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ENERGY SAVING IN MINING PRODUCTION

Introduction. *Mining is a rather energy-intensive industry because of severe conditions of technological processes with energy consumption optimized by engineering modernization, for instance, by producing settable mixes and processing their components to obtain the required size and activity.*

Problem Statement. *Reducing energy consumption while escalating production, energy efficiency of technological processes and cost reduction in energy supply are relevant problems for mining industry, which determine the competitiveness of a mining corporation.*

Purpose. *The research aims at determining the effect of disintegration and increased activity of ore minerals on energy consumption by mining enterprise.*

Materials and Methods. *Efficiency of mechanical activation is conditioned by difference in strength of concrete based on basic and activating binding materials. Efficient combination of technologies has been found as optimal solution taking into consideration variable factors, including energy consumption. The range of optimal values of binding materials has been found by solving the equations describing the obtained regularities.*

Results. *The research presents the results of industrial experiment aiming at replacing the binding components of concrete mixes by the activated blast-furnace slag. The quantitative indicators and regularities of electric energy consumption necessary to activate components of settable mixes have been determined. The obtained data have been used to simulate mix design at one of Norilsk enterprises. The general regularities of mechanical activation efficiency have been established and a concept and an algorithm of efficient energy consumption while activating mining production wastes have been formulated.*

Conclusions. *For the demographic factors of the development, the mining industry will increase energy-intensity of industrial processes. When transiting to underground deposit mining, production of settable mixes will result in increased energy consumption. Efficient energy consumption in energy-intensive industrial processes becomes especially important. In the specified conditions, optimized energy consumption facilitates the recovery of costs for mining diversification.*

Keywords: energy efficiency, energy saving, mining production, disintegrator, and activation.

The use of energy resources is one of the key issues in the sustainable development of industry. Mining, which is distinguished by energy consumption growing faster than industrial output, is a very energy-intensive industry [1—3].

The main factor affecting the energy consumption is the production capacity. The energy consumption is determined by the operating conditions of mining equipment. Electricity consumption at the mining industry enterprises is characterized by irregular production and consumption of electricity, the need for uninterrupted power supply, requirements for the quality and accounting of electricity in accordance with given operating conditions of the electric plant, as well as the characteristics of power-consuming units.

Electric consumption in mining industry depends on many factors that not all are taken into consideration while planning the mining works. The best practice shows that intensification of production processes and their optimization ensure energy saving, therefore, specific energy consumption can be used as indicator of technological development of mining operations [4—6].

One of the most energy-intensive process in mining operations is preparation of settable mixtures, in which a lion's share belongs to grinding of components to required fineness and activity.

The mining corporations of the regions are more powerful than other corporations of the industry in terms of number of staff, revenues, energy consumption and environment effect. Output per employee in the regions specialized in production of mineral resources is higher than the countrywide average by 32%. Mineral resource management as one of the most powerful economy sectors is characterized by sustainable trend towards growing environment effects even at a low pace of escalating production capacity.

In mining operations, an increase in labor efficiency and production capacity is achieved by engineering improvements [7].

Reducing energy consumption toensure technological processes is an objective of many researches. Unlike the energy saving that aims at reducing energy consumption, the energy efficiency deals with efficient energy consumption.

The enhancement of process energy efficiency is a priority factor of reducing operating expenses and gaining profit. Enhancement of energy efficiency of industrial corporation facilitates an economic growth, creates favorable social and environment situation, and improves staff living standards.

In advanced economies, energy efficiency is the key component of technology design.Energy efficiency aims at cutting consumption of fuel and energy resources. Minimization of energy consumption at the same or increased production is an objective of scientific progress. Enhancement of energy efficiency of processes is assured by energy saving measures and advanced technologies for consumption and transportation of energy resources.

The enhancement of energy efficiency of corporations enables to raise competitive ability ofnot only the products, but also of the entire country.

Numerous studies of energy efficiency problem are reduced to the fact that energy consumption depends on the correctness of operating conditions of energy consumers within the framework of technologies applied and reagents used [8—10].

