ИНОСТРАННЫЙ ЯЗЫК

АНГЛИЙСКИЙ ЯЗЫК В ОБЛАСТИ ОБОГАЩЕНИЯ ПОЛЕЗНЫХ ИСКОПАЕМЫХ

Методические указания к самостоятельной работе для студентов специальности 21.05.04

FOREIGN LANGUAGE

MINERAL PROCESSING ENGLISH

САНКТ-ПЕТЕРБУРГ
2019

Министерство науки и высшего образования Российской Федерации

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Санкт-Петербургский горный университет

Кафедра иностранных языков

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ИНОСТРАННЫЙ ЯЗЫК. Английский язык в области обогащения полезных ископаемых: Методические указания к самостоятельной работе / Санкт-Петербургский горный университет. Сост. *О.В. Токарева*. СПб, 2019. 46 с.

Методические указания предназначены для студентов специальности 21.05.04 «Горное дело» специализации «Обогащение полезных ископаемых». Материал, представленный в данных методических указаниях, направлен на формирование у студентов навыков работы со словарем, чтения и перевода специальной литературы. Тематика текстов и задания к ним способствуют накоплению словарного запаса, включающего в себя основные английские термины по специализации «Обогащение полезных ископаемых», а также частотные слова технического английского языка.

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ВВЕДЕНИЕ

Данные методические указания предназначены для студентов специальности 21.05.04 «Горное дело» специализации «Обогащение полезных ископаемых». Основной целью методических указаний является формирование у студентов навыков работы со словарем, навыков чтения и перевода специальной литературы.

Языковой материал делится на разделы, в каждом из которых описываются подготовительные, основные и вспомогательные процессы обогащения, а также оборудование обогатительных фабрик. Тексты сопровождаются заданиями, нацеленными на формирование у студентов словарного запаса как по специализации «Обогащение полезных ископаемых», так и в более широкой области технического английского языка.

Студентам рекомендуется работать с текстами в том порядке, в котором они представлены в методических указаниях, поскольку для введения лексических единиц используется последовательный принцип. Если студент желает ознакомиться с отдельными текстами или разделами, для лучшего освоения материала целесообразным будет выполнить в качестве подготовительной работы предтекстовые лексические задания в предыдущих разделах данных методических указаний.

UNIT 1. INTRODUCTION TO MINERAL PROCESSING

Text 1. Mineral Processing and Extractive Metallurgy

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: extractive metallurgy, ore, beneficiation, mineral dressing, coal, comminution, concentration, valuable constituent, treatment, sampling, sizing, dewatering, amount, property.

b) Verbs: refine, subject, require, prepare, separate, determine.

Task 2. Read the text and translate it into Russian.

Mineral processing is a major division in the science of extractive metallurgy. Extractive metallurgy has been defined as the science and art of extracting metals from their ores, refining them and preparing them for use. Within extractive metallurgy, the major divisions in the order they may most commonly occur are mineral processing (or beneficiation), hydrometallurgy, pyrometallurgy, and electrometallurgy. The field of mineral processing has also been given other titles such as mineral dressing, ore dressing, mineral extraction, mineral beneficiation, and mineral engineering. These terms are often used interchangeably.

Mineral processing is a broad term that includes a number of different processes and is, as a whole, one of the most important aspects of the overall mining operation. Most mined materials, from hard-rock ores to solid-fuel minerals such as coal, are subjected to some sort of size reduction and/or other beneficiation process. Often, several mineral processing operations are performed in sequence to produce a marketable product.

The primary operations in a modern mineral processing plant are comminution and concentration, but there are other operations which are required to prepare and classify ores before the valuable constituents can be separated or concentrated and then forwarded on for use or further treatment. Among these operations are sampling, sizing, and dewatering.

Mineral processors and extractive metallurgists also work with geologists thought most of the exploration phase to help identify the type and amount of minerals present and how they are associated with one another. After the minerals are identified and qualified, mineral processors and extractive metallurgists will catalog their properties and evaluate differences to determine which can be exploited to provide the best separation.

Text 2. Minerals, Ores and Run-Of-Mine Materials

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: compound, deposit, waste, gangue, ore body, processing facility, limestone, clay, diamond, gemstone, purity, application, content, copper.

b) Verbs: mine, extract, contain, consider, liberate, deliver.

c) Adjectives and adjective phrases: solid, naturally occurring, run-of-mine, value-bearing, metalliferous.

Task 2. Read the text and translate it into Russian.

In mineralogy and geology, minerals are defined as solid, inorganic, naturally occurring substances (elements or compounds) with a definite chemical formula and general structure. Ore is a term used to describe an aggregate of minerals from which a valuable constituent, especially a metal, can be profitably mined and extracted. Most rock deposits contain metals or minerals, but when the concentration of valuable minerals or metals is too low to justify mining, it is considered a waste or gangue material. Within an ore body, valuable minerals are surrounded by gangue and it is the primary function of mineral processing, to liberate and concentrate those valuable minerals.

Generally, mineral processing begins when an ore is delivered from a mine, to a processing facility. At this point, the ore is called run-of-mine material because there has been no treatment performed on it.

There are three primary types of run-of-mine materials:

1) Run-of-mine materials consisting of useful materials. These could include granites, building sand, limestone, coal and clays. Note that materials in this category are not classified as minerals.

2) Run-of-mine materials containing useful minerals. The minerals in this category among others include fluorite, apatite, diamonds and gemstones, vermiculite, barite, and chromite and are often referred to as industrial minerals. The unit value of this class of minerals is low but the purity is high, approaching a chemical grade. The minerals in this class

are used directly for industrial applications once they are separated from a gangue content that must be low to start with.

3) Run-of-mine containing value-bearing minerals. This class of run-of-mine is similar to the previous descriptions. In this case, however, the target mineral obtains its value from the contained metal and these categories of deposits are referred to as metalliferous. For example, an ore containing the mineral chalcopyrite ($CuFeS_2$) derives its value from the contained copper. Chalcopyrite does not in and of itself have any direct use as a mineral. Once chalcopyrite is concentrated (separated from the gangue), it requires further treatment to extract copper via hydrometallurgical or pyrometallurgical methods.

UNIT 2. PARTICLE SIZE ANALYSIS

Text 1. Test Sieving

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: sieving, particle, weight, sample, screen aperture, charge, bed of material, requirement.

b) Verbs: carry out, divide, blind, remove.

c) Adjectives: wet, dry, representative.

Task 2. Read the text and translate it into Russian.

Test sieving is the most widely used method for particle size analysis. It is accomplished by passing a known weight of sample material successively through finer sieves and weighing the amount collected on each sieve to determine the percentage weight in each size fraction. Sieving is carried out with wet or dry materials and the sieves are usually agitated to expose all the particles to the openings.

The process of sieving may be divided into two stages: first, the elimination of particles considerably smaller than the screen apertures, which should occur fairly rapidly and, second, the separation of the so-called "near-size" particles, which is a gradual process rarely reaching final completion. Both stages require the sieve to be manipulated in such a way that all particles have opportunities for passing the apertures, and so that any which blind an aperture may be removed from it. Ideally, each particle should be presented individually to an aperture, as is permitted for the largest aperture sizes, but for most sizes this is impractical.

The effectiveness of a sieving test depends on the amount of material put on the sieve (the 'charge') and the type of movement imparted to the sieve. If the charge is too large, the bed of material will be too deep to allow each one a chance to meet an aperture in the most favourable position for sieving in a reasonable time. The charge, therefore, is limited by a requirement for the maximum amount of material retained at the end of sieving appropriate to the aperture size. On the other hand, the sample must contain enough particles to be representative of the bulk, so a minimum size of sample is specified. In some cases, the sample will have to be subdivided into a number of charges if the requirements for preventing overloading of the sieves are to be satisfied.

Text 2. Sub-Sieve Techniques

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: sedimentation, elutriation, rate of settling, fluid, size range, fine particles, current, dilute suspension, particle size distribution.

b) Verbs: perform, observe, measure, scatter, detect.

c) Adjectives: separate, coarse.

Task 2. Read the text and translate it into Russian.

Sieving is rarely carried out on a routine basis below 38 μm; below this size the operation is referred to as sub-sieving. The most widely used methods are sedimentation, elutriation, microscopy, and laser diffraction, although many other techniques are available.

Sedimentation methods are based on the measurement of the rate of settling of the powder particles uniformly dispersed in a fluid. The method is simple and cheap, and has the advantage over many other sub-sieve techniques in that it produces a true fractional size analysis, i.e. reasonable quantities of material in specific size ranges are collected, which can be analysed chemically and mineralogically. This method is, however, extremely tedious, as long settling times are required for very fine particles, and separate tests must be performed for each particle size.

Elutriation is a process of sizing particles by means of an upward current of fluid, usually water or air. The process is the reverse of gravity sedimentation.

Microscopy can be used as an absolute method of particle size analysis since it is the only method in which individual mineral particles are observed and measured. The image of a particle seen in a microscope is two-dimensional and from this image an estimate of particle size must be made.

Laser diffraction instruments are fast, easy to use, and give very reproducible results. In these instruments, laser light is passed through a dilute suspension of the particles which circulate through an optical cell. The light is scattered by the particles, and is detected by a solid state detector which measures light intensity over a range of angles. A theory of light scattering is used to calculate the particle size distribution from the light distribution pattern, finer particles inducing more scatter than coarse.

However, light scattering theory does not give a definition of size that is compatible with other methods, such as sieving. In most mineral processing applications, for example, laser diffraction size distributions tend to appear coarser than those of other methods. In addition, the results can depend on the relative refractive indices of the solid particles and liquid medium (usually water), and even particle shape. For these reasons, laser diffraction size analysers should be used with caution.

