to it having the second highest reliability rating at 91% and yielding almost double the water savings of Turf Field 1, at 59956.3kL. The combined gardens 1 scenario allows over 50% of the gardens surrounding the café to be irrigated effectively. The implementation of this system has the potential to contribute to the positive public image surrounding GPC and the East Shores Precinct as well as reduce the precincts reliance on municipal water supplies, create potential water and cost savings and increase the sustainability of the project.

The aim of this consultancy report was achieved. The design was found to be feasible therefore, it is recommended that further investigation be completed into the economic feasibility and sustainability of implementing the recommended system. It is also recommended that multiple arrangement options within each structure including different variations of tank

locations and sizes, be more thoroughly considered and investigated when selecting the most suitable structure.

Further works also include modifying the starting storage amount, the tank size and shape, the irrigation method to investigate the impacts those modifications have on the systems reliability, water savings and overflow volumes. Further investigation should also be conducted into the relationship between the overflow, reliability and the water savings.

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TO THE QUESTION OF REVITALIZATION OF INDUSTRIAL AREAS IN THE HISTORICAL CENTER OF SAINT PETERSBURG FOR A PUBLIC FUNCTION

The scientific and technological progress has led to mass industrialization, building of plants and factories on the city´s periphery since the mid-19th century. Developing geographically in the 20th century, cities preserved the 19th century buildings in their central part. This led to a large number of industrial areas within the city, which partially or completely ceased operations and were moved outside of the residential territory at the present time. Thus, the problem of reorganization of urban areas, which were industrial in the past and lost their initial functional value, and of their adaptation became more relevant in the beginning of the 21st century.

For solving this problem, new approaches are being developed, one of which is revitalization. Under revitalization in the context of urban studies, adaptive reuse of territories, buildings, structures and complexes with a change in their functional purpose, but without a significant change in the historical appearance, is understood [1]. The process of revitalization requires an integrated approach, compliance with the principles of sustainable development, preservation of local identity of the territory [2]. The problem of unused industrial areas in Saint Petersburg is represented by the so-called "Grey Belt". In the first half of the 2010s, these industrial areas, which were allocated by urban planners in St. Petersburg, occupied 13.6% of the total area of the city. 2/3 of these are empty and abandoned depressed territories, which are "shrouding" the central part of the city.

Coastal depressive industrial zones have a special place among the potential areas for new functions. For Saint Petersburg it is characterized by the presence of such coastal areas, which are allotted, including under the transport function. These limits access to the coastal territories that form the water "facades" of the city. These sites have the potential to be filled with functions demanded by the urban population and the formation of new public spaces. One of the first projects implemented to revitalize the industrial zone was "Port Sevkabel", which is situated on the Gulf of Finland. After the modernization of the cable and electric enterprise in the 2010s, it was decided to give part of the vacated area of 3 hectares for the organization of the public open space. The company "Miles & Yards" and "Khvoya" architectural bureau (Russian Federation) were involved in the project. The main tasks for architects and developers were to create a "point of attraction" and to organize an accessible exit to the Gulf of Finland. The openness of the site, its close proximity to the sea make "Port Sevkabel" an attractive place for organizing mass cultural events. Significant resources are required for the qualitative renovation of this territory.

Architectural ensemble "New Holland" became one of the examples of successful industrial area renovation and historical building reconstruction with the aim of adaptive reuse for new functions in the historical centre. There are two artificial islands, created at the time of Peter I between the Moyka river, Admiralty and Krukov canals. Since 2001, the "New Holland"

Ensemble has been an object of cultural heritage of federal importance. In 2014, based on the WorkAC (US) master plan, which won in the international contest in 2010, West 8 (the Netherlands) developed a project to reorganize the territory. The main purposes of "New Holland" renovation are reorganization of the historical urban context and filling it with modern functions (with an accent on the cultural development), formation of comfortable public space with adding of green zones and further adaptive use of the buildings that have historical value.

There is an urgent need in revitalization of industrial areas on the sites adjacent to the city center. It is necessary to remember about the status of the historic centre of Saint Petersburg and related groups of monuments as UNESCO world heritage site [3]. Preserving of the place identity and cultural landscape is important. Thus, Saint Petersburg needs a complex program of moving of industrial enterprises beyond the city line [4]. The city needs to develop its own approach, taking into account international experience in this area.

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ARCHITECTURAL AND URBAN APPROACHES IN THE CONTEXT OF THE REFUNCTIONALIZATION OF INACTIVE INDUSTRIAL ENTERPRISES

This article discusses the issue of architectural and urban planning approaches for the re-functionalization of inactive industrial enterprises. The article also discusses the directions, methods and techniques for adapting inactive industrial enterprises to the modern context of the city.

Currently, from a functional point of view, three fundamentally different directions of transformation of inactive industrial enterprises are being implemented, such as partial re-functionalization, full re-functionalization and full preservation of the industrial function.

The complex process of refunctionalization includes three priority actions, such as:

- refunctionalization of existing inactive industrial enterprises according to urban demand and demand [3] (industrial facilities redesigned for residential buildings, office and office centers, educational institutions, cultural and entertainment centers, hotels, trade enterprises, sports facilities);
- ecological restoration of the territory due to the creation of new green spaces or the restoration of disturbed territories;
- comprehensive demolition of an industrial facility and use of the territory for other purposes suitable for operation.

