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TECHNOLOGY OPTIMIZATION FOR PROCESSING OF RAW MATERIALS FROM HETEROGENEOUS CARBONATE DEPOSITS

Purpose. The research is aimed at determining the qualitative and quantitative characteristics of complex limestone processing from the Oleshiv limestone deposit while calculating the energy absorption rates in the processes of processing non-metallic mineral raw materials.

Methodology. The authors of the paper sampled limestone in three outcropped locations of the Oleshiv mineral deposit. The degree of limestone purity in marketable products by type of fraction is examined using an X-ray DRON-3 diffractometer. The ultimate compressive strength of limestone is determined in laboratory conditions using a specialized test press KL 200/CE-Tecnotest. Energy absorption rates are calculated based on parameters characterizing the main stages of limestone processing, including crushing, transportation and screening.

Findings. The main trends in the field of limestone mining and processing have been analyzed, highlighting previously unresolved problems. On the example of processing limestone from the Oleshiv deposit, a technological scheme for its beneficiation has been developed; qualitative and quantitative parameters of the beneficiation process have been determined; the mineral composition of the fractional marketable product has been studied; the parameters of limestone compressive strength, as well as energy absorption rates in the processing processes to obtain finished products have been found.

Originality. The patterns of change in the flux limestone content during its beneficiation with preliminary dry extraction of marketable fractions of 80–130, 40–80 and 20–40 mm have been revealed. The patterns of the finished product yield distribution have been identified, taking into account the movement of clay-sand raw materials in the 0–20 mm fraction and its combination with the preliminary extraction of the 0–40 mm fraction before crushing. Based on mineralogical analysis of limestone composition by fraction types, it has been found that the degree of its purity increases from 85.54 to 94.0 %. The energy absorption rates during limestone processing have been determined, taking into account the physical-mechanical properties of the mineral and the parameters of equipment operation.

Practical value. A technological scheme for the beneficiation of limestone from the Oleshiv deposit has been developed, which allows for the production of seven fractions of limestone and one fraction of clay-sand raw materials. This scheme is optimized to maximize the extraction of the useful component, while ensuring high quality of the final product. The dynamics of energy absorption during limestone crushing, transportation, and screening has been determined, which makes it important to develop further recommendations for optimizing energy consumption in crushing processes.

Keywords: *limestone, processing, energy absorption, strength, Oleshiv deposit*

Introduction. Today in Ukraine, against the background of large-scale critical and civil infrastructure destruction, the need for building materials becomes particularly acute. Therefore, ensuring stable and efficient access to these resources is critical to sustaining the construction industry. The main building raw materials used in the construction industry are crushed stone, sand, limestone and clay, which are used to produce concrete, cement, bricks and other important materials necessary for the construction of buildings [1, 2]. In addition, these materials are used for the production of plasters, tiles and various types of decorative finishes, creating architectural solutions of varying degrees of complexity. Their versatility and affordability make these materials indispensable on a global scale, both for the restoration of damaged buildings and for new construction.

In Ukraine, according to the National Program for the Development of the Mineral Resource Base of Ukraine for the Period up to 2030, almost 20 thousand deposits and occurrences of 117 types of minerals have been discovered in the depths of our country. Of these, 8,290 deposits and 1,110 accounting objects, related to 98 types of mineral raw materials, are of industrial importance. These objects are registered in the state balance of mineral reserves, and 3,349 of these deposits are currently actively mined.

The supply of construction raw materials is based on enterprises that specialize in the open-pit mining of non-metallic mineral raw materials [3, 4]. In Ukraine, for example, about 400 enterprises actively mine and process such material as crushed stone [5]. Especially many deposits are concentrated in Zhytomyr Oblast, where there are 201 fields [6]. Crushed stone production is classified by its main types into granite crushed stone, gravel crushed stone, and limestone crushed stone. That is why limestone is another popular mineral raw material, which is also used as a raw material for the production of building materials (lime, cement, and concrete aggregate), as well as for use in metallurgy and chemical industry [7].