It has been noted that in the course of frequent impact treatment (impact rate of 250 m/s) of the material it changes its technologic properties.

From the standpoint of energy resource consumption, the theory of aggregate state control by activation in disintegrator can be used in mining operations with high rates of energy consumption and almost inexhaustible disposable waste, since metal extraction from the raw minerals that previously were wasted can many times recoup thecosts of energy consumed for the processes.

A new direction in utilization of material energy is called energy infusiology. It addresses the following problems:

- enhancing efficiency of activation with combining mechanical and parallel to them energy fields;
- enhancing stability of activation effect;
- establishing correlation between activation, physical and chemical and technological processes.

A super-problem of energy consumption management at mining corporations issupporting energy-saving projects. To optimize energy consumption, experimental data on power rating of industrial processes are used [11—13].

The energy intensity of mining operations ups asthe production capacity grows,the number of processing factories increases, and operating conditions of consumers, especially in uncomfortableregions, stiffen.This process strengthens as the location of mining corporations gets more uneven and energy consumption increases.

The energy intensity of individual discontinuous processes of mining operations (for example, the preparation of settable mixtures used to control the state of ore-containing rocks and surfaces above them) increases.

Efficient use of energy generated and distributed between the consumers inside the corporation becomes crucially important.

This research aims at identifying effects of disintegration by intensification of ore mineral activation on energy consumption at the mining corporation. The disintegrator consists of two rotors revolving in opposite directions, which are mounted on coaxial shafts (Fig. 1).

The material is impacted byfingers rotating at a speed of 500—1000 rpm in opposite directions.

When processing the rock substance, on the newly formed surfaces, energy that reaches several dozen percent of the total energy used for processing is accumulated. For example, in the case of silica, it comes to 30%. The amount of this energy during the same treatment time exceeds the amount of energy in the case of milling.

To distinguish the concepts of mechanical activation in the mills and in the disintegrator, the observed effect is called activation with a high mechanical energy.

The accumulated deformation energy is used for grinding the material and for the subsequent chemical processes.

In the Shokpak (North Kazakhstan) field, for 10 years, the blast furnace slag was activated in the industrial plant DU-65 to reduce the manufacturing costs of binder cements (Fig. 2) [14].

The disintegrator ensured the yield of active blast furnace slag at a rate of up to 55%, with the subsequent activation in vibro-mill increasing it to 70%, which makes the activated slag competitive with cement.

The use of activated blast-furnace slag additive significantly reduced the consumption of cement. The comparison of the mix strength after 28 days at a consumption rate of 180 kg/m^3 of cement only andthat at a consumption rate of 80 kg/m^3 of cement with 370 kg/m^3 activated slag added has showed that 4 kg activated tails can be an equivalent to 1 kg cement. Due to the activation effect, the treatment in the disintegrator provides an increase in strength of 25—30% than in the case of milling.

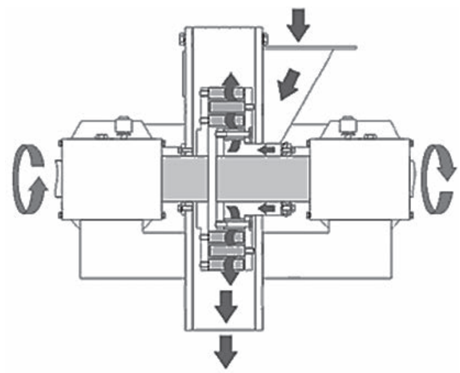

Fig. 1. Scheme of disintegrator (the rotors revolve as shown by the arrows)

The comparison was based on grinding finenessor yield of fractions having a size of 0.074 mm obtained by milling in a ball mill. The fineness in the disintegrator at a fraction yield of 40—60% was provided by the processing of blast furnace granulated slag at a total counter velocity of about 100 m/s [15].

The effectiveness of mechanical activation is determined by the difference in the strength of concretesbasedon binder composites activated in the disintegrator. These indicators are accepted as basic ones.

