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Санкт-Петербургский горный университет**

Кафедра иностранных языков

ИНОСТРАННЫЙ ЯЗЫК

ТЕПЛОТЕХНИКА МЕТАЛЛУРГИЧЕСКИХ ПРОЦЕССОВ

Методические указания к практическим занятиям для студентов магистратуры направления 22.04.02

FOREIGN LANGUAGE

THERMAL ENGENEERING OF METALLURGICAL PROCESSES

**САНКТ-ПЕТЕРБУРГ
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Методические указания включают аутентичные научно-технические тексты металлургической направленности на английском языке, содержащие материалы по теплотехнике, с разработанным комплексом упражнений, необходимых для совершенствования навыков просмотрового и изучающего чтения и расширения словарного запаса.

Предназначены для студентов магистратуры направления 22.04.02. «Металлургия».

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Предисловие

Данные методические указания к практическим занятиям по дисциплине «Иностранный язык» предназначены для аудиторной работы студентов магистратуры, обучающихся по направлению подготовки 22.04.02 «Металлургия», направленность (профиль) программы «Теплотехника металлургических процессов».

Изучение предлагаемого материала направлено на развитие навыков просмотрового и изучающего чтения будущих магистров-инженеров в рамках совершенствования их иноязычной профессиональной компетенции. Тематика аутентичных научно-технических текстов затрагивает основные проблемы теплотехники металлургической отрасли, а именно: процессы и устройства для создания энерго- и ресурсосберегающих технологий, обеспечивающих защиту окружающей среды при проведении технологических операций, переработку руд и других материалов с целью получения концентратов, металлов и сплавов, а также горение топлива и применяемые топливосжигающие устройства.

Методические указания способствуют комплексному формированию общекультурных и профессиональных компетенций магистрантов и согласованы с программой по иностранному языку для неязыковых вузов.

UNIT I. FUNDAMENTAL FACTS AND DEFINITIONS

Text 1.1 Thermal engineering

1. Using a dictionary, practice pronouncing the following words. Translate these words and make up as many word combinations or sentences as you can.

vehicle; physical; naturally; region; temperature; determine; engine; climate; liquid; circulator; transfer; chemical.

2. With a partner, discuss the questions below. Compare your ideas with other students.

- How does it happen that heat flows from the higher-temperature region to the lower-temperature one?
- Is heat transfer important to the design of machines?

3. Read the text to check your answers.

Thermal engineering is a broad field of engineering that encompasses technologies dealing with heating and cooling systems, transfer of heat, and fluid mechanics. Instruments that control temperature are essential in many areas, including the electric power industry; the automobile industry; and the heating, ventilation, and air conditioning (HVAC) industry. The principles of thermal engineering are also crucial to the operation of vehicles and other machines.

Heat transfer is a major concern within the field. The transfer of energy, in the form of heat, across different physical regions is heat transfer. When an area of high temperature is next to an area of lower temperature, heat naturally flows from the higher-temperature region to the lower-temperature region. This principle, known as conduction, is used in many thermal engineering settings to increase or decrease the temperature of a system. Insulation, for example, minimizes the conduction of heat and keeps temperature regions relatively distinct.

The heating and cooling of liquids is important in many industrial settings, and constitutes another branch of thermal engineering. An engineer in this field must also understand fluid dynamics. Coolant, a cooling substance, is used to reduce the temperature of processes and prevent overheating. Boiling is another method used to create vapour which may be condensed in refining a chemical product. The study of these processes helps thermal engineers determine the optimal regulation of temperature in each case. Thermal engineering has applications outside industrial plants as well. An example is the HVAC industry, which deals with refrigeration, ventilation, and temperature regulation within buildings. An office building in a hot, humid climate may need more ventilation and air conditioning to promote cooling than the same building in a cold climate. Commercial establishments such as restaurants may require extensive refrigeration systems for the storage of food. All of these technical considerations would be within the realm of this type of engineering.

On a smaller scale, vehicles such as cars use thermal engineering in their everyday function. The heating and cooling of the car is controlled by thermal management systems integrated into the design. Heat transfer, fluid dynamics, and other principles of engineering are at work in cooling the engine and maintaining oil flow.

Thermal engineering is important to the design of almost any machine. Mechanical elements and electric circuits generate heat during operation, and the buildup of heat can often threaten the device. Cooling mechanisms, usually fans or liquid circulators are added to compensate and help regulate the machine's internal temperature. Devices that use this principle include computers and car batteries.

Source: https://www.wisegeek.com/what-is-thermal-engineering.htm

4. Look through the text and find antonyms for the following words.

big; heating; to increase; cold; narrow; low; dry.

5. Express the meaning of the phrases according to the pattern.

Example: the radio-active clock method – the method which makes use of the radio-active clock.

fluid mechanics, electric power industry, heat transfer, higher-temperature region, thermal engineering settings, cooling substance, thermal engineers, extensive refrigeration systems, machine's internal temperature.

6. Answer the questions.

- What is thermal engineering?
- Why is the heating and cooling of liquids important in many industrial settings?
- What functions does the coolant have?
- How can optimal regulation of temperature be determined?

7. Writing a summary.

a) Give each paragraph a suitable title.
b) Develop the titles of the paragraphs into topic sentences. Join the topic sentences together.
c) Re-read your summary and make sure that the sentences are presented in a logical order. Make any changes that you think are necessary.

Text 1.2 Temperature

1. Using a dictionary, practice pronouncing the following words. Translate these words and make up as many word combinations or sentences as you can.

warmth; measure; measurement; quantitative; qualitative, vary; pressure; mechanical; observation; equilibrium.

2. **With a partner, discuss the questions below. Make a list of possible answers. Compare your ideas with other students**.

- What does warmth depend on?
- How can degree of heat of two bodies be compared?

3. Read the text to check your answers.

The conception of "heat" arises from that particular sensation of warmth or coldness which is immediately experienced on touching a body. This direct sensation, however, furnishes no quantitative scientific measure of a body's state with regard to heat; it yields only qualitative results, which vary according to external circumstances. For quantitative purposes we utilize the change of volume which takes place in all bodies when heated under constant pressure, for this admits of exact measurement. Heating produces in most substances an increase of volume, and thus we can tell whether a body gets hotter or colder, not merely by the sense of touch, but also by a purely mechanical observation affording a much greater degree of accuracy. We can also tell accurately when a body assumes a former state of heat.