Currently, the development of non-metallic mineral raw materials is of strategic importance, since this process includes not only mining, but also processing of a wide range of minerals, such as limestone, gypsum, chalk, kaolin, and others [8, 9]. And ensuring a steady supply of these important resources is key to supporting various industries, from construction to chemical. Effective management of these resources necessitates the development and implementation of modern technologies and approaches that will not only maximize the yield of marketable products, but also minimize the environmental impact in the process of mining and processing of minerals.

Literature review. The research on the efficiency of mineral mining processes covers technological [10], economic [11], environmental [12] and social aspects aimed at optimizing the mining processes [13, 14]. At the same time, an important life cycle of mined minerals is their further beneficiation, which contributes to a significant increase in the quality of final products and their market value [15, 16]. The beneficiation process includes various methods of purification, classification and chemical treatment of minerals, which are aimed at eliminating unwanted impurities and increasing the concentration of valuable components [17, 18]. This is crucial for ensuring high quality products that are ready for use.

Today, limestone, as a strategically important raw material, is widely used in various fields, which makes its processing important from both a scientific and practical point of view [19]. Limestone is one of the most common rocks found on the earth's surface and about 10 % of the earth's surface of our planet consists of limestone or similar rocks [20].

A literature review of research on the development and processing of limestone deposits shows that current research in this area is aimed at solving a number of technical, environmental, and social problems. Key areas of focus include improving methods to increase rock strength and stability during mining, minimizing environmental impact, economic feasibility of processes, utilization of waste, and consideration of environmental aspects during mining operations.

In [21], researchers from Saudi Arabia focused on the problem of mechanical stability of weak limestone rocks, especially in the presence of karst cavities. They conducted laboratory and on-site tests to determine correlations between rock strength characteristics, such as the uniaxial compressive strength (UCS), and geomechanical properties of the mass. The authors have developed a methodology using modified Hoek-Brown criteria that can help improve the reliability of wall-rock stability predictions, which is an important aspect for fields with unstable zones, such as karst cavities.

The study [22] is aimed at economic optimization of the mining process, in particular, at reducing the costs of drilling-blasting operations, which are one of the most costly parts of the mining process. The researchers used the Rock Engineering System (RES) method to construct a comprehensive model that takes into account parameters such as rock hardness, well geometry, and the amount of explosive. This approach not only reduces costs, but also mitigates the negative impact on the environment, as improved calculation accuracy helps to reduce the need for drilling-blasting operations.

The paper [23] explores the possibility of using limestone deposit wastes to create synthetic carbonate rocks. The scientists combined limestone powder with epoxy resin to produce samples that show similar mechanical and pore properties to natural carbonates. The results confirmed that such samples can be used in future studies related to rock mechanics and "rock-fluid" interaction. Thus, the proposed approach not only allows for the rational use of waste, but also opens up new opportunities for scientific experiments.

The paper [24] proposes a technology for beneficiation of carbonate raw materials, which involves the forced separation of clay impurities from limestone, followed by effective screening in quarry conditions. In this case, the authors use a mathematical model to predict beneficiation efficiency parameters with a limited amount of data. This can affect the accuracy and reliability of model predictions, especially when applied to different mining-geological conditions.

The study [25] focuses on the impact of limestone quarries on the environment, in particular, on air, water, soil, flora and fauna. The authors emphasize that limestone mining causes landscape changes and environmental degradation, affecting the quality of life of local residents. They emphasize the importance of complying with European environmental standards, which can significantly minimize the negative impact on the environment. The proposed measures include dust and noise control, as well as restoration of disturbed landscapes, which contributes to achieving more sustainable development in the mining industry.

The paper [26] provides an overview of methods for assessing the environmental impact of limestone mining, which is especially relevant in the context of growing global attention to the environmental consequences of industrial activity in India. The authors propose using hyperspectral survey to identify the cleanest limestone zones, which can reduce the volume of mining operations and improve the environmental efficiency of quarries. The proposed measures also include water purification, land reclamation and pollution monitoring, which is consistent with the principles of sustainable development. At the same time, study [27] raises the issue of social responsibility in the mining industry when mining limestone deposit, considering the impact of quarrying on the local population. Studies were conducted to assess the impact of mining operations on the health and quality of life of the population within the mining and industrial region of the Republic of South Africa. In particular, it has been found that the lack of transparency and compliance with laws by companies are the main causes of environmental and social conflict. The authors call for stronger government regulation and accountability of mining companies to protect the interests of local communities.