Thus, the composition of 1 m^3 mix with 150 kg cement was replaced by a complex binder with cement and activated slag. At K = 0.9, the weight of complex binder was 163 kg/m^3.

A rational combination of wastes is an optimum solution taking into account variable factors, including strength, cost, and transportability, according to the criterion of maximum waste utilization. The joint solution of the equations determines the range of optimal values of environment friendly technology.

The energy consumption for activation in disintegrator varies from 5 to 30 kW · h/t.

At the first stage, at idle speed, the average current in the outer rotor engine (2 and 4 circles) is

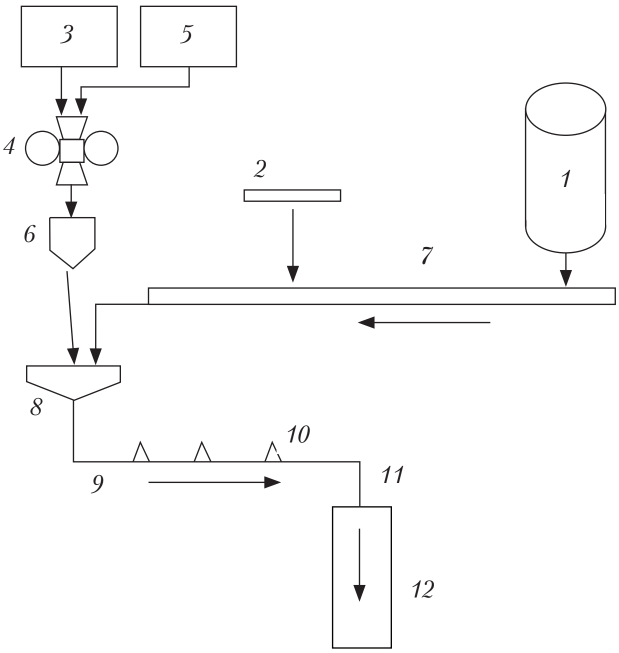

Fig. 2. Scheme of stowage facility with disintegrator: *1* — binders; *2* — dropping inert materials; *3, 5* — admixtures to binder; *4* — disintegrator; *6* — vibrating mill; *6, 8* — mixer units; *7* — conveyer; *9* — vibrating supply pipeline; *10* — vibrator; *11* — stowing hole; *12* — products

$I_{(2-4)}$ = 168 A, that of the inner rotor (1 and 3 circles) $I_{0(1-3)}$ = 126 A. While operating, the current amounts to $I_{(2-4)}$ = 564 A; $I_{(1-3)}$ = 271 A, respectively.

At the second stage, at idle speed, the current is the same as at the first stage, whereas while operating, it comes to $I_{(2-4)}$ = 564 A; $I_{(1-3)}$ = 336 A, respectively.

The total input power of engine (*N*, kW) is:

$$N = IU \cdot \sqrt{3} \cdot \cos\gamma,$$

where *I* is current, A*; U* is voltage, B; and *cos* is active power use ratio.

At idle speed, cosγ = 0.81 and the input power is as follows:

$$N_{(2-4)} = 89.6 \text{ kW};$$

$$N_{(1-3)} = 67.2 \text{ kW}.$$

The total input power at idle speed is

$$N_0 = 89.6 + 67.2 = 156.8 \text{ kW}$$

While treating slag in disintegrator cosγ = 0.92 and the input power is:

— at the first stage, $N_{(2-4)}$ = 267 kW, $N_{(1-3)}$ = = 164 kW;

— at the second stage, $N_{(2-4)}$ = 341.5 kW, $N_{(1-3)}$ = = 203.5 kW

The total input power is:

— at the first stage, N_1 = 267 + 164 = 431 kW;

— at the second stage, N_2 = 341.5 + 203.5 = 545 kW.