UNIT 3. COMMINUTION

Text 1. Basics of Comminution

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: blasting, explosives, mill, crushing, grinding, degree of liberation, compression, impact, surface, abrasion, motion, rod, pebble, reduction ratio, tumbling mill, slurry feed.

b) Verbs: reduce, handle.

Task 2. Read the text and translate it into Russian.

Comminution is the process in which the particle size of the ore is progressively reduced until the valuable components can be separated from the waste rock.

Blasting – the controlled use of explosives in mining aimed at removing ores from their natural beds – can be regarded as the first stage in comminution. In order to make the freshly excavated material easier to handle by scrapers, it is broken into smaller pieces, which can also be considered as comminution.

Comminution in the mineral processing plant, or 'mill', takes place as a sequence of crushing and grinding processes. Crushing reduces the particle size of run-of-mine ore to such a level that grinding can be carried out until the mineral and gangue are substantially produced as separate particles. The processes of crushing and grinding will produce a range of particles with varying degrees of liberation (Figure 1).

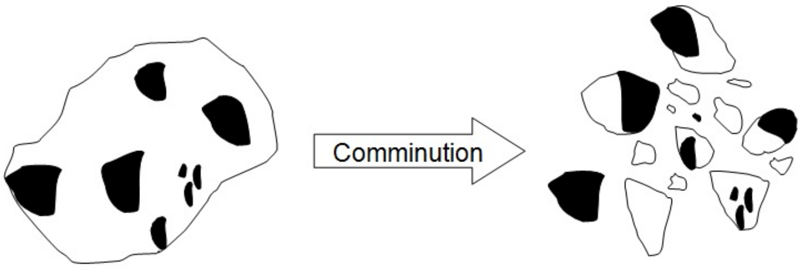

Figure 1. Varying degrees of liberation. The black regions represent the valuable mineral.

Crushing is accomplished by compression of the ore against rigid surfaces, or by impact against surfaces in a rigidly constrained motion path. This is contrasted with grinding which is accomplished by abrasion and impact of the ore by the free motion of unconnected media such as rods, balls, or pebbles.

Crushing is usually a dry process, and is performed in several stages, reduction ratios being small, ranging from three to six in each stage. The reduction ratio of a crushing stage can be defined as the ratio of maximum particle size entering to maximum particle size leaving the crusher, although other definitions are sometimes used.

Tumbling mills with either steel rods or balls, or sized ore as the grinding media, are used in the last stages of comminution. Grinding is usually performed 'wet' to provide a slurry feed to the concentration process, although dry grinding has limited applications. There is an overlapping size area where it is possible to crush or grind the ore.

Text 2. Primary Crushers: Jaw and Gyratory Crushers

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: crushing circuit, jaw crusher, gyratory crusher, compressive force, bottom, gap, shell, spindle, frame.

b) Verbs: feed, gyrate.

c) Adjectives: primary, secondary, stationary, movable, concave.

Task 2. Read the text and translate it into Russian.

Within the crushing circuit, a primary crusher reduces material down to a size that can be conveyed and fed to the secondary crushing circuit. The two most common primary crushers used for coarse run-of-mine material are the jaw and gyratory crushers. These primary crushers break rock through compressive forces created by a hard moving surface forcing and squeezing the rocks towards a hard stationary surface.

A jaw crusher reduces large rocks by dropping them into a flat V-shaped space created between a fixed surface and a movable surface. The compression is created by forcing the rock against the stationary plate as shown in Figure 2.

The opening at the bottom of the jaw plates is the crusher product size gap. The rocks remain in the jaws until it is small enough to pass through this adjustable gap at the bottom of the jaws.

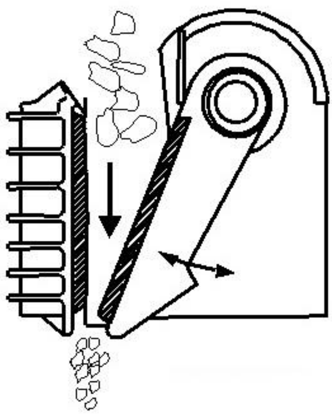

Figure 2. Jaw crusher

In a gyratory crusher, a round moving crushing surface is located within a round hard shell which serves as the stationary surface (Figure 3). The crushing action is created by closing the gap between the hard crushing surface attached to the spindle and the concave liners mounted on the main frame of the crusher. The gap is opened and closed by an eccentric drive on the bottom of the spindle that causes the central vertical spindle to gyrate.

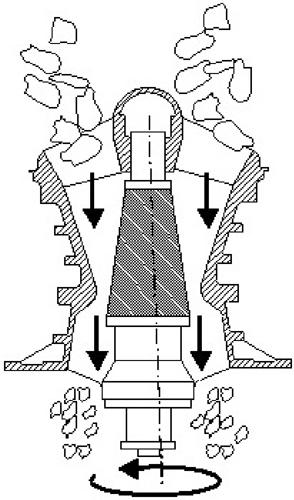

Figure 3. Gyratory crusher

Text 3. Secondary Crushers: Cone, Impact and Roll Crushers

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: cone crusher, dimension, throw, hammer, discharge grate, wear.

b) Verbs: flow, permit, involve, utilise, consist.

c) Adjectives: additional, rotating, soft, inner, tertiary, opposite.

Task 2. Read the text and translate it into Russian.

The most common type of secondary crusher is the cone crusher (Figure 4). A cone crusher is very similar to the gyratory crusher but has a much shorter spindle with a larger diameter crushing surface relative to its vertical dimension. The eccentric motion of the inner crushing cone is similar to that of the gyratory crusher.

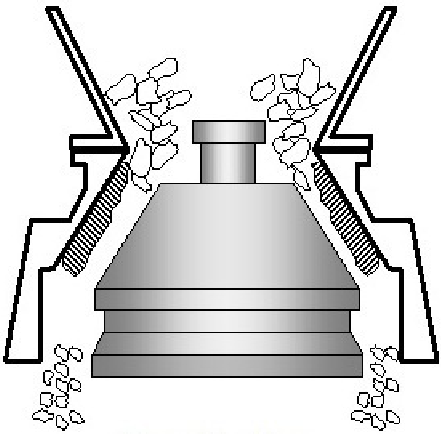

Figure 4. Cone crusher

The throw of cone crushers can be up to five times that of primary crushers, which must withstand heavier working stresses. They are also operated at much higher speeds. The material passing through the crusher is subjected to a series of hammer-like blows rather than being gradually compressed as by the slowly moving head of the gyratory crusher.

The high-speed action allows particles to flow freely through the crusher, and the wide travel of the head creates a large opening between it and the bowl when in the fully open position. This permits the crushed fines to be rapidly discharged, making room for additional feed.

Impact crushers (Figure 5) involve the use of high speed impact rather than compression to crush material. They utilise hinged or fixed heavy metal hammers or bars attached to the edges of horizontal rotating disks. The bars repeatedly strike the material to be crushed. Then the material is thrown against a rugged solid surface which further degrades the particle size. Finally, the material is forced over a discharge grate or screen by the hammers through which the finer particles drop while larger particles are swept around for another crushing cycle until they are fine enough to fall through a discharge grid. This type of crusher is normally used on soft materials such as coal or limestone due to the high wear experienced by the impact hammers, bars and inner surfaces. These crushers are normally employed for secondary or tertiary crushing.

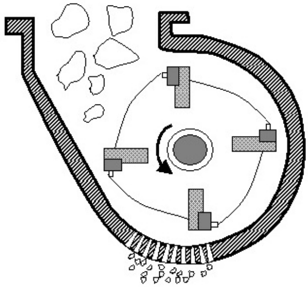

Figure 5. Basic elements of an impact crusher

Rolls crushers (Figure 6) consist of a pair of horizontal cylindrical rollers through which material is passed. The two rollers rotate in opposite directions and crush material between them. These types of crushers are used in secondary or tertiary crushing applications. They are seeing a significant increase in use due to advances in their design and the improved liberation of minerals in the crushed product.

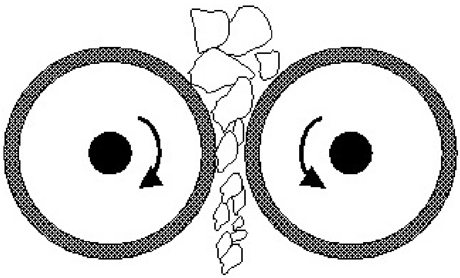

Figure 6. Basic elements of a rolls crusher

Text 4. Grinding Mills

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: grinding media, volume, downstream processing, rod mill, maintenance, ball mill, pebble mill, iron.

b) Verbs: range, prevent, avoid, install, exceed, obtain.

c) Adjectives: autogenous, semi-autogenous, inconsistent.

Task 2. Read the text and translate it into Russian.

Autogenous (AG) and semi-autogenous (SAG) milling has seen increased use in recent years, especially in large mineral processing operations. These mills typically have a large diameter relative to their length, typically in the ratio or 2 or 2.5 to 1. AG mills (Figure 7) employ ore as the grinding media. However, one of the challenges with AG mills is that properties of the ore can vary, resulting in inconsistent grinding behaviour. The addition of steel grinding balls rectifies this situation. This approach is then termed semi-autogenous grinding and the total amount of balls in these mills ranges between 5 and 10 percent of the volume.