If two bodies, one of which feels warmer than the other, be brought together (for example, a piece of heated metal and cold water), it is invariably found that the hotter body is cooled, and the colder one is heated up to a certain point, and then all change ceases. The two bodies are then said to be in thermal equilibrium. Experience shows that such a state of equilibrium finally sets in, not only when two, but also when any numbers of differently heated bodies are brought into mutual contact. From this follows the important proposition: If a body, A, be in thermal equilibrium with two other bodies, B and C, then B and C are in thermal equilibrium with one another. For, if we bring A, B, and C together so that each touches the other two, then, according to our supposition, there will be equilibrium at the points of contact AB and AC, and, therefore, also at the contact BC. If it were not so, no general thermal equilibrium would be possible, which is contrary to experience.

These facts enable us to compare the degree of heat of two bodies, B and C, without bringing them into contact with one another; namely, by bringing each body into contact with an arbitrarily selected standard body, A. By observing the volume of A in each case, it is possible to tell whether B and C are in thermal equilibrium or not. If they are not in thermal equilibrium, we can tell which of the two is the hotter.

The degree of heat of A, or of any body in thermal equilibrium with A, can thus be very simply defined by the volume of A, or, as is usual, by the difference between the volume of A and an arbitrarily selected normal volume, namely, the volume of A when in thermal equilibrium with melting ice under atmospheric pressure. This volumetric difference, which, by an appropriate choice of unit, is made to read 100 when A is in contact with steam under atmospheric pressure, is called the temperature in degrees Centigrade with regard to A as thermometric substance. Two bodies of equal temperature are, therefore, in thermal equilibrium, and vice versa.

The temperature readings of no two thermometric substances agree, in general, except at 0 ^{0}C and 100 ^{0}C. The definition of temperature is therefore somewhat arbitrary. This we may remedy to a certain extent by taking gases, in particular those hard to condense, such as hydrogen, oxygen, nitrogen, and carbon monoxide, and all so-called permanent gases as thermometric substances. They agree almost completely within a considerable range of temperature, and their readings are sufficiently in accordance for most purposes. Besides, the coefficient of expansion of these different gases is the same, inasmuch as equal volumes of them expand under constant pressure by the same amount about 1 \ 273 of their volume when heated from 0 ^{0}C to 1 ^{0}C. Since, also, the influence of the external pressure on the volume of these gases can be represented by a very simple law, we are led to the conclusion that these regularities are based on a remarkable simplicity in their constitution, and that, therefore, it is reasonable to define the common temperature given by them simply as temperature. We must consequently reduce the readings of other thermometers to those of the gas thermometer.

The definition of temperature remains arbitrary in cases where the requirements of accuracy cannot be satisfied by the agreement between the readings of the different gas thermometers, for there is no sufficient reason for the preference of any one of these gases. A definition of temperature completely independent of the properties of any individual substance, and applicable to all stages of heat and cold, becomes first possible on the basis of the second law of thermodynamics (160, etc.). In the mean time, only such temperatures will be considered as are defined with sufficient accuracy by the gas thermometer.

Source: Max Planck Treatise on Thermodynamics. DoverPublications. Apr 15, 2013.

4. Write out the words with the same root from the text, define their part of speech and translate them into Russian.

Example: compare (v) – comparison (n) сравнить (гл.) – сравнение (с.)

5. Decide if the following sentences are true or false. Correct the false ones.

- The definition of temperature is therefore somewhat arbitrary.
- For quantitative purposes the change of volume which takes place in all bodies when heated under constant pressure is not utilized.
- Heating produces a decrease of volume in most substances.

6. Continue the following sentences using your own ideas and the information from the text.

- The change of volume takes place …
- If two bodies, one of which feels warmer than the other, be brought together …
- To compare the degree of heat of two bodies …

7. Retell the text about temperature.

Text 1.3 Quantity of heat

1. Using a dictionary, practice pronouncing the following words. Translate these words and make up as many word combinations or sentences as you can.

iron; lead; weight; phenomenon; substance; causes; vice versa; quantity; equal; through; certain; supply; measurements.

2. **With a partner, discuss the questions below. Make a list of possible answers. Compare your ideas with other students**.

- Are there any differences between temperature and quantity of heat?
- How can the unit of heat be defined?
- How much does a given amount of heat transfer change the temperature of a substance?

3. Read the text to check your answers.

If we plunge a piece of iron and a piece of lead, both of equal weight and at the same temperature (100 ^{0}C.), into two precisely similar vessels containing equal quantities of water at 0 ^{0}C., we find that, after thermal equilibrium has been established in each case, the vessel containing the iron has increased in temperature much more than that containing the lead. Conversely, a quantity of water at 100 ^{0}C is cooled to a much lower temperature by a piece of iron at 0 ^{0}C, than by an equal weight of lead at the same temperature. This phenomenon leads to a distinction between temperature and quantity of heat. As a measure of the heat given out or received by a body, we take the increase or decrease of temperature which some normal substance (e.g. water) undergoes when it alone is in contact with the body, provided all other causes of change of temperature (as compression, etc.) are excluded. The quantity of heat given out by the body is assumed to be equal to that received by the normal substance, and vice versa. The experiment described above proves, then, that a piece of iron in cooling through a given interval of temperature gives out more heat than an equal weight of lead (about four times as much), and conversely, that, in order to bring about a certain increase of temperature, iron requires a correspondingly larger supply of heat than lead.

It was, in general, customary to take as the unit of heat that quantity which must be added to 1 gr. of water to raise its temperature from 0 ^{0}C to 10 ^{0}C (zero calorie). This is almost equal to the quantity of heat which will raise 1 gr. of water 1 ^{0}C at any temperature. The refinement of calorimetric measurements has since made it necessary to take account of the initial temperature of the water, and it is often found convenient to define the calorie as that quantity of heat which will raise 1 gr. of water from 14.5 ^{0}C to 15.5 ^{0}C. This is about 1 / 1.008 of a zero calorie. Finally, a mean calorie has been introduced, namely, the hundredth part of the heat required to raise 1 gr. of water from 0 ^{0}C to 100 ^{0}C. The mean calorie is about equal to the zero calorie. Besides these so-called small calories, there are a corresponding number of large or kilogram calories, which contain 1000 small calories.