Assuming that for the slag treatment in disintegrator DU-65, the yield rate is Q_1 = 28.3 t/h and Q_2 = 41.1 t/h, the energy consumption can be calculated by the formula:

At the first stage:

$$E_{\text{net}(2-4)} = \frac{N_{(2-4)} - N_{0(2-4)}}{Q_1}, \text{ kW} \cdot \text{h/t},$$

$$E_{\text{gross}(2-4)} = \frac{N_{(2-4)}}{Q_1}, \text{ kW} \cdot \text{h/t},$$

where $E_{\text{gross}(2-4)}$ is gross energy consumption of the outer rotor, kW · h/t; $N_{(2-4)}$ is input power of the outer rotor, kW; Q_1 is yield rate, t/h.

$$E_{\text{gross}(2-4)} = \frac{267}{28.3} = 9.4, \text{ kW} \cdot \text{h/t},$$

$$E_{\text{gross}(1-3)} = \frac{164}{28.3} = 5.8, \text{ kW} \cdot \text{h/t},$$

$$E_{\text{net}(2-4)} = \frac{N_{(2-4)} - N_{0(2-4)}}{Q_1}, \text{ kW} \cdot \text{h/t},$$

where $E_{\text{net}(2-4)}$ is net energy consumption of the outer rotor, kW · h/t; $N_{0(2-4)}$ is input power of the outer rotor in the operating mode, kW; $N_{0(2-4)}$ is input power of the outer rotor at idle speed, kW; Q_1 is yield rate, t/h.

$$E_{\text{net}(2-4)} = \frac{267 - 89.6}{28.3} = 6.3, \text{ kW} \cdot \text{h/t},$$

$$E_{\text{net}(2-4)} = \frac{164 - 67.2}{28.3} = 3.4, \text{ kW} \cdot \text{h/t};$$

– at the second stage:

$$E_{\text{gross}(2-4)} = \frac{341.5}{41.1} = 9.4, \text{ kW} \cdot \text{h/t},$$

$$E_{gross(1-3)} = \frac{203.5}{41.1} = 5.0, \text{ kW} \cdot \text{h/t},$$

$$E_{net(2-4)} = \frac{341.5 - 89.6}{41.1} = 6.1, \text{ kW} \cdot \text{h/t},$$

$$E_{net(1-3)} = \frac{203.5 - 67.2}{41.1} = 3.3, \text{ kW} \cdot \text{h/t}.$$

For practical determination of rotor input power it is advisable to use the following formulas:

$$N_{(1-3)} = N_{0(1-3)} + E_{net(1-3)} \cdot Q, \text{ kW} \cdot \text{h/t},$$
$$N_{(2-4)} = N_{0(2-4)} + E_{net(2-4)} \cdot Q, \text{ kW} \cdot \text{h/t}.$$

The design power of disintegrator engines with four inlinerotors while treating the granulated slag is as follows:

$$0.8\, N_{(1-3)} = 67 + 4Q, \text{ kW} \cdot \text{h/t},$$
$$0.8\, N_{(2-4)} = 90 + 7Q, \text{ kW} \cdot \text{h/t}.$$

The phenomenon of high-energy activation during the treatment in disintegrator has been reported while treating many materials, including plug-back mixtures, silicalcite, iron ore, tungsten, copper, and iron ore concentrates, water, protein concentrate, etc.

Engineering improvement of ore beneficiation processesis realized by combining hydro-metallurgy and chemical treatment with the use of new technology processes. A promising direction is simultaneous reagent desalination and mechanical activation in disintegrator.

A reason for increasing amount of substandard mineral raw materials in the storage facilities is a dominant tendency for the gross extraction of ores in the hope of a progress in the beneficiation technologies, which in reality does not occur.

The possibilities of conventional beneficiation technologies are limited by the design of equipment and the use of mainly mechanical energy in the beneficiation processes. To increase the efficiency of beneficiation it is necessary to use other types of energy as well.

The possibilities of activation phenomenon in mining operations have been studied in the conditions of a particular corporation, *Norilsk Nickel*.