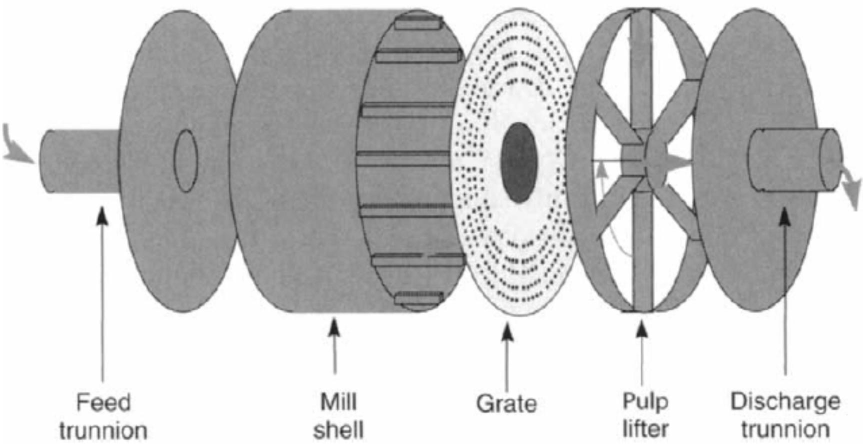

Figure 7. Schematic of various sections of an AG mill

The products from AG or SAG mills typically feed secondary grinding mills with particles that range in size from 5 cm down to below 100 microns (0.1 mm). The final particle size is determined by downstream processing requirements. Grinding is carried out as a wet process with water content between 50 – 70% by weight.

Rod mills are long cylinders filled with steel rods that grind by compressive forces and abrasion. The length of the cylinder is typically 1.5 to 2.5 times longer than the diameter. As the mill turns, the rods cascade over each other in relatively parallel fashion. One of the primary advantages of a rod mill is that it prevents over-grinding of softer particles because coarser particles act as bridges and preferentially take the compressive forces. Rod mills can take particles as coarse as 5 cm. Many of the newer operations tend to install ball mills in combination with SAG mills and avoid rod mills due to the cost of the media, the cost of replacing rods, and general maintenance costs. Many older operations have rod mills in combination with ball mills.

Ball mills have a similar shape to that of the rod mill except that they are shorter, with length to diameter ratios of 1 to 1.5. As the name implies, the grinding media in these mills are steel balls. The particle size of the feed usually does not exceed 2.5 cm. A ball mill grinds material by rotating a cylinder with steel grinding balls, causing the balls to fall back into the cylinder and onto the material to be ground. The rotation is usually between 4 to 20 revolutions per minute, depending upon the diameter of the mill. The larger the diameter, the slower the rotation. If the peripheral speed of the mill is too great, it begins to act like a centrifuge and the balls do not fall back, but stay on the perimeter of the mill.

Pebble mills are similar to ball mills except that rocks or pebbles are used as the grinding media. These mills can be used where product contamination by iron from steel balls must be avoided. Quartz and silica are commonly used because they are inexpensive to obtain.

UNIT 4. SCREENING

Text 1. Basics of Industrial Screening

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: screening, fineness, equipment, objective, purpose, unit process, scalping, grading, quarrying, media recovery, dense medium circuit, moisture, desliming, dedusting.

b) Verbs: demand, drain.

c) Adjectives: capable, varied.

Task 2. Read the text and translate it into Russian.

Industrial screening is extensively used for size separations from 300 mm down to around 40 μm, although the efficiency decreases rapidly with fineness. Dry screening is generally limited to material above about 5 mm in size, while wet screening down to around 250 μm is common. Although there are screen types that are capable of efficient size separations down to 40 μm, sizing below 250 μm is also undertaken by classification. Selection between screening and classification is influenced by the fact that finer separations demand large areas of screening surface and therefore can be expensive compared with classification for high-throughput applications.

The types of screening equipment are many and varied. Likewise, there are a wide range of screening objectives. The main purposes in the minerals industry are:

(a) sizing or classifying, to separate particles by size, usually to provide a downstream unit process with the particle size range suited to that unit operation;

(b) scalping, to remove the coarsest size fractions in the feed material, usually so that they can be crushed or removed from the process;

(c) grading, to prepare a number of products within specified size ranges. This is important in quarrying and iron ore, where the final product size is an important part of the specification;

(d) media recovery, for washing magnetic media from ore in dense medium circuits;

(e) dewatering, to drain free moisture from a wet sand slurry;

(f) desliming or dedusting, to remove fine material, generally below 0.5 mm from a wet or dry feed; and

(g) trash removal, usually to remove wood fibres from a fine slurry stream.

Text 2. Screening Equipment

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: oversize material, discharge end, vibrating screen, screening deck, undersize material, mesh, capacity, mill outlet, ball scats.

b) Verbs: convey, manufacture, introduce, mount.

c) Adjectives: rectangular, robust, subsequent, sticky, ultrasonic.

Task 2. Read the text and translate it into Russian.

In its simplest configuration, a screen is a hard perforated surface with a matrix of fixed dimension apertures. The material is presented to the screen surface so that material finer than the apertures falls through the screen and the oversize material is conveyed to the discharge end of the screen. Screening is generally difficult below 0.5 mm.

There are numerous different types of industrial screens available. The dominant screen type in industrial applications is the vibrating screen, of which there are many subtypes in use for coarse and fine-screening applications. There are also numerous other screen types in wide use for both coarse and fine screening applications. Among them are trammels, roller screens, and circular screens.

Vibrating screens (Figure 8) have a rectangular screening surface with feed and oversize discharge at opposite ends. They perform size separations from 300 mm in size down to 45 μm and they are used in a variety of sizing, grading, scalping, dewatering, wet screening, and washing applications. Vibrating screens of most types can be manufactured with more than one screening deck. On multiple-deck systems, the feed is introduced to the top coarse screen; the undersize material falling through to the lower screen decks, thus producing a range of sized fractions from a single screen.

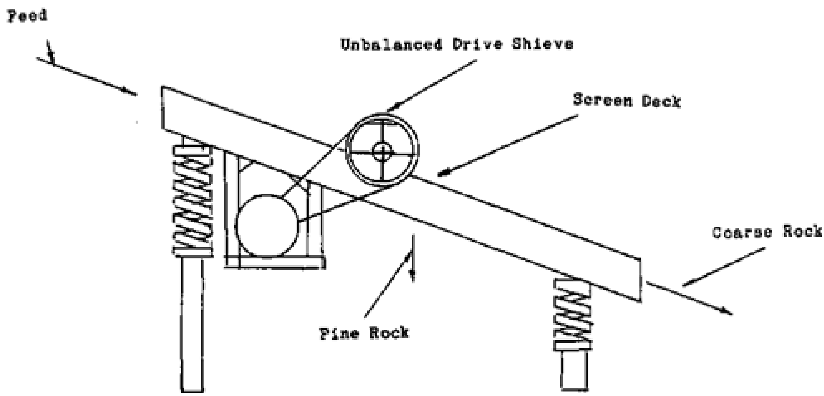

Figure 8. Schematic of a vibrating screen

One of the oldest screening devices is the trommel (or revolving screen), which is a cylindrical screen (Figure 9) typically rotating at between 35 and 45% critical speed. Trommels are installed on a small angle to the horizontal or use a series of internal baffles to transport material along the cylinder. Trommels can be made to deliver several sized products by using trommel screens in series from finest to coarsest such as the one shown; or using concentric trommels with the coarsest mesh being innermost. Trommels can handle material from 55 mm down to 6 mm, and even smaller sizes can be handled under wet screening conditions. Although trommels are cheaper, vibration-free, and mechanically robust; they typically have lower capacities than vibrating screens since only part of the screen surface is in use at any one time, and they can be more prone to blinding.

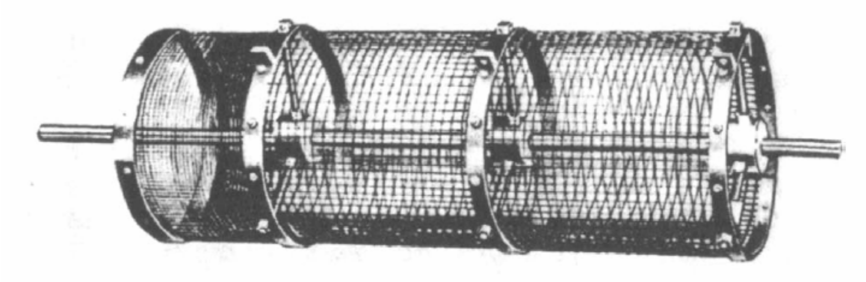

Figure 9. Trommel screen

AG, SAG, and ball mill discharge streams usually pass through a trommel screen attached to the mill outlet to prevent ball scats from reaching subsequent processing equipment and to prevent a build-up of pebbles in the mill. Trommels are also used for wet-scrubbing ores such as bauxite.

Roller screens can be used for screening applications from 3 to 300 mm. Roller screens (Figure 10) use a series of parallel driven rolls (circular, elliptical, or profiled) or discs to transport oversize across the series of rolls while allowing fines to fall through the gaps between rolls or discs. Roller screens offer advantages of high capacity, low noise levels, require little head-room, subject the material to less impact, and permit screening of very sticky materials.

Circular, gyratory, or tumbler screens (Figure 11) impart a combined gyratory and vertical motion. They are widely used for fine screening applications, wet or dry, down to 40 μm. The basic components consist of a nest of sieves up to around 2.7 m in diameter supported on a table which is mounted on springs on a base. Suspended from beneath the table is a motor, which drives eccentric weights and effects horizontal gyratory motion. Vertical motion is imparted by the bottom weights, which swing the mobile mass about its centre of gravity, producing a circular tipping motion to the screen, the top weights producing the horizontal gyratory motion. Ball trays and ultrasonic devices may be fitted below the screen surfaces to reduce blinding. Circular screens are often configured to produce multiple size fractions.