Source: Max Planck Treatise on Thermodynamics. DoverPublications. Apr 15, 2013.

4. a) Here are some of the words from the text. Check you know what they mean. Try to remember the sentence in the passage in which you saw them.

hundredth; quantity; exclude; general; add; mean; measurements; cool.

b) In pairs, look back at the passage and check.

c) Decide what part of speech they are (noun, verb or adjective). Then, underline the verbs. Which nouns go with them? Compare with your partner.

5. Decide if the following sentences are true or false. Correct the false ones.

- A piece of iron in cooling gives out more heat than an equal weight of lead.
- To bring about a certain increase of temperature, lead requires a larger supply of heat than iron.
- The mean calorie is not equal to the zero calorie.

6. **Explain the meaning of the following terms from the text in English. Find their Russian equivalents.**

quantity of heat; unit of heat; to cool; temperature interval.

7. Write a summary of the text.

Text 1.4 Energy

1. Using a dictionary, practice pronouncing the following words. Translate these words and make up as many word combinations or sentences as you can.

motion; nuclear; chemical; thermal; microscopic; natural; science; hydrogen; hydroelectric; hurricane; photosynthesis; carbohydrate.

2. With a partner, discuss the questions below. Make a list of possible answers. Compare your ideas with other students.

- When does a body possess energy?
- Do you know what types of energy are of the greatest demand currently?

3. Read the text to check your answers.

Energy is the capacity to do work. Energy comes in various forms, such as motion, heat, light, electrical, chemical, nuclear energy, and gravitational. Total energy is the sum of all forms of the energy a system possesses. In the absence of magnetic, electrical and surface tension effects, the total energy of a system consists of the kinetic, potential, and internal energies. The internal energy of a system is made up of sensible, latent, chemical, and nuclear energies. The sensible internal energy is due to translational, rotational, and vibrational effects of atoms and molecules.

Thermal energy is the sensible and latent forms of internal energy. The classification of energy into different ‘‘types’’ often follows the boundaries of the fields of study in the natural sciences. For example, chemical energy is the kind of potential energy stored in chemical bonds, and nuclear energy is the energy stored in interactions between the particles in the atomic nucleus. Microscopic forms of energy are related to the molecular structure of a system and they are independent of outside reference frames. Hydrogen represents a store of potential energy that can be released by fusion of hydrogen in the Sun. Some of the fusion energy is then transformed into sunlight, which may again be stored as gravitational potential energy after it strikes the earth. For example, water evaporates from the oceans, may be deposited on elevated parts of the earth, and after being released at a hydroelectric dam, it can drive turbines to produce energy in the form of electricity. Atmospheric phenomena like wind, rain, snow, and hurricanes, are all a result of energy transformations brought about by solar energy on the atmosphere of the earth. Sunlight is also captured by plants as chemical potential energy in photosynthesis, when carbon dioxide and water are converted into carbohydrates, lipids, and proteins. This chemical potential energy is responsible for growth and development of a biological cell. British thermal unit (Btu) is the energy unit in the English system needed to raise the temperature of 1 lbm of water at 68 ^{0}F by 1 ^{0}F. Calorie is the amount of energy in the metric system needed to raise the temperature of 1 g of water at 15 ^{0}C by 1 ^{0}C.

Source: https://www.coursehero.com/file/12802241/Energy-forms-transformation/

4. a) Look at the way these nouns are formed.

noun	stem	suffix
prediction	predict (verb)	+ (a)tion
constructor	construct (verb)	+ (e) or
equipment	equip (verb)	+ ment

b) Using a dictionary, check that you understand the meaning of the words below and put them into the correct columns in the table. In which does the pronunciation change?

organize, disagree, prepare, construct, relate, develop, base, produce, describe

ment	ness	ity	tion	or

5. Decide if the following sentences are true or false. Correct the false ones.

- Energy is defined as the capacity of a system to do work or the capacity to cause change, such as synthesizing molecules or moving objects.
- One form of energy cannot be transformed into another one.
- The falling weight performs work.

6. **Continue the following sentences using your own ideas and the information given in the passage.**

- To transfer mechanical energy over a great distance …
- Kinetic energy is …
- Calorie is the amount of energy…

7. Write a summary of the text.

Text 1.5 Energy types. Primary and secondary energy

1. Using a dictionary, practice pronouncing the following words. Translate these words and make up as many word combinations or sentences as you can.

capture; environment; important; supply; hydropower; sufficiently; primary; record; type; natural; renewable.

2. With a partner, discuss the questions below. Make a list of possible answers. Compare your ideas with other students.

- Is waste primary energy?
- In the definition of primary energy, what should be the class? a. Sources b. Natural resources and waste
- In the definition of secondary energy, what should be the class? a. Sources b. Commodities
- Is there a statistical need to classify electricity as primary and secondary energy? a. If yes, should this be incorporated into a new definition, or b. could other terms be used to avoid confusion and double counting?

3. Read the text to check your answers.

Primary and secondary types of energy are the two main types. Primary energy is extracted or captured directly from the environment, while the secondary energy is converted from the primary energy in the form of electricity or fuel. Distinguising the primary and secondary energy sources are important in the energy balances to count and record energy supply, transformations, and losses. Primary energy is the energy extracted or captured directly from the environment. Three distinctive groups of primary energy are:

• Nonrenewable energy (fossil fuels): coal, crude oil, natural gas, nuclear fuel.

• Renewable energy: hydropower, biomass, solar energy, wind, geothermal, and ocean energy.

• Waste.

Primary sources of energy consisting of petroleum, coal, and natural gas amount to about 85% of the fossil fuels in primary energy consumption in the world. Projected energy use in the world shows that petroleum, coal, and natural gas will still be the dominant energy sources by 2035. The principle of supply and demand suggests that as fossil fuels diminish, their prices will rise and renewable energy supplies, particularly biomass, solar, and wind resources, will become sufficiently economical to exploit.