The settable mixture consists of anhydrite, slag, and cement. Anhydrite fractions after crushing in a hammer crusher are fed into a mill where they are ground until up to 30% of the aggregates has a size of less than 0.08 mm and is used as inert filler instead of binder.

The disadvantage of the technology applied is the use of settable mixturecomponents without the use of activation.

Anhydrite can be a substitute for cement if its binder properties are realized by opening the working surfaces of up to 50% of the aggregates having a size of up to 0.08 mm in the disintegrator that is placed between the mill and the mixer.

The mentioned processes take place in the case of slag and cement activation in the disintegrator, as well. The grained furnace slag having been milled without aggregate size control is hard to transport in the stowing pipe without crushing. The activation of cement upgrades it from M300 to M400.

In disintegrator, simultaneously with mechanical activation up to 50–70% valuable components are desalinated. It should be noted that the activated substances possess properties of both inert fillers and binders and can be a substitute both for cement and for anhydrite.

The use of disintegrators in the conditions of *Norilsk Nickel* ensures:

- replacement of cement with anhydrite with reduced transportation costs;
- reduced anhydrite consumption at increased activity;
- weakened effect of mix component price situation;
- improved transportability of settable mixture in the pipeline;
- metal extraction from mill tailings;
- environment rehabilitation.

The expected technical and economic results are as follows:

- a 20–30% reduction in the costs of preparation of settable mixtures;
- a 15–20% reduction in energy consumption for the stowing operations;

- utilization of up to 50% mill tailings;
- a 1–2% increase in metal yield.

The useful effects of mechanical activation are as follows:

1. The energy of mechanical treatment of material leads to accumulation of special type energy in the material. Under the action of four million gravity accelerations the material undergoes structural transformations with work converting into heat energy.

2. Absolute temperature of treated material has the most significant influence on the process efficiency factor.

3. During mechanical activation the system is exposed to abruptlyvarying load. The highest kinetic energy is obtained by counter impactsat high speeds.

4. While treating the components that react with each other the mechanical energy is used for both mechanical activation and for chemical processes.

5. In disintegrator, one can reach much higher pulse powerand frequency as compared with the treatment in ball or vibration mill. The particles of material receive more energy than in the case of longer treatment in ball or vibration mill.

The disintegration effect has been reported for adjacent industries as well. It causes the following quantitative parameters of quality:

- The plants much better intake activated phosphorite flour than thatof the same fineness milled in a ball mill;
- When milling the same clinker in a ball mill and in a disintegrator to the same fineness, in the latter case Portland cement is obtained, the strength of products from which in 16 days is equal to that achieved for the cement milled in the ball mill in 28 days;
- The activation of mixes for fixing the walls of deep boreholes during the extraction of oil and gas makes it possible to increase the concrete stretching strength up to 5 times;
- The activation of drilling fluid enables to increase the drilling speed by 20–25%, to decrease the content of solid phase in them 2.0–2.5 times, and to reduce the wear of the drill;
- The activation of silicalcite makes it possible to produce artificial stone twice cheaper as energy consumption reduces by 50%;
- The activation of the glass mix and furnace charge for the production of refractories lowers the melting or calcination temperatureby more than 20 °C, speedsup the process twice and improves the quality of products;
- The activation of iron ore enables to lower the metal reduction temperature by more than 100 °C for a time 20% shorter as compared with duration of ore treatmentin a ball mill to the same fineness;
- The activation of tungsten concentrate increases the metal extraction by 10% and reduces by 15–20% the duration of hydrothermal treatment;
- The treatment of copper and iron-ore concentrates together with a binder increases the strength of pellets by 25–35%;
- The treatment of silica several times increases its adsorption capacity;
- The treatment of starch-containing raw materials in alcohol production increases the fermentation rate by 20% and raises the yield of alcohol;
- The treatment of water-oil mixtures increases by 5–7% their caloric content, raises the engine efficiency and ensures complete combustion of fuel;
- The activation of nutrient medium for growing microorganisms increases their growth rate by 15–25%;
- The treatment of waste rubber, fiber reinforced plastic, fiberglass enables to obtain a valuable powder product used as filler for polymers;
- The treatment of mixed feed improves by several dozen percent the quality of products, saves energy and reduces operating costs;
- The treatment of protein concentrate increases the yield of cell fluid 2 times.