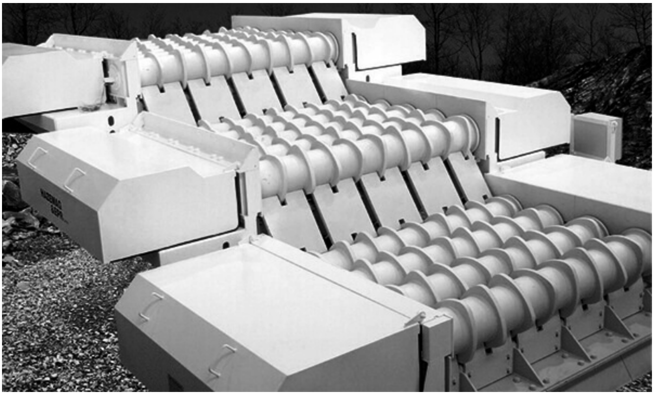

Figure 10. Roller screen

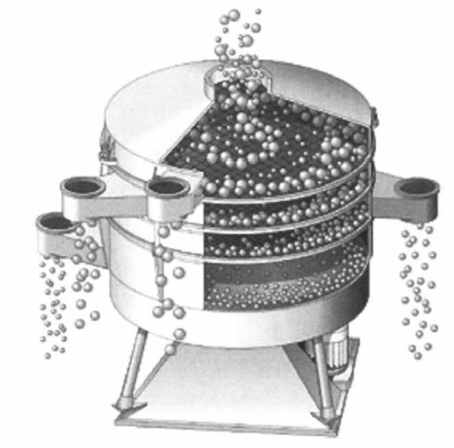

Figure 11. Circular screen

UNIT 5. CLASSIFICATION

Text 1. Basics of Classification

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: velocity, grain, specific gravity, performance, grinding circuit, free-settling type, hindered-settling type, density.

b) Verbs: apply, increase.

Task 2. Read the text and translate it into Russian.

Classification is a method of separating mixtures of minerals into two or more products on the basis of the velocity with which the grains fall through a fluid medium. In mineral processing, this is usually water, and wet classification is generally applied to mineral particles which are considered too fine to be sorted efficiently by screening. Since the velocity of particles in a fluid medium is dependent not only on the size, but also on the specific gravity and shape of the particles, the principles of classification are important in mineral separations utilising gravity concentrators. Classifiers also strongly influence the performance of grinding circuits.

Many different types of classifiers have been designed and built. They may be grouped, however, into two broad classes depending on the direction of flow of the carrying current. Horizontal current classifiers such as mechanical classifiers are essentially of the free-settling type and accentuate the sizing function; vertical current or hydraulic classifiers are usually hindered-settling types and so increase the effect of density on the separation.

Text 2. Types of Classifiers

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: chamber, tank, column, settling rate, spigot product, slime, vessel, rake classifier, centrifugal force, rotary motion, inflow, axis.

b) Verbs: exploit, sink.

c) Adjectives: successive, previous, inclined, heavy, light.

Task 2. Read the text and translate it into Russian.

Hydraulic classifiers (Figure 12) are essentially large chambers, tanks, or columns with vertical currents of water. They exploit differences in the settling rates of particles. The coarser particles sink and are removed from the bottom of the settling zone. The rising currents are graded from a relatively high velocity in the first sorting column, to a relatively low velocity in the last, so that a series of spigot products can be obtained, with the coarser, denser particles in the first spigot and the fines in the latter spigots. Very fine slimes overflow the final sorting column of the classifier. The size of each successive vessel is increased, partly because the amount of liquid to be handled includes all the water used for classifying in the previous vessels and partly because it is desired to reduce, in stages, the surface velocity of the fluid flowing from one vessel to the next.

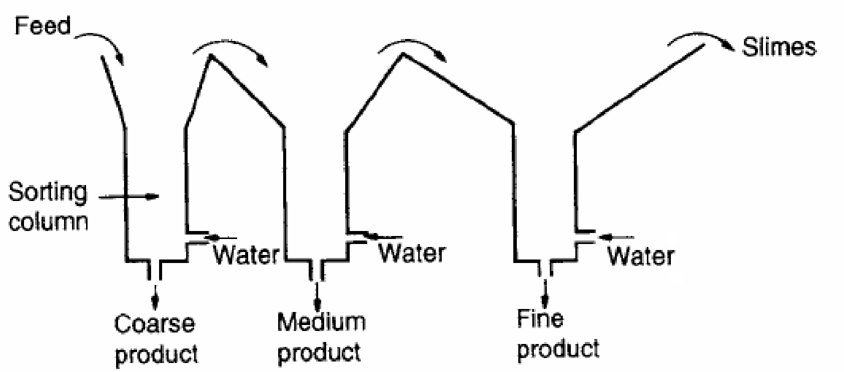

Figure 12. Hydraulic classifier

Mechanical classifiers such as spiral and rake classifiers work in a similar fashion in that both drag sediment and sand along the bottom of an inclined surface to a higher discharge point on one end of the settling chamber. The primary difference in the two systems is the mechanism by which the settled material is moved up the inclined surface (see Figure 13). Spiral classifiers are generally preferred as material does not slide backwards which occurs in rake classifiers when the rakes are lifted between strokes. This also allows spiral classifiers to operate at steeper inclines and produce a drier product.

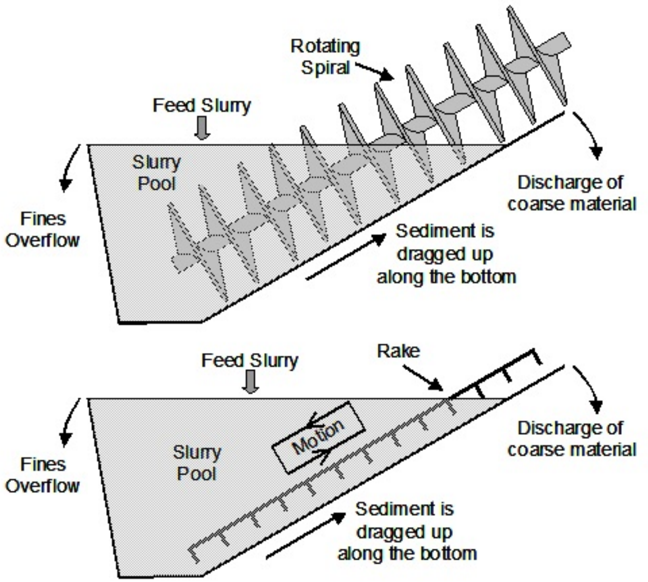

Figure 13. Spiral classifier and rake classifier

Hydrocyclones (Figure 14) are devices that apply centrifugal force to a flowing liquid mixture so as to promote the separation of heavy and light components. The classic hydrocyclone is a closed vessel designed to convert incoming liquid velocity into rotary motion. It does this by directing inflow tangentially near the top of a cylindroconical vessel. This spins the entire contents of the vessel, creating centrifugal force in the liquid. Heavy components move outward toward the wall of the vessel where they agglomerate and spiral down the wall to the outlet at the bottom of the vessel. Light components move toward the axis of the hydrocyclone where they move up toward the overflow outlet at the top of the vessel.

Hydrocyclones have become one of the most important and widely used classifiers in the mineral processing industry. They are most commonly employed within grinding circuits and are used to return coarse material back to the ball or rod mill for further grinding. The main advantage of hydrocyclones is that they have large capacities relative to their size and can separate at finer sizes than most other screening and classification equipment.

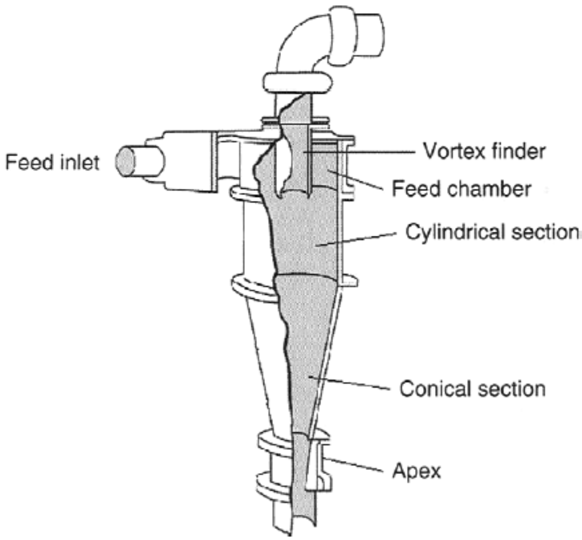

Figure 14. Hydrocyclone

UNIT 6. SEPARATION

Text 1. Gravity and Dense Medium Separation

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: resistance, rejection, end product, shale, high-ash coal, jig, pinched sluice, shaking table, layer, ragging, tailings, eccentric drive, hutch water, launder, width, pulp, splitter, tray, conduit, cross-section, stroke, film of water, tin, tungsten, mica, scrap.

b) Verbs: float, discard, enhance, diminish, stratify.

c) Adjectives: viscous, suitable, various, complex.

Task 2. Read the text and translate it into Russian.

Gravity concentration methods separate minerals of different specific gravity by their relative movement in response to gravity and one or more other forces, the latter often being the resistance to motion offered by a viscous fluid, such as water or air. Gravity methods of separation are used to treat a great variety of materials, ranging from heavy metal sulphides such as galena to coal, at particle sizes in some cases below 50 μm.

Dense medium separation (or heavy medium separation (HMS), or the sink-and-float process) is the simplest of all gravity processes and has long been a standard laboratory method for separating minerals of different specific gravity. Heavy liquids of suitable density are used, so that those minerals lighter than the liquid float, while those denser than it sink. This method is applied to the pre-concentration of minerals, i.e. the rejection of gangue prior to grinding for final liberation. It is also used in coal preparation to produce a commercially graded end product, clean coal being separated from the heavier shale or high-ash coal.