Distinguising the primary and secondary energy sources are important in the energy balances to count and record energy supply, transformations, and losses.The primary energy is transformed to secondary energy in the form of electrical energy or fuel, such as gasoline, fuel oil, methanol, ethanol, and hydrogen. The primary energy of renewable energy sources, such as sun, wind, biomass, geothermal energy, and flowing water is usually equated with either electrical or thermal energy produced from them. Final energy is often electrical energy and fuel, which is referred to as useful energy. The selected four types of final energy are electrical, thermal, mechanical, and chemical energy. These types of final energy set a boundary between the energy production and the consumption sectors.

Source: http://www.biologydiscussion.com/energy/classification-of-energy-resources-primary-and-secondary-environment/16707

4. Define what parts of speech the words in bold belong to. Translate the following word combinations or sentences.

1. A reliable simple method for prediction of the standard Gibbs **energy** of formation of **energetic** compounds containing nitroaromatic, acyclic, and cyclic nitramine and nitroaliphatic compounds is introduced herein.
2. Investments have largely returned to pre-crisis levels and helped the metallurgical industry **recover**. Its overall influence on economic **recovery** is currently complex and difficult to evaluate.
3. **Technical** progress; highly skilful **technician**; modern **technique**.
4. In the course of **smelting** activity; the **smelted** iron ore. Cooper has been **smelted** for many thousand years.
5. One can use a **hammer**. **Hammering** is a very important process.The **hammered** sword is the best one.

5. Reread the passage and make up 5 yes-no questions and 5 questions with a question word. Ask and answer them with your partner.

6. Translate the following sentences into English.

Первичная энергия — форма энергии в природе, которая не была подвергнута процессу искусственного преобразования.

Первичная энергия может быть получена из невозобновляемых или возобновляемых источников энергии. В энергетике, источник первичной энергии относится к форме энергии, которая требуется энергетическому сектору для преобразования и совершения последующей поставки, полученных энергоносителей в целях их использования человеческим обществом.

7. **Discuss in groups what you have learnt about energy types**.

Text 1.6 Non Renewable Energy Sources

1. Using a dictionary, practice pronouncing the following words. Translate these words and make up as many word combinations or sentences as you can.

combustible; lignite; bituminous; ignite; impurity; sulfur; nitrogen; combustor; weight; alkane; hydrogen; mixture.

2. What do you know about non renewable energy sources? Write questions you expect the text to provide answers to. Compare your ideas with your partner's ones.

3. Read the following passage to check if you were right.

It is generally accepted that nonrenewable energy sources or fossil fuels are formed from the remains of dead plants and animals by exposure to heat and pressure in the earth's crust over the millions of years. Major nonrenewable energy sources are coal, petroleum, natural gas, nuclear energy.

Coals are sedimentary rocks containing combustible and incombustible matters as well as water. Coal comes in various composition and energy content depending on the source and type. The poorest lignite has less than 50% carbon and an energy density lower than wood. Anthracites have more than 90% carbon, while bituminous coals mostly between 70 and 75%. Bituminous coal ignites easily and burns with a relatively long flame. If improperly fired, bituminous coal is characterized with excess smoke and soot. Anthracite coal is very hard and shiny and the ultimate maturation.Anthracite coal creates a steady and clean flame and is preferred for domestic heating. Furthermore it burns longer with more heat than the other types. It was in the 1880s when coal was first used to generate electricity for homes and factories. Since then coal played a major role as source of energy in the industrial revolution. Coal has impurities like sulfur and nitrogen and when it burns the released impurities can combine with water vapor in the air to form droplets that fall to earth as weak forms of sulfuric and nitric acid as acid rain. Coal also contains minerals, which do not burn and make up the ash left behind in a coal combustor. Carbon dioxide is one of several gases that can help trap the earth's heat and, as many scientists believe, cause the earth's temperature to rise and alter the Earth's climate. Because of high carbon content, coals generate more CO_2 per unit of released energy than any other fossil fuel such as crude oil.

Oil is a naturally occurring flammable liquid consisting of a complex mixture of hydrocarbons of various molecular weights, which define its physical and chemical properties, like heating value, color, and viscosity. The composition of hydrocarbons ranges from as much as 97% by weight in the lighter oils to as little as 50% in the heavier oils. The hydrocarbons in crude oil are mostly alkanes, cycloalkanes and various aromatic hydrocarbons while the other organic compounds contain nitrogen, oxygen, sulfur, and trace amounts of metals. The relative percentage of each varies and determines the properties of oil.

- Alkanes, also known as paraffin, are saturated hydrocarbons with straight or branched chains containing only carbon and hydrogen and have the general formula C_nH_{2n}+2. They generally have from 5 to 40 carbon atoms per molecule. For example, CH_4 represents the methane, which is a major component of natural gas. The propane (C_3H_8) and butane (C_4H_{10}) are known as petroleum gases. At the heavier end of the range, paraffin wax is an alkane with approximately 25 carbon atoms, while asphalt has 35 and up. These long chain alkanes are usually cracked by modern refineries into lighter and more valuable products.

- Cycloalkanes, also known as naphthenes, are saturated hydrocarbons which have one or more carbon rings to which hydrogen atoms are attached according to the formula C_nH_{2n}. Cycloalkanes have similar properties to alkanes but have higher boiling points.

- Aromatic hydrocarbons are unsaturated hydrocarbons which have one or more six-carbon rings called benzene rings with double and single bonds and hydrogen atoms attached according to the formula CnHn.

Natural gas is a naturally occurring mixture, consisting mainly of methane. The International Energy Agency predicts that the demand for natural gas will grow by more than 67% through 2030. Natural gas is becoming increasingly popular as an alternative transportation fuel. Typical theoretical flame temperature of natural gas is 1960 ^{0}C (3562 ^{0}F), ignition point is 593 ^{0}C. Natural gas is a major source of electricity production through the use of gas turbines and steam turbines. It burns more cleanly and produces about 30% less carbon dioxide than burning petroleum and about 45% less than burning coal for an equivalent amount of heat produced. Combined cycle power generation using natural gas is thus the cleanest source of power available using fossil fuels, and this technology is widely used wherever gas can be obtained at a reasonable cost. The gross heat of combustion of one cubic meter of natural gas is around 39 MJ and the typical caloric value is roughly 1,000 Btu per cubic foot, depending on gas composition.