In order to determine the energy component effect on the materialduring the activation of the metal extraction processes, the mill tailings of the Sadonskoe polymetallic deposit have been treated (Fig. 3).

The content of lead and zinc in the desalination objects is as follows, %:

– Mill tailings: zinc – 0.95, lead – 0.84;

– Ore: zinc – 3.2, lead – 1.6.

Experiments for mill tailings or ore have been carried out in the following regimes:

1 – agitation desalination;

2 – agitation desalination of material activated in the dry state;

3 – desalination at the moment of activation with solutions in disintegrator;

4 – agitation desalination with pre-activation in disintegratorwith leaching solution;

5 – desalination in disintegrator with repeat cycle.

The energy parameters are measured usingAR-5 electric energy quantity and quality analyzer.

Having treated 1 kg dry ore (moisture content 2.0%) with an aggregate size lesser than 2.0 mm, at a feed rate of 10 kg/h and rotation frequency ofdisintegrator rotors of 200 Hz, a powder containing 93% fraction finer than 0.1 mm is obtained.The rotor engine current is 8.5 A; the tailing temperature increases by 32 °C.

Having treated 1 kg dry ore (moisture content 2.0%) pre-milled to an aggregate size lesser than 2.0 mm, at a feed rate of 10 kg/h and rotation frequency ofdisintegrator rotors of 200 Hz, a powder containing 95.3% fraction finer than 0.1 mm is obtained. The rotor engine current is 9.2 A; the ore temperature increases by 37 °C.

Having treated 1 kg effluent obtained by adding 1 liter leaching solution that contains 100 g/l sodium chloride and 6 g/l sulfuric acid to 0.2 kg tailings with an aggregate size lesser than 2.0 mm, at a feed rate of 10 kg/h and rotation frequency of disintegrator rotors of 200 Hz, a powder containing 92.7% fraction finer than 0.1 mm is obtained. The rotor engine current is 8.1 A; the effluent temperature increases by 22 °C.

Having treated 1 kg effluent obtained by adding 1 liter leaching solution that contains 100 g/l sodium chloride and 6 g/l sulfuric acid to 0.2 kg ore with an aggregate size lesser than 2.0 mm, at a feed rate of 10 kg/h and rotation frequency ofdisintegrator rotors of 200 Hz, a powder containing 92.1% fraction finer than 0.1 mm is obtained. The rotor engine current is 8.3 A; the effluent temperature increases by 26 °C.

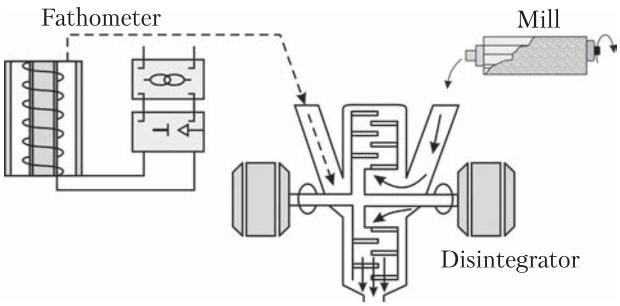

Fig. 3. Mechano-chemical desalinization of minerals in disintegrator

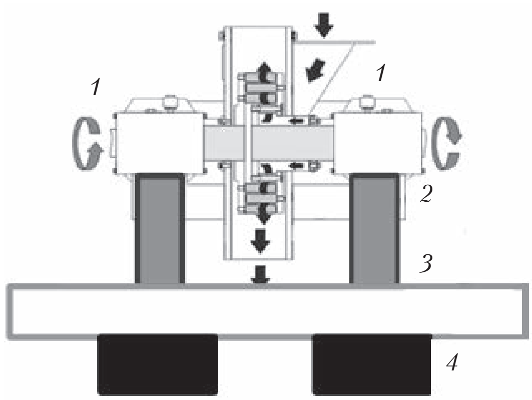

Fig. 4. Scheme of disintegrator upgrade: *1* — disintegrator; *2* — vibration generator; *3* –base; *4* — vibro-insulating support

The disintegrator technology advances, including, due to improvement disintegrator configuration. For example, the disintegrator is placed on vibrating baseand a force field provoking reduced energy consumption for activation process is created (Fig. 4).