Many different machines have been designed and built in the past to effect separation of minerals by gravity. Among them are jigs, pinched sluices, cones, spirals, and shaking tables.

Jigs

Jigging is one of the oldest concentration methods. Essentially the jig is an open tank filled with water, with a horizontal jig screen at the top, and provided with a spigot in the bottom for concentrate removal (Figure 15).

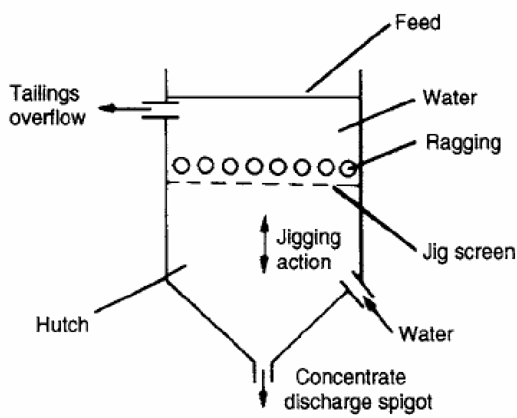

Figure 15. Basic jig construction

The jig bed consists of a layer of coarse, heavy particles, or ragging, placed on the jig screen on to which the slurry is fed. The feed flows across the ragging and the separation takes place in the jig bed so that grains with a high specific gravity penetrate through the ragging and screen to be drawn off as a concentrate, while the light grains are carried away by the cross-flow to be discarded as tailings. The harmonic motion produced by the eccentric drive is supplemented by a large amount of continuously supplied hutch water, which enhances the upward and diminishes the downward velocity of the water.

Pinched sluices

Pinched sluices of various forms have been used for heavy mineral separations for centuries. In its simplest form (Figure 16), it is an inclined launder about 1 m long, narrowing from about 200 mm in width at the feed end to about 25 mm at the discharge. Pulp of between 50 and 65% solids enters gently and stratifies as it descends; at the discharge end these strata are separated by various means, such as by splitters, or by some type of tray.

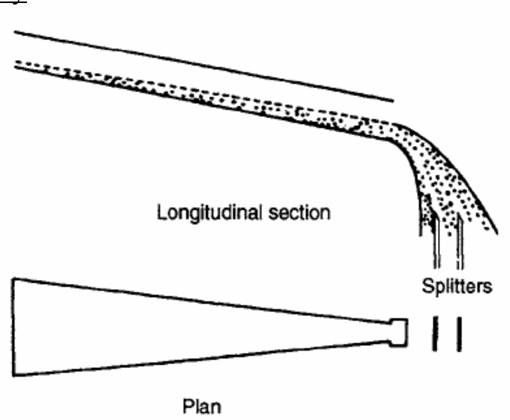

Figure 16. Pinched sluice

Reichert cones

The Reichert cone (Figure 17) is a wet gravity concentrating device designed for high-capacity applications. Its principle of operation is similar to that of a pinched sluice, but the pulp flow is not restricted or influenced by side-wall effect, which is somewhat detrimental to pinched-sluice operation.

Reichert cones have a high capacity. They accept feeds of up to 3 mm in size and can treat material as fine as 301 µm, although they are most efficient in the 100-600 µm size range.

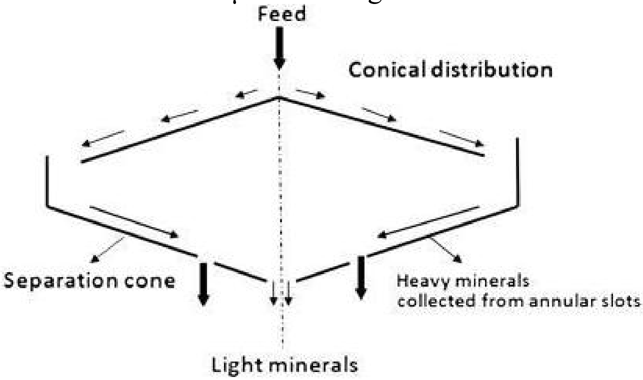

Figure 17. Reichert cone

Spirals

Spiral concentrators (Figure 18) are complex, being much influenced by the slurry density and particle size. The Humphreys spiral is composed of a helical conduit of modified semicircular cross-section.

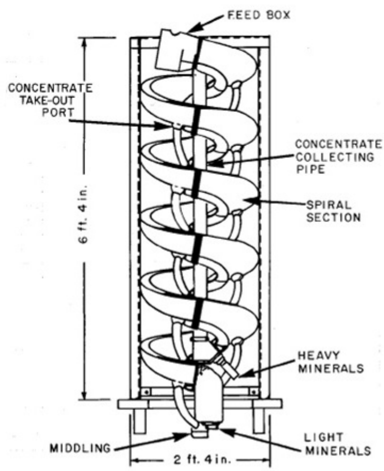

Figure 18. Spiral concentrator

Feed pulp of between 15 and 45% solids by weight and in the size range 3 mm to 75 μm is introduced at the top of the spiral and, as it flows spirally downwards, the particles stratify due to the combined effect of centrifugal force, the differential settling rates of the particles, and the effect of interstitial trickling through the flowing particle bed.

Shaking tables

The shaking table (Figure 19) consists of a slightly inclined deck, A, on to which feed, at about 25% solids by weight, is introduced at the feed box and is distributed along C; wash water is distributed along the balance of the feed side from launder D. The table is vibrated longitudinally, by the mechanism B, using a slow forward stroke and a rapid return, which causes the mineral particles to "crawl" along the deck parallel to the direction of motion. The minerals are thus subjected to two forces, that due to the table motion and that, at right angles to it, due to the flowing film of water. The net effect is that the particles move diagonally across the deck from the feed end and, since the effect of the flowing film depends on the size and density of the particles, they will fan out on the table, the smaller, denser particles tiding highest towards the concentrate launder at the far end, while the larger lighter particles are washed into the tailings launder, which runs along the length of the table.

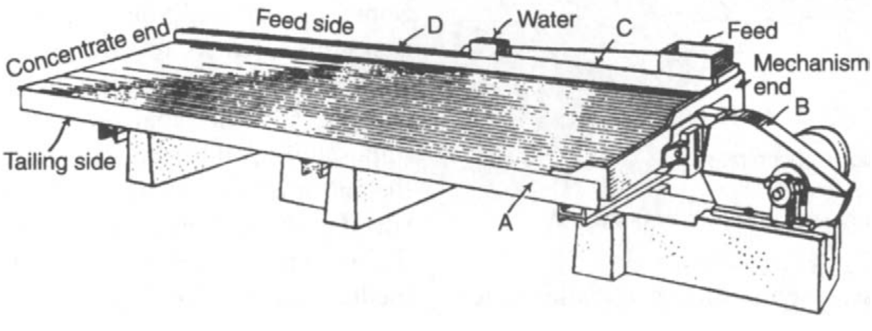

Figure 19. Spiral concentrator

Ore-concentrating tables are used primarily for the concentration of minerals of tin, iron, tungsten, tantalum, mica, barium, titanium, zirconium, and, to a lesser extent, gold, silver, thorium, uranium, and others. Tables are now being used in the recycling of electronic scrap to recover precious metals.

Text 2. Magnetic Separation

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: contaminant, magnetic field, drum separator, alternating polarity, permanent magnet, alloy, compartment, stainless steel shaft, adhesion, flux, throughput, winding.

b) Verbs: attract, repel.

c) Adjectives: certain, serrated, superconducting, ancillary, conventional.

Task 2. Read the text and translate it into Russian.

Magnetic separators exploit the difference in magnetic properties between the ore minerals and are used to separate either valuable minerals from non-magnetic gangue, e.g. magnetite from quartz, or magnetic contaminants or other valuable minerals from the non-magnetic values. An example of this is the tin-bearing mineral cassiterite, which is often associated with traces of magnetite or wolframite which can be removed by magnetic separators.

All materials are affected in some way when placed in a magnetic field, although with most substances the effect is too slight to be detected. Materials can be classified into two broad groups, according to whether they are attracted or repelled by a magnet:

(1) Diamagnetics are repelled along the lines of magnetic force to a point where the field intensity is smaller. The forces involved here are very small and diamagnetic substances cannot be concentrated magnetically.

(2) Paramagnetics are attracted along the lines of magnetic force to points of greater field intensity. Paramagnetic materials can be concentrated in high-intensity magnetic separators.

Some elements are themselves paramagnetic, such as Ni, Co, Mn, Cr, Ce, Ti, O, and the Pt group metals, but in most cases the paramagnetic properties of minerals are due to the presence of iron in ome ferromagnetic form.

Magnetic separators can be classified into low- and high-intensity machines, which may be further classified into dry-feed and wet-feed separators. Certain elements of design are incorporated in all magnetic separators, whether they are low or high intensity, wet or dry. The prime requirement is the provision of a high-intensity field in which there is a steep field strength gradient.

Low-intensity magnetic separation

Dry low-intensity magnetic separation is confined mainly to the concentration of coarse sands which are strongly magnetic. It is often carried out in drum separators.

Drum separators (Figure 20) consist essentially of a rotating non-magnetic drum containing three to six stationary magnets of alternating polarity. Although initially drum separators employed electromagnets, permanent magnets are used in modern devices, utilising ceramic or rare earth magnetic alloys, which retain their intensity for an indefinite period. Separation is by the 'pick-up' principle. Magnetic particles are lifted by the magnets and pinned to the drum and are conveyed out of the field, leaving the gangue in the tailings compartment. Water is introduced into the machine to provide a current which keeps the pulp in suspension. Field intensities of up to 0.7 T at the pole surfaces can be obtained in this type of separator.