Thus, today, modern research is mainly aimed at improving the efficiency and environmental safety of limestone mining and processing, as well as taking into account social aspects to achieve harmonious interaction with the environment and communities living near the fields.

Unsolved aspects of the problem. In the process of designing mining enterprises for mining non-metallic mineral raw materials, a processing complex is formed. The operating parameters of this complex primarily depend on the physical-mechanical properties of the mined raw materials (strength, density, moisture content, etc.), the method of moving the rock from one technological process to another, and the parameters for obtaining feedstock. The qualitative and quantitative parameters of mineral beneficiation play a decisive role in the operation of enterprises specializing in the processing of non-metallic mineral raw materials. Ensuring high performance of these parameters is key to improving production efficiency and reducing environmental burden. Optimization of beneficiation processes makes it possible to maximize the potential of mined raw materials, reducing the percentage of losses in waste, and improving the quality of final products. At the same time, to ensure economic efficiency, special attention should be paid to optimizing operating costs, including fuel and energy costs, which are critical to ensuring the smooth operation of processing plants. The amount of these costs directly affects the efficiency of work processes and the overall productivity of the mining enterprise. Therefore, the optimization of these costs is key to increasing the profitability of its operation. In addition, effective management of energy resources allows not only to reduce the cost of processing processes, but also to reduce emissions of harmful substances, thereby raising environmental standards during the operation of the mining enterprise and increasing production capacity.

Therefore, the purpose of this research is to determine the qualitative and quantitative characteristics of complex limestone processing from the Oleshiv limestone deposit while calculating the energy absorption rates in the processes of processing non-metallic mineral raw materials.

To achieve the purpose set in this paper, it is necessary to: analyze the mining-geological conditions of the Oleshiv limestone deposit mining; develop a water-sludge scheme for limestone beneficiation and assess its qualitative and quantitative beneficiation parameters; study the mineral composition of the fractional marketable product; determine limestone compressive strength parameters; calculate the energy absorption rates during processing processes to obtain finished products.

Research Methods. ***Characterization of the research object.*** The Oleshiv limestone deposit is located 0.5 km north-east of the village of Oleshiv in Tlumach Raion of Ivano-Frankivsk Oblast (Fig. 1).

The Oleshiv limestone deposit area is 30.7 hectares, of which 4.7 hectares are disturbed by mining operations, while 26.0 hectares are not disturbed. During the preliminary min-

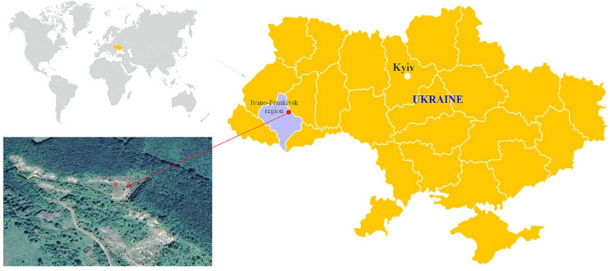

Fig. 1. Location of the Oleshiv limestone deposit

ing of part of the Oleshiv deposit, a 2.8 hectare area of an old quarry mined-out space was formed. The quarry was mined to the +250.0 m level, which is the lower reserve estimation limit. Given the peculiarities of the geological structure of the field, in fact, the only consistent horizon over the entire field area is +250.0 m level. Other horizons are separated by a gully that runs through the field from north-west to south-east. In terms of rock composition, the horizons are mixed – there are both overburden rocks (on the flanks of the horizons) and minerals.

The mining-geological and engineering-geological conditions of mineral occurrence and the experience gained from mining of limestone deposits have determined the method of mining operations at the Oleshiv limestone deposit according to the transport mining system with the parallel advance of the front of mining operations. During the preliminary mining of part of the Oleshiv deposit, a mined-out space of old quarry was formed, which is shown in Fig. 2.