In all cases with the formation of new substances and endothermic reactions, in addition to activation, the electric energy is 3–30 times repayable.

The establishment of regularities in the dependence of energy consumption for energy intensive plants and technological limits on operating factors is necessary for substantiating the technological processes of mining operations [16–18].

The implementation of conception for rationalizing energy utilization consists of the following stages:

1. To identify the limitations of conventional beneficiation technologies resulting in the formation of tailings based on analysis of existing assumptions.

2. To experimentally determine the possibility of all metal from the mill tailings by simultaneous chemical beneficiation and activation in disintegrator.

3. To study the factors determining the parameters of metal desalination technology, including the compositionof leaching solution, liquid to solid fraction ratio, and desalination time.

4. To study options for identifying the content of all extractable metals at their low concentration.

5. To study options for separating metals in pregnant solution.

6. To identify options for ensuring a proper strength of disintegrator operating bodies.

7. To assess the environment impactin terms of chemical contamination of lands with products of natural desalination with mining corporation age and danger of metal extraction technologies taken into consideration.

8.To estimate environment and economic efficiency of metal production from tailingsas combination of innovative methods with conventional ones.

9. To assess prospects for practical application, implementation in education activities,and commercialization.

10. To design an industrial plant.

11. To build an industrial plant.

12. To organize an enterprise for disposal of ore processing waste.

New approaches to energy utilization are implemented in the following way:

- Using a new type of energy action on mineral raw materials, the activation;
- Combining mechanical and chemical technologies results in a synergetic effect that gives new opportunities for efficient use of energy;
- In the case of conventional beneficiation methods, as much as possible useful components are extracted from tailings.The rest of them either remains in the primary tailings or is lost in the secondary tailings. Unlike the conventional methods, the proposed solution enables extracting all metals from the tailings up to background level;
- The conventional methods do not make possible to dispose the tailing dumps with purifying the secondary tailings to environment standards, while the proposed method enables solving this problem.

The mentioned specific features of energy consumption while raising energy efficiency with the use of new technological solutions correspond to the results of similar studies in advanced economies [19–22].

CONCLUSIONS

The mining operations will escalate energy intensity as producing capacity of mining and processing corporations grows and operating conditions of their consumers stiffen.

The importance of factors specific for mining operations, including irregularities in production and energy consumption, as well as specificity of electric load using equipment, will grow.

In connection with the transition to the development of deposits by underground method, the energy intensity of the preparation of settable mixtures with the activation of their components will increase.

In addition to the tasks of reducing energy consumption as part of the problem of raising energy efficiency, the efficientuse of energy, which will be considered in advanced technologies, for example, the activation of processes in the disintegrator, becomes urgent.

Fine grinding of discrete rock minerals in the disintegrator is a newapproach to the use of energy resources, which has not been well studied yet.

The extraction of metals from mineral raw materials that previously were wasted is a breakthrough process that repeatedly pays for the costs of diversifying the production.

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ДО ПРОБЛЕМИ ЕНЕРГОЗБЕРЕЖЕННЯ В ГІРНИЧОМУ ВИРОБНИЦТВІ

Вступ. Гірська промисловість є досить енергоємнісною галуззю через напруженість режимів технологічних процесів, в яких енерговитрати оптимізуються шляхом технічної модернізації, наприклад, процесу виготовлення твердіючих сумішей з обробкою компонентів суміші до необхідного розміру часток та їх активності.