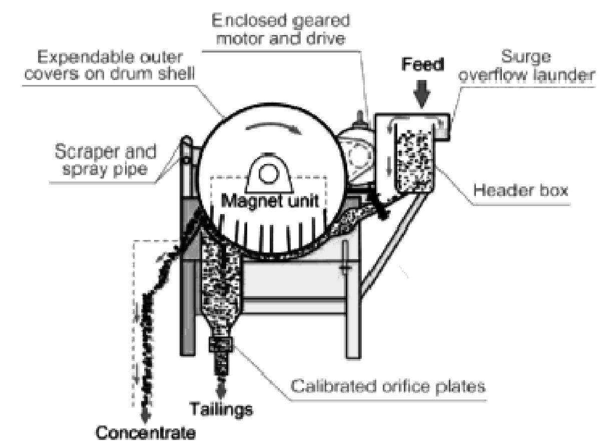

Figure 20. Magnetic drum separator

High-intensity separators

Induced roll magnetic separators, IRMs (Figure 21), are widely used to treat beach sands, wolframite, tin ores, glass sands, and phosphate rock. The roll, on to which the ore is fed, is composed of phosphated steel laminates compressed together on a non-magnetic stainless steel shaft. By using two sizes of lamination, differing slightly in outer diameter, the roll is given a serrated profile which promotes the high field intensity and gradient required. Field strengths of up to 2.2 T are attainable in the gap between feed pole and roll. Nonmagnetic particles are thrown off the roll into the tailings compartment, whereas magnetics are gripped, carried out of the influence of the field and deposited into the magnetics compartment.

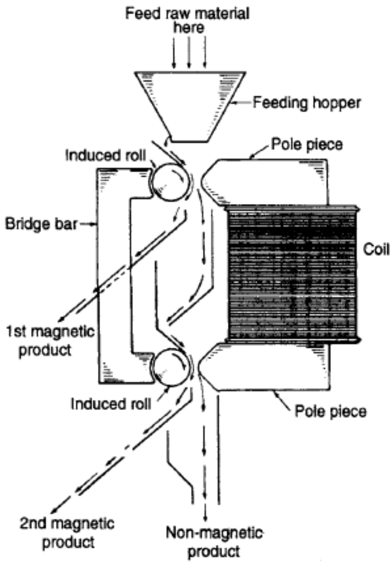

Figure 21. Induced roll separator

Dry high-intensity separation is largely limited to ores containing little, if any, material finer than about 75 μm. The effectiveness of separation on such fine material is severely reduced by the effects of air currents, particle-particle adhesion, and particle-rotor adhesion.

Wet high-intensity magnetic separators, or WHIMS machines, reduce the minimum particle size for efficient separation. They allow ores to be concentrated magnetically that cannot be concentrated effectively by dry high-intensity methods because of the fine grinding necessary to ensure complete liberation of the magnetic fraction.

High-gradient magnetic separators

High-gradient magnetic separators are best suited to the treatment of very fine particles. They are used mainly in the kaolin industry for removing micron-sized particles which contain iron. Several large separators, with the ferromagnetic matrix contained in baskets approximately 2 m in diameter are in commercial use in the United States and in Cornwall, England. They operate with fields of 2 T, and have capacities ranging between 10 and 80 t h^{-1} depending on the final clay quality desired.

Superconducting separators

In 1986, a superconducting high-gradient magnetic separator was designed and built to process kaolinite clay in the United States. This machine uses only about 0.007 kW in producing 5 T of flux, the ancillary equipment needed requiring another 20kW. In comparison, a conventional 2 T high-gradient separator of similar throughput would need about 250 kW to produce the flux, and at least another 30 kW to cool the magnet windings.

Text 3. Electrical Separation

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: conductivity, placer, voltage, electrical discharge, attraction, humidity.

b) Adjectives: inefficient, sensitive.

Task 2. Read the text and translate it into Russian.

Electrical separation utilises the difference in electrical conductivity between the various minerals in the ore feed. Since almost all minerals show some difference in conductivity it would appear to represent the universal concentrating method. In practice, however, the method has fairly limited application, and its greatest use is in separating some of the minerals found in heavy sands from beach or stream placers. The fact that the feed must be perfectly dry imposes limitations on the process, but it also suffers from the same great disadvantage as dry magnetic separation – the capacity is very small for finely divided material. For most efficient operation, the feed should be in a layer, one particle deep, which severely restricts the throughput if the particles are as small as 75 µm.

The first mineral separation processes utilising high voltage were virtually true electrostatic processes employing charged fields with little or no current flow. High-tension separation, however, makes use of a comparatively high rate of electrical discharge, with electron flow and gaseous ionisation having major importance.

The attraction of particles carrying one kind of charge towards an electrode of the opposite charge is known as the "lifting effect", as such particles are lifted from the separating surface towards the electrode. Materials which have a tendency to become charged with a definite polarity may be separated from each other by the use of the lifting effect even though their conductivities may be very similar. As an example, quartz assumes a negative charge very readily and may be separated from other poor conductors by an electrode which carries a positive charge. Pure electrostatic separation is relatively inefficient, even with very clean mineral, and is sensitive to changes of humidity and temperature.

Text 4. Froth Flotation

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: froth flotation, air bubble, attachment, entrainment, entrapment, drainage, agitator, collision, collector, frother, regulator.

b) Verbs: expand, comprise.

c) Adjectives: versatile, selective, apparent, water-repellent, stable.

Task 2. Read the text and translate it into Russian.

Flotation is undoubtedly the most important and versatile mineral processing technique, and both its use and application are continually being expanded to treat greater tonnages and to cover new areas. Originally patented in 1906, flotation has permitted the mining of low-grade and complex ore bodies which would have otherwise been regarded as uneconomic.

Flotation is a physico-chemical separation process that utilises the difference in surface properties of the valuable minerals and the unwanted gangue minerals. The theory of froth flotation is complex, involving three phases (solids, water, and froth) with many subprocesses and interactions.

The process of material being recovered by flotation from the pulp comprises three mechanisms:

(1) Selective attachment to air bubbles (or "true flotation").

(2) Entrainment in the water which passes through the froth.

(3) Physical entrapment between particles in the froth attached to air bubbles (often referred to as “aggregation”).

The attachment of valuable minerals to air bubbles is the most important mechanism and represents the majority of particles that are recovered to the concentrate. Although true flotation is the dominant mechanism for the recovery of valuable mineral, the separation efficiency between the valuable mineral and gangue is also dependent on the degree of entrainment and physical entrapment. Unlike true flotation, which is chemically selective to the mineral surface properties, both gangue and valuable minerals alike can be recovered by entrainment and entrapment. Drainage of these minerals occurs in the froth phase and controlling the stability of this phase is important to achieve an adequate separation. In industrial flotation plant practice, entrainment of unwanted gangue can be common and hence a single flotation stage is uncommon. Often several stages of flotation (called “circuits”) are required to reach an economically acceptable quality of valuable mineral in the final product.

True flotation utilises the differences in physicochemical surface properties of particles of various minerals. After treatment with reagents, such differences in surface properties between the minerals within the flotation pulp become apparent and, for flotation to take place, an air bubble must be able to attach itself to a particle, and lift it to the water surface. Figure 22 illustrates the principles of flotation in a mechanical flotation cell.

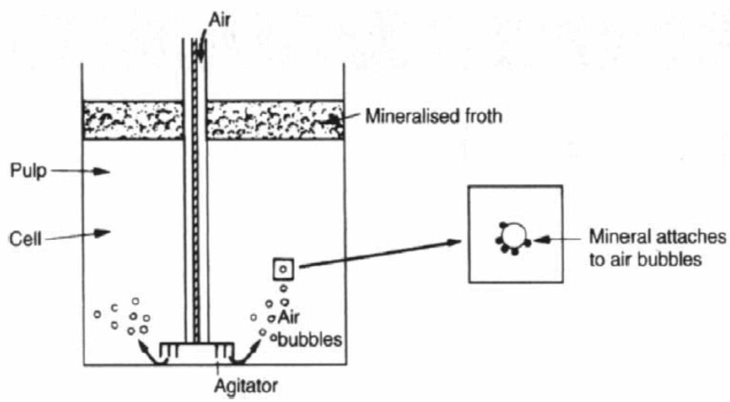

Figure 22. Principle of froth flotation

The agitator provides enough turbulence in the pulp phase to promote collision of particles and bubbles which results in the attachment of valuable particles to bubbles and their transport into the froth phase for recovery.

The process can only be applied to relatively fine particles, because if they are too large, the adhesion between the particle and the bubble will be less than the particle weight and the bubble will therefore drop its load. There is an optimum size range for successful flotation.

The mineral particles can only attach to the air bubbles if they are to some extent water-repellent, or hydrophobic. Having reached the surface, the air bubbles can only continue to support the mineral particles if they can form a stable froth, otherwise they will burst and drop the mineral particles. To achieve these conditions it is necessary to use the numerous chemical compounds known as flotation reagents.

The most important reagents are the collectors, which adsorb on mineral surfaces, rendering them hydrophobic (or aerophilic) and facilitating bubble attachment. The frothers help maintain a reasonably stable froth. Regulators are used to control the flotation process; these either activate or depress mineral attachment to air bubbles and are also used to control the pH of the system.

Text 5. Laboratory Flotation Testing

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: flowsheet, chemical composition, dissemination, drill core, faulting, grease, oil, batch laboratory grinding, floatability.

b) Verbs: establish, assess, inhibit, facilitate, interfere.

c) Adjectives: preliminary, preferable, substantial, initial, in-situ.