Local re-functionalization, as well as full re-functionalization, is based on the following processes:

- reconstruction of the planning structure, the basic principle of which is the isolation and preservation of the most stable planning characteristics;
- reequipment (reorganization) of the object into a museum or art gallery;
- the merger of new objects into historical and industrial territories.

Maintaining an industrial function — it can be a memorial path — which is a complete restoration of a building while preserving its original appearance; or improvement is the introduction of new production technologies into the existing building volume.

Among the many other existing methods of reconstruction or refunctionalization of buildings, several basic ones can be distinguished that allow adapting industrial architecture to modern urban conditions. [2,4]

The first is the application method. It includes the creation of a composition based on the existing design - a reconstruction of the facade or the creation of a "false facade". The "application" method involves working with the latest materials, creating modern beautiful shells.

The second is the analogy method. He intends to compare the designed object with those or other properties of a figurative analogue. The method is applied just in the case when it is necessary to give the object new qualities. For industrial architecture, it is more appropriate to use functional analogies: pictures, details, elements that speak not only about the function of the building, but also about the features of the enterprise. Reception: images created on the basis of technological processes of an industrial facility or conditional display on the facade of this process. You can also use an artificial technological effect, for example, backlight.

The third is "integration." This is an insert of additional elements and structures into existing building structures. Reception: expanding a building or creating new ones or strengthening old dominants.

Based on the proportional ratio of industrial and residential facilities that are in the structure of urban development, it is necessary to note the most ideal and effective methods of adapting inactive industrial enterprises to modern conditions:

• transformation - based on a change in an object or its parts in proportion, shape or configuration;

• change - based on the introduction of new forms, functions, structures, materials, etc.;

• the exclusion or addition of a number of forms, designs, functions or the addition of new, expanding opportunities;

• combination - the relationship of the properties of the functional components of the elements of the object among themselves;

• inversion - the process of considering a problem from a different perspective or perception format. [4]

Thus, there are several directions, methods and techniques for adapting inactive industrial enterprises to the modern context of the city. The future of industrial architecture lies in its adaptation to rapidly developing technologies, which is achieved through the re-functionalization of inactive industrial enterprises. And various architectural and compositional techniques make it possible to adapt and harmonize inactive industrial enterprises to the structure of an actively developing modern city. [1]

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THE CONCEPT OF FORMING A NEW TYPE OF EDUCATIONAL ORGANIZATIONS IN RUSSIA

In the conditions of a post-industrial society in Russia, one of the priority areas is education and its quality for all age groups of students. The general factor of development is human capital. Professionals, highly-educated people are individuals who need personal growth through the satisfaction of physical, social and spiritual needs. Such vector can become a continuous new system of education in which a person gradually learns throughout life, engages in self-education and self-knowledge, taking into account the needs for professional and creative growth, which is the key to a harmonious and self-sufficient personality and contributes to the favorable development of the country in its entirety.

A school of Mikhail Schetinin in Krasnodar was an example of the successful implementation of new experimental educational methods for the first time in the Russian Federation since 1980 [3]. This systematic approach is characterized by the formation of the school space, the presence of an individual program for each of the students, depending on learning abilities at various disciplines. It was a fundamental link in the process of forming lifelong education in the country. The successor at development of Russian education was the Sirius Centre for Gifted Children, Sochi (operating from 2014 to the present). One of the key ideas of the center is contacts between talented children in different fields. There are three buildings on the territory: "School", "Sport", "Art", for various educational functions and a bedroom-administrative building for children and teenagers from 7 to 18 years old. The architecture of the newly constructed buildings is sustained in a single key of plastic streamlined forms of a spherical and ellipsoidal configuration, which distances them from the existing administrative-residential building. The basis of an idea of the Smart School in Irkutsk (operating from 2017 to the present) is the education of children with different starting abilities. The educational cluster will include: cottages for families with foster children, a kindergarten, an elementary school building, a high school building, a sports complex, a cultural and leisure complex. The complex has a circular ring structure with a closed inner zoned courtyard in accordance with the age characteristics of students, where children can freely engage in creativity and sports.The structure of the entire school complex has a closed ring shape with an internal zoned courtyard. In it, different age groups of students are free to engage in creativity and sports [1].

The concept of lifelong education owes its appearance and development primarily to international cooperation with UNESCO. One of the main goals of continuing education is the expansion and diversification of educational services that complement basic school or university education. This recognizes the insufficiency or inability of the basic system to teach a person everything that he will have to do during his working life. To a certain extent, continuing education is equated with adult education, since we are talking about various forms of retraining, advanced training and the cultural level of people who have exceeded the usual age of basic education [2].

It is necessary to formulate a regulatory framework for continuing education centers. Based on the obtained data, urban planning and architectural requirements for continuing education centers will be formed. As recommendations for designing a new type of building, an architectural-conceptual project will be developed taking into account the existing regulation in the field of designing educational organizations and the needs for continuing education (architectural-planning, urban planning, conceptual solution).The ideas of the modern approach to the formation of the architectural and conceptual solution of educational organizations in

Russia are based on several substantive axes that determine their specifics: figurative-artistic modeling of the world, psychologization of the educational process, intensive study of foreign languages, productive work, school sports, an individual approach to students with the possibility of developing personal educational programs.

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