Проблематика. Мінімізація енергозатрат при збільшенні обсягу виробництва, підвищення енергоефективності технологічних процесів та зниження затрат на енергозабезпечення формує самостійну проблему гірничої галузі, що визначає конкурентоздатність гірничого підприємства.

Мета. Визначення впливу процесів дезінтеграції та підвищення активності рудних матеріалів на енергоспоживання гірничого підприємства.

Матеріали й методи. Ефективність механоактивації визначається різницею міцності бетонів, виготовлених на основі базових та активованих в'яжучих компонентів. Раціональна комбінація технологій знаходиться як оптимум рішення з урахуванням змінних факторів, зокрема й енерговитрат. Область оптимальних значень в'яжучих компонентів знаходиться спільним розв'язуванням рівнянь, які описують отримані закономірності.

Результати. Наведено результати промислового експерименту з заміни в'яжучих компонентів бетонних сумішей активованими доменними шлаками. Визначені кількісні значення та закономірності витрат електроенергії на активацію компонентів твердіючих сумішей. Отримані дані використані для моделювання процесів підготовки суміші в умовах одного з підприємств Норильська. Встановлено загальні закономірності корисної дії механічної активації. Сформульовано концепцію та алгоритм раціоналізації енергокористування в процесах активації відходів гірничої промисловості.

Висновки. У зв'язку з демографічними факторами розвитку гірська промисловість буде збільшувати енергоємність виробничих процесів. При переході на розробку родовищ підземним способом витрати енергії на виготовлення твердіючих сумішей зростають. Особливої актуальності набуває напрямок корисної витрати енергії в електроємнісних процесах. Оптимізація витрат енергії у визначених умовах сприяє компенсації витрат на диверсифікацію гірської промисловості.

Ключові слова: енергоефективність, енергозбереження, гірська промисловість, дезінтегратор, активація.

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К ПРОБЛЕМЕ ЭНЕРГОСБЕРЕЖЕНИЯ В ГОРНОМ ПРОИЗВОДСТВЕ

Введение. Горное производство является весьма энергоемкой отраслью из-за напряженности режимов технологических процессов, в которых расход энергии оптимизируется путем технической модернизации, например, процесса приготовления твердеющих смесей с обработкой компонентов смеси до нужного уровня крупности и активности.

Проблематика. Минимизация затрат энергии при увеличении объема производства, повышение энергоэффективности технологических процессов и снижение затрат на энергообспечение формирует самостоятельную проблему горного производства, определяющую конкурентоспособность горного предприятия.

Цель. Определение влияния процессов дезинтеграции и повышения активности рудных минералов на электропотребление горного предприятия.

Материалы и методы. Эффективность механоактивации определяется разницей прочности бетонов, приготовленных на основе базовых и активированных вяжущих. Рациональная комбинация технологий находится как оптимум решения с учетом переменных факторов, в том числе и энергозатрат. Область оптимальных значений вяжущих находится совместным решением уравнений, описывающих полученные закономерности.

Результаты. Приведены результаты промышленного эксперимента по замене вяжущих компонентов бетонных смесей активированными доменными шлаками. Определены количественные значения и закономерности расхода электроэнергии на активацию компонентов твердеющих смесей. Полученные данные использованы для моделирования процессов подготовки смеси в условиях одного из предприятий Норильска. Установлены общие закономерности полезного действия механической активации. Сформулирована концепция и алгоритм рационализации энергопользования в процессах активации отходов горного производства.

Выводы. В связи с демографическими факторами развития горное производство будет увеличивать энергоемкость производственных процессов. При переходе на отработку месторождений подземным способом расход энергии на приготовление твердеющих смесей возрастет. Особенную актуальность приобретает направление полезного расходования энергии в электроемких процессах. Оптимизация расхода энергии в определенных условиях способствует компенсации затрат на диверсификацию горного производства.

Ключевые слова: энергоэффективность, энергосбережение, горное производство, дезинтегратор, активация.