Task 2. Read the text and translate it into Russian.

In order to develop a flotation circuit for a specific ore, preliminary laboratory testwork must be undertaken in order to determine the choice of reagents and the size of plant for a given throughput as well as the flowsheet and peripheral data. Flotation testing is also carried out on ores in existing plants to improve procedures and for development of new reagents.

It is essential that testwork is carried out on ore which is representative of that treated in the commercial plant. Samples for testwork must be representative not only in chemical composition, but also relative to mineralogical composition and degree of dissemination. A mineralogical examination of drill cores or other individual samples should therefore be made before a representative sample is selected. Composite drill core samples are ideal for testing if drilling in the deposit has been extensive; the cores generally contain ore from points widely distributed over the area and in depth. It must be realised that ore bodies are variable and that a representative sample will not apply equally well to all parts of the ore body; it is used therefore for development of the general flotation procedure. Additional tests must be made on samples from various areas and depths to establish optimum conditions in each case and to give design data over the whole range of ore variation.

Characterisation of the flotation response of ore deposits must therefore recognise that the ore deposit could represent a variety of rock types, with different ore mineralogy, textures (fine or coarse grain) and faulting. It is therefore preferable that drill core samples be selected to represent the variations within the ore body. Each sample should be tested separately and the overall value of the deposit is then assessed by compositing the metallurgical responses of each sample mathematically.

Having selected representative samples of the ore, it is necessary to prepare them for flotation testing, which involves comminution of the ore to its optimum particle size. Crushing must be carried out with care in order to avoid accidental contamination of the sample by grease or oil, or with other materials which have been previously crushed. Even in a commercial plant, a small amount of grease or oil can temporarily upset the flotation circuit. Samples are usually crushed with small jaw crushers or cone crushers to about 0.5 cm and then to about 1 mm with crushing rolls in closed circuit with a screen.

Storage of the crushed sample is important, since oxidation of the surfaces is to be avoided, especially with sulphide ores. Not only does oxidation inhibit collector adsorption, but it also facilitates the dissolution of heavy metal ions, which may interfere with the flotation process. Sulphides should be tested as soon as possible after obtaining the sample and ore samples must be shipped in sealed drums in as coarse a state as possible. Samples should be crushed as needed during the testwork, although a better solution is to crush all the samples and to store them in an inert atmosphere.

Wet grinding of the samples should always be undertaken immediately prior to flotation testing to avoid oxidation of the liberated mineral surfaces. Batch laboratory grinding, using ball mills, produces a flotation feed with a wider size distribution than that obtained in continuous closed-circuit grinding; to minimise this, batch rod mills are used which give products having a size distribution which approximates closely to that obtained in closed-circuit ball mills. True simulation is never really achieved, however, as overgrinding of high specific gravity minerals, which is a feature of closed-circuit grinding, is avoided in a batch rod mill.

A soft dense mineral, such as galena, will be ground finer in closed circuit than predicted by the batch tests, and its losses due to production of ultra-fine particles may be substantial. Some sulphide minerals, such as sphalerite and pyrite, can be depressed more easily at the coarser sizes produced in batch grinding, but may be more difficult to depress at the finer sizes resulting from closed-circuit grinding. Predictions from laboratory tests can be improved if the mineral recovery from the batch tests is expressed as a function of mineral size rather than overall product size. The optimum mineral size can be determined and the overall size estimated to give the optimum grind size. This method assumes that the same fineness of the valuable mineral will give the same flotation results both from closed-circuit and batch grinding, irrespective of the differences in size distributions of the other minerals.

It must be appreciated that the optimum grinding size of the particles depends not only on their grain size but also on their floatability. Initial examination of the ore should be made to determine the degree of liberation in terms of particle size in order to estimate the required fineness of grind.

The potential for liberation of the minerals contained in the ore can be determined by characterizing the grain sizes of the minerals present. This can be achieved by breaking the drill core samples at a relatively coarse size (typically about 600 microns). This preserves the in-situ texture of the samples, including grain size, association, and shape. The texture can be characterised by using a scanning electron microscope configured as a mineral liberation analyser. Such an analyser can measure the grain sizes and composition of the component minerals of the ore.

Testwork should then be carried out over a range of grinding sizes in conjunction with flotation tests in order to determine the optimum flotation feed size distribution. In certain cases, it may be necessary to overgrind the ore in order that the particles are small enough to be lifted by the air bubbles. If the mineral is readily floatable, a coarse grind may be utilised, the subsequent concentrate requiring regrinding to further free the mineral from the gangue before further flotation is performed to produce a high-grade concentrate.

UNIT 7. ORE SORTING

Text 1. Basics of Ore Sorting

Task 1. Translate the following words and phrases into Russian.

Nouns and noun phrases: appraisal, removal, timber, tramp iron, barren waste, sustainability, consumption, tailings disposal.

Task 2. Read the text and translate it into Russian.

Ore sorting is the original concentration process, having probably been used by the earliest metal workers several thousand years ago. It involves the appraisal of individual ore particles and the rejection of those particles that do not warrant further treatment.

Hand sorting has declined in importance due to the need to treat large quantities of low-grade ore which requires extremely fine grinding. Hand sorting of some kind, however, is still practiced at some mines, even though it may only be the removal of large pieces of timber, tramp iron, and other materials from the run-of-mine ore. Electronic ore-sorting equipment was first produced in the late 1940s, and although its application is fairly limited, it is an important technique for the processing of certain minerals.

Sorting can be applied to preconcentration, in which barren waste is eliminated to reduce the tonnage reporting to the downstream concentration processes, such as in uranium or gold ore sorting, or to the production of a final product, such as in limestone or diamond sorting. The ore must be sufficiently liberated at a coarse size (greater than 5-10 mm) to allow barren waste to be discarded without significant loss of value. Preconcentration by sorting is seen as a method of improving the sustainability of mineral processing operations by reducing the consumption of energy and water in grinding and concentration, and achieving more benign tailings disposal.

Text 2. Electronic Sorting Principles

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: reflectance, luminescence, valve.

b) Adjectives: visible, infrared, distinct.

Task 2. Read the text and translate it into Russian.

Many rock properties have been used as the basis of electronic sorting, including reflectance and colour in visible light (magnesite, limestone, base metal and gold ores, phosphates, talc, coal), ultraviolet (scheelite), natural gamma radiation (uranium ore), magnetism (iron ore), conductivity (sulphides), and X-ray luminescence (diamonds). Infrared, Raman, microwave attenuation, and other properties have also been tested.

Electronic sorters inspect the particles to determine the value of some property (e.g. light reflectance) and then eject those particles which meet some criterion (e.g. light vs dark rocks). Either valuables or waste may be selected for ejection. It is essential, therefore, that a distinct difference in the required physical property is apparent between the valuable minerals and the gangue.

The particle surfaces must be thoroughly washed before sorting, so that blurring of the signal does not occur and, as it is not practical to attempt to feed very wide rock size ranges to a single machine, the feed must undergo preliminary sizing. The ore must be fed in a monolayer, as display of individual particles to the sorting device must be effected.

Photometric sorting is the mechanised form of hand-sorting, in which the ore is divided into components of differing value by visual examination. The basis of the photometric sorter is a laser light source and sensitive photomultiplier, used in a scanning system to detect light reflected from the surfaces of rocks passing through the sorting zone. Electronic circuitry analyses the photomultiplier signal, which changes with the intensity of the reflected light and produces control signals to actuate the appropriate valves of an air-blast rejection device to remove certain particles selected by means of the analysing process.

UNIT 8. DEWATERING

Text 1. Basics of Dewatering

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: water-solids ratio, shipment, carrier liquid, thickening, filter cake.

b) Adjectives: partial, moist.

Task 2. Read the text and translate it into Russian.

With few exceptions, most mineral separation processes involve the use of substantial quantities of water and the final concentrate has to be separated from a pulp in which the water-solids ratio may be high.

Dewatering, or solid-liquid separation, produces a relatively dry concentrate for shipment. Partial dewatering is also performed at various stages in the treatment, so as to prepare the feed for subsequent processes.

Dewatering methods can be broadly classified into three groups:

(1) sedimentation;

(2) filtration;

(3) thermal drying.

Sedimentation is most efficient when there is a large density difference between liquid and solid. This is always the case in mineral processing where the carrier liquid is water. Sedimentation cannot always be applied in hydrometallurgical processes, however, because in some cases the carrier liquid may be a high-grade leach liquor having a density approaching that of the solids. In some cases, filtration may be necessary.

Dewatering in mineral processing is normally a combination of the above methods. The bulk of the water is first removed by sedimentation, or thickening, which produces a thickened pulp of perhaps 55-65% solids by weight. Up to 80% of the water can be separated at this stage. Filtration of the thick pulp then produces a moist filter cake of between 80 and 90% solids, which may require thermal drying to produce a final product of about 95% solids by weight.

Text 2. Gravity Sedimentation

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: flocculation, thickener, clarifier, blade, torque, compaction, concrete.

b) Verbs: withdraw, rake.

c) Adjectives: batch, continuous.

Task 2. Read the text and translate it into Russian.

Gravity sedimentation or thickening is the most widely applied dewatering technique in mineral processing, and it is a relatively cheap, high-capacity process, which involves very low shear forces, thus providing good conditions for flocculation of fine particles.

The thickener is used to increase the concentration of the suspension by sedimentation, accompanied by the formation of a clear liquid. In most cases the concentration of the suspension is high and hindered settling takes place. Thickeners may be batch or continuous units, and consist of relatively shallow tanks from which the clear liquid is taken off at the top, and the thickened suspension at the bottom. The clarifier is similar in design, but is less robust, handling suspensions of much lower solid content than the thickener.