Nuclear energy plants produce electricity through the fission of nuclear fuel, such as uranium, so they do not pollute the air with harmful gases. Nuclear fission is a nuclear reaction in which the nucleus of an atom splits into smaller parts, often producing free neutrons and photons in the form of gamma rays and releasing large amounts of energy. Nuclear fuels undergo fission when struck by free neutrons and generate neutrons leading to a self-sustaining chain reaction that releases energy at a controlled rate in a nuclear reactor. This heat is used to produce steam to be used in a turbine to produce electricity. This is similar to most coal, oil, and gasfired power plants. Typical fission release about two hundred million eV (200 MeV) of energy, which is much higher than most chemical oxidation reactions. The energy of nuclear fission is released as kinetic energy of the fission products and fragments, and as electromagnetic radiation in the form of gamma rays in a nuclear reactor. The energy is converted to heat as the particles and gamma rays collide with the atoms that make up the reactor and its working fluid, usually water or occasionally heavy water. The products of nuclear fission, however, are far more radioactive than the heavy elements which are normally fissioned as fuel, and remain so for a significant amount of time, giving rise to a nuclear waste problem.

Source: International Journal of Science and Research (IJSR). Issue № 6.2015.

4. Write out the words with the same root from the text, define their part of speech and translate them into Russian.

Example: evident (adj.) – evidence (n.) очевидный (прил.) – доказательство (сущ.)

5. Match the highlighted words with their meaning.

A. The use of nuclear reactions that release nuclear energy to generate heat, which most frequently is then used in steam turbines to produce electricity in a nuclear power plant.
B. An organic compound consisting entirely of hydrogen and carbon.
C. Types of rock that are formed by the accumulation or deposition of small particles and subsequent cementation of mineral or organic particles on the floor of oceans or other bodies of water at the Earth's surface.
D. Any nonpolar chemical substance that is a viscous liquid at ambient temperatures and is both hydrophobic and lipophilic. It has a high carbon and hydrogen content and is usually flammable and surface active.

6. Continue the following sentences using your own ideas and the information given in the passage.

- As for the origin of fossil fuels they have been formed by ...
- According to the latest information the main sources of energy are ... .
- As it is known fossil fuels are mostly associated with ...
- As far as petroleum is concerned, it can be found in ...
- Generally speaking, all types of fuel are important …

7. **Give a presentation on fossil fuels using some expressions given in brackets.**

- Fossil fuels as a source of energy, their origin, *(to represent, energy, the decay of organic materials, to accumulate, to be found in, to*be abundant in)
- The types of fossil fuels. Solid fuels, natural and manufactured, their usage, *(to divide into, to include, to obtain)*
- Liquid fuels. Petroleum, its origin, occurrence and usage, *(to be derived from, to contain, to be associated with, to be found in)*
- Gaseous fuels and their use in the economy *(to make it pos sible, to be widely used, to be of importance).*

Text 1.7 Heat transfer

1. Using a dictionary, practice pronouncing the following words. Translate these words and make up as many word combinations or sentences as you can.

capacity; substance; conduction; liquid; mechanism; transparent; buoyancy; bulk; motion; pushing; occur; inadvertently.

2. In pairs, discuss the following questions.

- Which of the following is concerned with both heat and mass transfer?

1. Lewis relationship
2. Nusselt number
3. Kutateladze number
4. Froude number

- Thermal conductivity of a conducting solid material depends upon its

1. temperature
2. porosity
3. both (1) & (2)
4. neither (1) nor (2)

3. Choose the most suitable heading from the list A-C for each paragraph of the text.

A. Convection
B. Radiation
C. Conduction

Energy is defined as the capacity of a substance to do work. It is a property of the substance and it can be transferred by interaction of a system and its surroundings. The different types of heat transfer are usually referred to as ‘modes of heat transfer’. There are three of these: conduction, convection and radiation.

1. ____________This occurs at molecular level when a temperature gradient exists in a medium, which can be solid or fluid. Heat is transferred along that temperature gradient by conduction. The conductive transfer is of immediate interest through solid materials. However, conduction within fluids is also important as it is one of the mechanisms by which heat reaches and leaves the surface of a solid. Moreover, the tiny voids within some solid materials contain gases that conduct heat, albeit not very effectively unless they are replaced by liquids, an event which is not uncommon. Provided that a fluid is still or very slowly moving, the following analysis for solids is also applicable to conductive heat flow through a fluid.

2. _____________Happens in fluids in one of two mechanisms: random molecular motion which is termed diffusion or the bulk motion of a fluid carries energy from place to place. Convection can be either forced through for example pushing the flow along the surface or natural as that which happens due to buoyancy forces. Convection heat transfer occurs both due to molecular motion and bulk fluid motion. Convective heat transfer may be categorised into two forms according to the nature of the flow: natural convection and forced convection. In natural of ‘free’ convection, the fluid motion is driven by density differences associated with temperature changes generated by heating or cooling. In other words, fluid flow is induced by buoyancy forces. Thus the heat transfer itself generates the flow which conveys energy away from the point at which the transfer occurs. In forced convection, the fluid motion is driven by some external influence. Examples are the flows of air induced by a fan, by the wind, or by the motion of a vehicle, and the flows of water within heating, cooling, supply and drainage systems. In all of these processes the moving fluid conveys energy, whether by design or inadvertently.

3. __________Occurs where heat energy is transferred by which the sun is a particularly important source. It happens between surfaces at different temperatures even if there is no medium between them as long as they face each other. While both conductive and convective transfers involve the flow of energy through a solid or fluid substance, no medium is required to achieve radiative heat transfer. Indeed, electromagnetic radiation travels most efficiently through a vacuum, though it is able to pass quite effectively through many gases, liquids and through some solids, in particular, relatively thin layers of glass and transparent plastics.