The continuous thickener consists of a cylindrical tank, the diameter ranging from about 2 to 200 m in diameter, and of depth 1-7 m. Pulp is fed into the centre via a feed-well placed up to 1 m below the surface, in order to cause as little disturbance as possible (Figure 23).

The clarified liquid overflows a peripheral launder, while the solids which settle over the entire bottom of the tank are withdrawn as a thickened pulp from an outlet at the centre. Within the tank are one or more rotating radial arms, from each of which are suspended a series of blades, shaped so as to rake the settled solids towards the central outlet. On most modern thickeners these arms rise automatically if the torque exceeds a certain value, thus preventing damage due to overloading. The blades also assist the compaction of the settled particles and produce a thicker underflow than can be achieved by simple settling. The solids in the thickener move continuously downwards, and then inwards towards the thickened underflow outlet, while the liquid moves upwards and radially outwards.

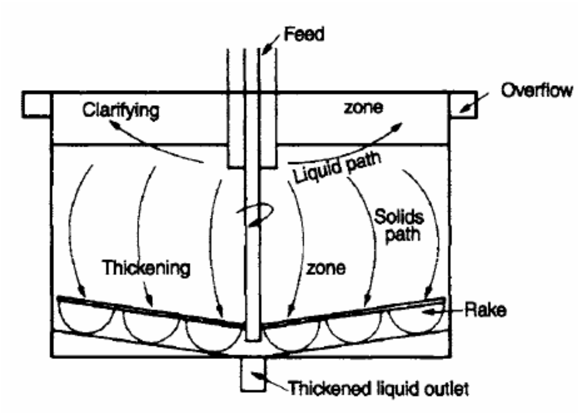

Figure 23. Flow in a continuous thickener

Thickener tanks are constructed of steel, <u>concrete</u>, or a combination of both, steel being most economical in sizes of less than 25 m in diameter. The tank bottom is often flat, while the mechanism arms are sloped towards the central discharge.

Text 3. Filtration

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: flocculant, filter medium, floc.

b) Verbs: retain, add.

c) Adjectives: uniform, corrosion-resistant.

Task 2. Read the text and translate it into Russian.

Filtration is the process of separating solids from liquid by means of a porous medium which <u>retains</u> the solid but allows the liquid to pass. Filtration in mineral processing applications normally follows thickening. The thickened pulp may be fed to storage agitators from where it is drawn off at <u>uniform</u> rate to the filters. <u>Flocculants</u> are sometimes <u>added</u> to the agitators in order to aid filtration. Slimes have an adverse effect on filtration, as they tend to “blind” the <u>filter medium</u>; flocculation reduces this and increases the voidage between particles, making filtrate flow easier.

The lower molecular weight flocculants tend to be used in filtration, as the flocs formed by high molecular weight products are relatively large, and entrain water within the structure, increasing the moisture content of the cake, even with the lower molecular weight flocculants, which have a higher shear resistance, and the resultant filter cake is a uniform porous structure which allows rapid dewatering, yet prevents migration of the finer particles through the cake to the medium. Other filter aids are used to reduce the liquid surface tension, thus assisting flow through the medium.

The choice of the filter medium is often the most important consideration in assuring efficient operation of a filter. Its function is generally to act as a support for the filter cake, while the initial layers of cake provide the true filter. The filter medium should be selected primarily for its ability to retain solids without blinding. It should be mechanically strong, corrosion-resistant, and offer as little resistance to flow of filtrate as possible. Relatively coarse materials are normally used and clear filtrate is not obtained until the initial layers of cake are formed, the initial cloudy filtrate being recycled.

Filter media are manufactured from cotton, wool, linen, nylon, silk, glass fibre, porous carbon, metals, rayon and other synthetics, and miscellaneous materials such as porous rubber. Cotton fabrics are by far the most common type of medium, primarily because of their low initial cost and availability in a wide variety of weaves. They can be used to filter solids as fine as 10 μm.

Cake filters are the type most frequently used in mineral processing, where the recovery of large amounts of solids from fairly concentrated slurries is the main requirement. Cake filters may be pressure, vacuum, batch, or continuous types.

Text 4. Drying

Task 1. Translate the following words and phrases into Russian.

a) Nouns and noun phrases: dust losses, thermal dryer, pressed cloth, compressed air, truck, rail car.

b) Verbs: aim, squeeze.

c) Adjectives: direct, indirect, counterflow.

Task 2. Read the text and translate it into Russian.

The drying of concentrates prior to shipping is the last operation performed in the mineral processing plant. It reduces the cost of transport and is usually aimed at reducing the moisture content to about 5% by weight. Dust losses are often a problem if the moisture content is lower.

Rotary thermal dryers are often used. These consist of a relatively long cylindrical shell mounted on rollers and driven at a speed of up to 25 rev min^{-1}. The shell is at a slight slope, so that material moves from the feed to discharge end under gravity. Hot gases, or air, are fed in either at the feed end to give parallel flow or at the discharge to give countercurrent flow. The method of heating may be either direct, in which case the hot gases pass through the material in the dryer, or indirect, where the material is in an inner shell, heated externally by hot gases. The direct-fired is the dryer most commonly used in the minerals industry. The indirect-fired type is used when the material must not contact the hot combustion gases. Parallel flow dryers (Figure 24) are used in the majority of current operations because they are more fuel efficient and have greater capacity than counterflow types. Since heat is applied at the feed end, build-up of wet feed is avoided, and in general these units are designed to dry material to not less than 1% moisture. Since counterflow dryers apply heat at the discharge end, a completely dry product can be achieved, but its use with heat-sensitive materials is limited because the dried material comes into direct contact with the heating medium at its highest temperature.

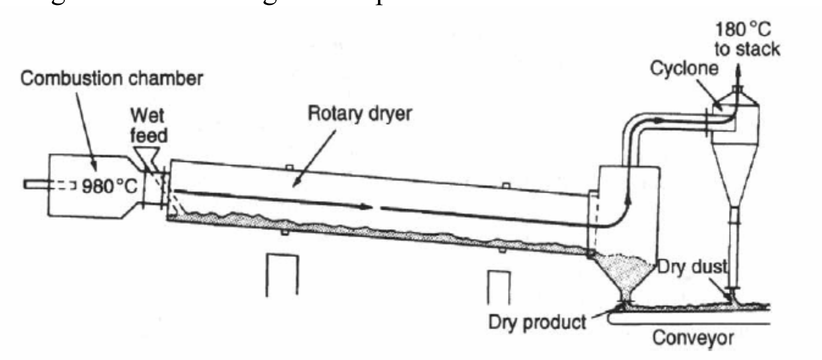

Figure 24. Direct-fired, parallel flow rotary dryer

An alternative to direct-fired drying of slurries is the tube press, which uses hydraulic pressure at 100 bars to squeeze water from the slurry that enters the annular space between the filter tube and an outer tube (Figure 25). The outer tube contains the filtration pressure that is applied hydraulically by a tubular membrane and squeezes the water from the slurry through perforations in the filter tube. The filtrate which collects in the central well of the filter tube is discharged from the press cloth by compressed air.

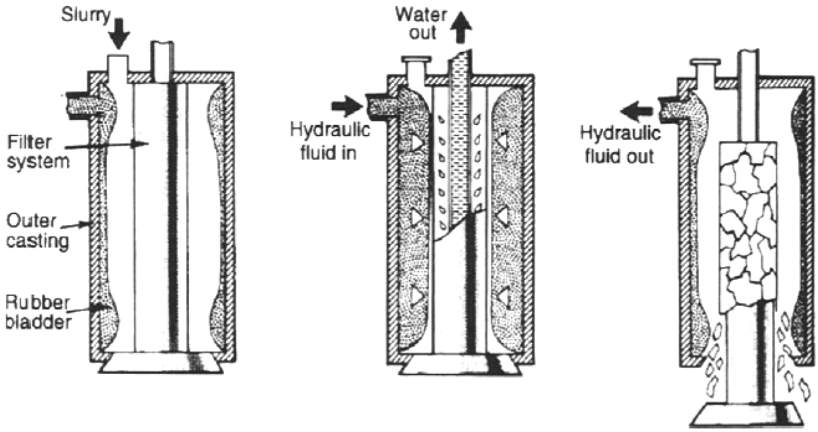

Figure 25. Operation of tube press

The product from the dryers is often stockpiled, before being loaded on to trucks or rail cars as required for shipment. The containers may be closed, or the surface of the contents sprayed with a skin-forming solution, in order to eliminate dust losses.

БИБЛИОГРАФИЧЕСКИЙ СПИСОК

1. Basics in Mineral Processing. [Электронный ресурс]. Режим доступа: https://www.metso.com/contentassets/0efc5d1a7c5a4357baecc5e990dc1fe7/basics-in-mineral-processing-handbook-18-lr.pdf

2. *Grewal I.* Mineral Processing Introduction. [Электронный ресурс]. Режим доступа: http://met-solvelabs.com/library/articles/mineral-processing-introduction

3. Mineral Processing. [Электронный ресурс]. Режим доступа: https://www.britannica.com/technology/mineral-processing

4. *Wills B.A.*, *Napier-Munn T.J.* Mineral Processing Technology. An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery. Elsevier Science & Technology Books. 2006. 450 p.

ОГЛАВЛЕНИЕ

ИНОСТРАННЫЙ ЯЗЫК

АНГЛИЙСКИЙ ЯЗЫК В ОБЛАСТИ ОБОГАЩЕНИЯ ПОЛЕЗНЫХ ИСКОПАЕМЫХ

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