In many practical problems, these three mechanisms combine to generate the total energy flow, but it is convenient to consider them separately at this introductory stage.

Source: Chris Long, Naser Sayma Heat Transfe /Ventus publishing ApS. 2009.

4. Write out the words with the same root from the text, define their part of speech and translate them into Russian.

Example: efficiency (n) – efficient (adj) эффективность (сущ.) – эффективный (прил.)

5. Do you agree with the following statements? Give your reasons.

1. The direct transfer of heat from one substance to another substance that is touching is referred to as convection.
2. The transfer of heat by the movement of a fluid is radiation.
3. The transfer of thermal energy between materials by the collision of particles is called conduction.

6. In pairs discuss the term *heat transfer*. Give some examples of this phenomenon you are familiar with.

7. Write down a summary of the facts you have learned about heat transfer (100-150 words) and get ready to retell the text about this process.

Multiple choice assessment

1 The units of heat flux are:

A. Watts
B. Joules

C. Joules / meters^2
D. Watts / meters^2
E. Joules / Kg K

2 The units of thermal conductivity are:

A. Watts / meters^2 K
B. Joules
C. Joules / meters^2
D. Joules / second meter K
E. Joules / Kg K

3. The heat transfer coefficient is defined by the relationship:

A. h = m Cp T
B. h = k / L
C. h = q / T
D. h = Nu k / L
E. h = Q / T

4. Which of these materials has the highest thermal conductivity?

A. air
B. water
C. mild steel
D. titanium
E. aluminium

5. In which of these is free convection the dominant mechanism of heat transfer?

A. heat transfer to a piston head in a diesel engine combustion chamber
B. heat transfer from the inside of a fan-cooled p.c.
C. heat transfer to a solar heating panel
D. heat transfer on the inside of a central heating panel radiator
E. heat transfer on the outside of a central heating panel radiator

6. Which of these statements is not true?

A. conduction can occur in liquids
B. conduction only occurs in solids
C. thermal radiation can travel through empty space
D. convection cannot occur in solids
E. gases do not absorb thermal radiation

7. What is the heat flow through a brick wall of area 10 m^2, thickness 0.2m k = 0.1 W/m K with a surface temperature on one side of 20 ºC and 10 ºC on the other ?

A. 50 Watts
B. 50 Joules
C. 50 Watts / m^2
D. 200 Watts
E. 200 Watts / m^2

8. The governing equations of fluid motion are known as:

A. Maxwell's equations
B. C.F.D.
C. Reynolds – Stress equations
D. Lame's equations
E. Navier – Stokes equations

9. A pipe of surface area 2m^2 has a surface temperature of 100 ºC, the adjacent fluid is at 20 ºC, and the heat transfer coefficient acting between the two is 20 W/m^2K. What is the heat flow by convection?

A. 1600 W
B. 3200 W
C. 20 W
D. 40 W
E. Zero

Source: http:Metallurgical%20Furnaces%20

UNIT II. METALLURGICAL FURNACES

1. In groups, make a list of words or phrases you already know related to metallurgical furnaces.

2. Read the title of the article given below. Try to predict its main issues.

3. Read the following passage and check if your gueses were correct.

Text 1.1 Rotary Kilns

A rotary kiln is an inclined, rotating cylindrical reactor through which a charge moves continuously. The rotary kiln is used when thermal processing of solids that is more severe than drying is required. The furnace walls make intermittent contact with the flue gas and the charge. Heat required for the various physical and chemical processes is delivered to the charge by lifting and overturning the charge as it moves through the interior of the rotary kiln.

The rotary kiln consists of a lined hollow cylinder, mounted in an inclined position on rolls and rotated slowly by a drive. The charge material moves from the feed end to the discharge as a result of the rotary motion and gravity. The inclination is between 1.5 and 5% and varies only in experimental kilns. Speed is between 0.2 and 2rpm; variable-speed drives used to control the residence time are common. Kiln diameter is usually constant over the full length. Diameters have increased to more than 7m, especially in the cement industry; kilns for wet cement processing can be more than 200m long. Some rotary kilns have internals such as conveying or lifting flights, built in crossed-hanging link chains, or ring dams. Air or other gases can also be introduced through ports in the lining.

The rotary kiln carries out several functions simultaneously: it is a device for conveying, mixing, heat transfer, and reaction. These functions must be in harmony. The charge in the kiln moves both radially and axially. Radial motion is determined by the degree of filling (percentage of cross-sectional area occupied by the charge) and the rotational speed. The angle of repose and the kiln inclination govern axial motion. The interior of the charge tends to have a higher bulk density than the exterior, and grain size increases toward the outside. This tendency can be counteracted by the internals, which also improve heat transfer into the charge. Dust production can be limited by pelletizing the feed.

Heat transfer occurs principally from the combustion gas (generated by a burner usually installed at the discharge end of the kiln) to the charge. The driving force is generally the temperature difference. The gas can move co- or countercurrent to the longitudinal motion of the charge. Cocurrent gas flow is advantageous only when the charge temperature does not have toexceed a certain value. The countercurrent arrangement is preferred because it involves increased total energy consumption. Rotary kilns were employed for the exothermic roasting of sulfidic ores and for the endothermic removal of water of hydration and carbon dioxide from fine-grained materials such as ores, phosphates, alumina, ilmenite, and titanium dioxide. Today these processes are performed almost exclusively in fluidized-bed reactors, which offer better heat- and mass-transport conditions. However, rotary kilns have advantages where softening, sticking, or even partial melting of the material cannot be avoided.

Source: http:Metallurgical%20Furnaces%20

4. Answer the following questions.

- What are the standard components and main parts of the rotary kiln?
- How does heat transfer occur in rotary kilns?
- Where are rotary kilns applied for?

Text 1.2 Multiple-Hearth Furnaces

1. Read the text to find the following information.

- The year of launching on industrial scales;
- The structure and features of multiple-hearth furnaces;
- Applications and materials.

From a dominant position as a roasting furnace for sulfide, the multiple-hearth furnace has been almost completely displaced by fluidized-bed roasting equipment since the 1960s. Fluidized-bed devices permit much higher throughputs than multiple-hearth furnaces, with substantially better control of reaction temperature and oxygen partial pressure in the roasting gas. Nonetheless, the multiple-hearth furnace will continue to find use in some special areas of process engineering. A multiple-hearth furnace consists of an internally lined steel cylinder with a number of horizontally mounted, lined platforms called hearths. The circular hearths are thinner near the center, which has an opening for a vertical shaft. An adjustable-speed drive with overload protection turns the shaft at 0.2 – 5 rpm. From one to four rabble arms per hearth are latched to the shaft in a gastight manner. These arms bear oblique stirring teeth to move the solids over the hearth; on one hearth the motion is from center to edge, on the next from edge to center depending on the inclination of the stirring teeth. The openings in the hearths, through which the charge travels from the top of the furnace to the bottom, therefore alternate from central to peripheral. Because of the high temperature in the furnace, the shaft and rabble arms are air cooled. The shaft has doublewalls; cool air supplied by a fan enters the outside space, passes through the shaft and arms, and exits the furnace at 200 – 300 ^{0}C by way of the center space. Each hearth has several doors, which allowmonitoring of the reaction and replacement of the rabble arms. The doors can be sealed tightly or can have adjustable air slots to admit cooling or combustion air if a slight subatmospheric pressure is maintained in the furnace. Multiple-hearth furnaces are built in various sizing, ranging from 2 to 8m in diameter and having 3 – 16 hearths. Residence time in the furnace is easily controlled by varying the shaft rotation speed or the number of rabble arms and teeth on each arm.

Ores that can be roasted only with great difficulty, such as molybdenum disulfide, are treated in multiple-hearth furnaces. Because roasting reactions are exothermic the furnace usually has to be heated only at the start of the process. The material fed to the top most hearths is distributed by the teeth on the rabble arms, slowly transported to the center of the hearth, and dried. Then the ore falls into the first croasting zone, where it is heated in contact with hot roasting gas until it ignites. The reaction goes to completion as the charge is transported further over the hearths. On the last hearths, roasting air drawn or blown into the furnace from the bottom is preheated by cooling the residue. The progress of the reaction is monitored by measuring the temperature on the individual hearths. The roasting of molybdenum disulfide is carried out at ca. 630 ^{0}C. The hearths on which the exothermic roasting reactions and occur are cooled by the admission of air or water. After the roasting reaction has gone largely to completion, the molybdenum dioxide product is oxidized to the trioxide. This reaction is not sufficiently exothermic to keep the temperature high enough to burn off the residual sulfur. In a furnace with a total of nine hearths, the seventh and eighth are therefore heated with oil or gas. For endothermic reactions such as the calcination of a magnesite, dolomite, bauxite, clay, or zinc carbonate, the heat required is delivered from outside into the furnace. If the feed materials can tolerate some overheating by flame radiation, one or more burners can be built into the furnace shell at the hearths where heating is required. Otherwise, hot flue gas is admitted at these locations after generation in one or more combustion chambers. Heat losses are higher and throughput capacities lower than those of fluidized-bed furnaces and rotary kilns, so the calcination reactions mentioned above are rarely carried out in multiple-hearth furnaces.The use of this type of equipment is restricted to residues containing vanadium and tungsten. The multiple-hearth furnace can also be used to oxidize tungsten- containing slags or residues from the metal fabrication industry (turning chips, grinding waste) in order to recycle the material in the form of WO_3 to tungsten production residues containing vanadium and tungsten.

Source: Sabrina Sopranzi Flash on English for technical assistance/ ESP series

2. Explain the meaning of the following terms from the text in English. Find their Russian equivalents.

Roasting; fluidized-bed roasting equipment; exothermic reactions; rabble arms; feed materials.

3. Do the following statements agree with the information in the article? Wrire TRUE if the statement agrees with the information. FALSE if the statement contradicts the information. NOT GIVEN if there is no information on this.

A. The multiple hearth furnace gasification system can accommodate commercial operations from 50-650 tons per day in a single train system.
B. The multiple hearth furnace has been utilized in the thermal reformation of solids since 1900.
C. Before the invention of the multiple-hearth furnaces, cement production was a much more laborious process. It was usually stirred continuously in a wheelbarrow or other receptacle equipment.
D. The multiple-hearth furnace can also be used to oxidize tungsten-containing slags or residues from the metal fabrication industry.

4. Write a summary of the facts you have learned about multiple-hearth furnaces (100-150 words).

Text 1.3 Shaft Furnaces

1. Read the text to find the following information

- Construction and profile of shaft furnaces;
- Shaft furnace reactions;
- Saving of resources.

The shaft furnaces have a variety of uses in metallurgy. The Rachette furnace is employed in lead production. The distinguishing feature of the lead blast furnace is that the throat widens upward. The products, lead bullion and slag, are obtained by reduction; the slag contains any zinc present as ZnO. The Imperial Smelting furnace was developed for the simultaneous processing of lead and zinc concentrates. It differs from ordinary lead blast furnaces by having a hot stack and a zinc splash condenser. The iron blast furnace is described in more detail as it is the most important type of shaft furnace.

The blast furnace has the form of two truncated cones set with their large bases together. The widening of the stack from top to bottom reduces the frictional resistance as the burden moves downward. Modern blast furnaces have a hearth diameter of 10 – 14m, a volume of 2000 – $4000m^3$, reach throat gas pressures of up to 0.35MPa, and have production capacities of $(1.5 - 3.5)\times 106$ t/a of pig iron. The blast furnace is divided into the following sections: throat, stack, bosh, and hearth. The blast furnace is charged with burden, coke, and additives via the charging platform (throat). The blast-furnace gas or top gas is also withdrawn from the furnace through the throat. For design reasons, the throat diameter should be kept as small as possible. The stack is conical and terminates in the throat at the top. It expands downward to the belly. The next section down is the bosh, which narrows toward the bottom and forms the transition to the blast-furnace hearth. The narrowing of the bosh corresponds to the decrease in burden volume as the coke is consumed. This cylindrical section has watercooled tuyeres through which the blast is introduced into the furnace. The hearth should have a relatively small diameter because the hot blast does not have a long penetration depth and otherwise would not reach the interior of the burden. The two main products of the furnace, slag and iron, collect in the hearth. Excess slag is withdrawn through slag holes, while the hot metal which has a higher density, is withdrawn through tap holes.

The main function of the iron blast furnace is to reduce iron oxides to metallic iron. The reducing melting of iron- containing substances takes place in a countercurrent arrangement; the ascending hot gas from coke combustion heats and reduces the descending burden.

Source: Sabrina Sopranzi Flash on English for technical assistance/ ESP series

2. Explain the meaning of the following terms from the text in English. Find their Russian equivalents.

3. Answer the following questions.

- What are the shaft furnace raw material requirements?
- Where are shaft furnaces used?
- Is it possible to recycle the shaft furnace by-products?

4. Write a summary of the facts you have learned about shaft furnaces (100-150 words).

Text 1.4 Smelting, Melting, and Refining in Bath and Flash Smelting Reactors

1. Read the text to find the following information

- Principles of design and use;
- Types of reactors.

Fine concentrates or secondaries can be smelted without agglomeration in flash (after drying) or bath smelting furnaces. The heat of exothermic chemical reactions provides the energy for autogenous smelting. All these furnaces are operated continuously.

In bath smelting furnaces and converters oxygen or oxygen-enriched air is blown into molten metal or matte baths via tuyeres (Fe, Cu), lances (Fe, Ni, Pb) or injectors (Fe) to oxidize elements that are to be removed as impurities. Coal or reducing gases may also be blown into molten slags via tuyeres, lances, and injectors for slag reduction (Pb). In the case of aluminum, chlorine is blown through pipes and stirrers into the molten metal bath to remove alkaline and alkaline-earth elements. Bath melting and refining furnaces are often used for melting, refining, and alloying metals. The furnace size ranges from 1 t to several hundred tons. These furnaces are operated batchwise and are fed with solid and liquid metal. They are of the stationary, tilting, or rotary type.

Converters are mainly used for

1) Conversion of pig iron together with scrap into steel;

2) Conversion of copper matte into blister copper and the refining of secondary black copper;

3) Refining of secondary aluminum;

4) Conversion of nickel matte into nickel and lead matte.

Source: Sabrina Sopranzi Flash on English for technical assistance/ ESP series

2. Explain the meaning of the following terms from the text in English. Find their Russian equivalents.

fine concentrates (secondaries); agglomeration; drying; to operate continuously; reducing gase; molten slag; refining; smelting process.

3. Answer the following questions.

- What is flash smelting?
- What can be produced in flash smelting furnaces?
- How do flash smelting furnaces operate?

4. Write a summary of the facts you have learned about bath and flash smelting reactors (100-150 words).

Text 1.5 Electrothermal Reactors

1. Read the passage to get a general idea of what electrothermal reactors are.

Resistance furnaces. In these furnaces heat transfer occurs either directly or indirectly according to Ohm’s and Joule’s laws. They can be operated in an a.c. or d.c. mode. Applications: Furnaces which implement direct resistance include:

1) Resistance furnaces for solid-state reactions, e.g., production of graphite and carbides.

2) Resistance furnaces for the production of copper, nickel, iron, tin, and zinc or their intermediate products from oxidic and sulfidic materials and slags.

3) Electroslag refining for the production of clean ferrous or nonferrous metals and alloys such as titanium, steels, and superalloys.

4) Furnaces that employ a combination of arc and resistance heating are used for the production of calcium carbide, ferroalloys, pig iron, phosphorus, and silicon compounds by reduction. Electrodes are situated within the charge; reduction and melting occur within the high-temperature zone around the electrodes.

5). Fused-salt electrolysis cells for the production of aluminum and alkali metals may also be considered to be electrochemical thermal reactors.

6) Salt-bath furnaces for the heat treatment of metals.

Indirect heating is mostly performed in a closed chamber in which heating elements, situated in the walls or suspended in the chamber; transfer their heat via radiation, conduction, and convection to the object to be heated. This type of furnace is applied for heat treatment of metals, ceramics, and for the production of carbides.

Arc furnaces. In arc furnaces the heating occurs because of the high temperature (>6000 ^{0}C) of a gas plasma created by the arc. These furnaces may be operated either in an a.c. or d.c. mode.

Induction furnaces. In induction furnaces the heat is generated according to Lenz's, Ohm's, and Joule's laws. Two types of furnaces are generally used for melting operations the crucible furnace and the channel furnace.

Electron-beam furnaces. In electronbeam furnaces electron guns produce high energy electrons, which impart their energy to the furnace charge to affect its melting.

Plasma furnaces. In these furnaces heating is performed by either transferred or nontransferred arc plasma torches. In contrast to arc furnaces, where arcs are produced between a graphite electrode and the charge, plasma furnaces use gas-stabilized plasma arcs produced by water-cooled plasma torches with nonconsumable electrodes.

Source: Sabrina Sopranzi Flash on English for technical assistance/ ESP series

2. Explain the meaning of the following terms from the text in English. Find their Russian equivalents.

arc furnaces; plasma furnaces; electron-beam furnaces ; induction furnaces; resistance furnaces.

3. Ask questions on all the parts of the following sentences.

- This type of furnace is applied for heat treatment of metals, ceramics, and for the production of carbides.
- In resistance furnaces heat transfer occurs either directly or indirectly according to Ohm's and Joule's laws.

4. a) Work in pairs. Imagine that you are starting a presentation. What phrases might you use? After you've thought, look below for some more ideas.

Useful Phrases:

Ladies and gentlemen, thank you very much for coming along here today.
The purpose of today's presentation is to discuss how we can…
Now let me begin by…
Secondly…
…and finally…
I'd be happy to invite you to ask questions at the end of the session.
At the end I'd be very happy to answer any of your questions.

b) It is the end of your presentation and you are asking if there are any questions. What phrases might you use or hear? Look below for some more ideas.

Useful Phrases:

If you have any questions, I would be happy to answer them now.
Are there any questions about any of that?
Yes, it's a very good question.
Can you explain …?

c) Prepare your own report on electrothermal reactors.

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