The field is stripped using a descent system (semi-trenches) formed within the previously existing quarry along the south-western boundary of reserve estimation from +265.0 m level to a horizon of +290.0 m level (actual +293.0 m). The first semi-trench was formed in a south-eastern direction at +265.0 m level to an intermediate site at +270.0 m level. The

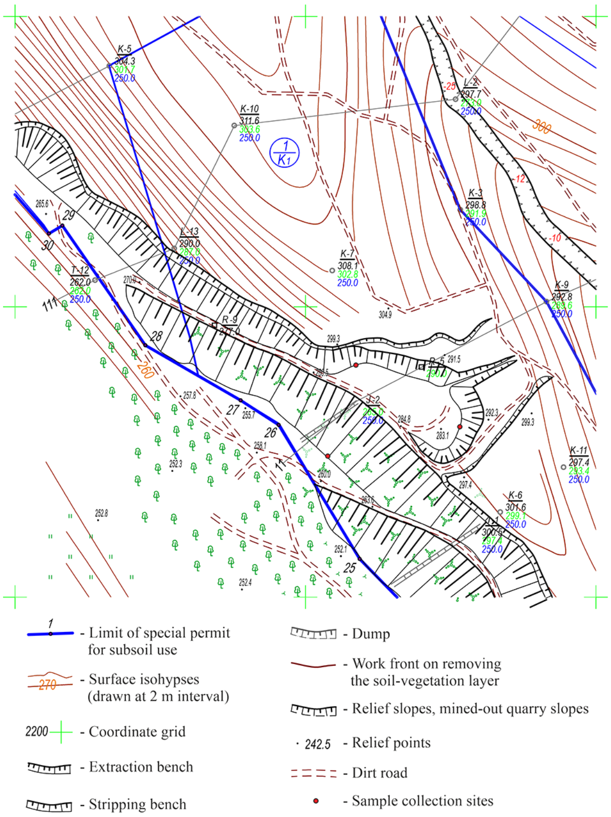

Fig. 2. Current state of overburden workings at the Oleshiv limestone deposit

descent is 69 m long and 22 m wide. From the intermediate site at +270.0 m level, a second semi-trench was formed in the south-eastern direction to the site at +280.0 m level. The descent is 125 m long and 5 m wide. The site at +280.0 m level is not supported along the bottom – the difference in levels reaches 6 m. From the site at +280.0 m level (actual +285.0 m) in the southern part of the mine working, a descent to the horizon at +290.0 m level (actual +293.0 m) was formed. The descent is 110 m long, width – from 4 to 14 m. Horizontal intermediate sites were formed between the semi-trenches of stripping.

Methodology for selecting equipment for limestone processing. The methodology for selecting equipment for processing limestone from the Oleshiv deposit is a complex process that involves conducting a detailed analysis of the technical parameters and characteristics of the required equipment. One of the key steps is to determine the overall degree of rock crushing, which takes into account both the initial and final material size. This makes it possible to select the most efficient crusher types and their configurations that can provide optimal production line operation at the mining enterprise. Therefore, when choosing equipment, considerable attention is paid to calculating the performance of crushers. This includes analyzing their ability to crush a certain amount of limestone raw material per unit of time and determining the optimal number of crushers to satisfy production needs. Depending on the chosen crushing scheme, a one-, two-, or three-stage system can be selected, where each crushing stage is adjusted to achieve a specific final product size.

For each crushing stage, equipment parameters such as the width of the feed and discharge holes are customized. These parameters are critical for efficient crushing and preventing undersized material from entering the working zone. To develop a water-sludge scheme for limestone beneficiation, the authors use the algorithm described in [28, 29], according to which the following parameters are set: crushing stage operating mode; rock crushing degree; conditional maximum crushing size; width of the crusher's feed and discharge holes; crusher performance and their number. It should be noted that in order to set up a rational crushing process and select the most suitable equipment, it is necessary to take into account the physical-mechanical properties of limestone (strength) and its mineralogical composition. For this purpose, the authors of the research selected limestone samples from three outcropped locations of the mineral deposit. A general view of the limestone samples selected for studying beneficiation processes and compressive strength is shown in Fig. 3.

The mineralogical composition of the beneficiated limestone samples is studied using an X-ray DRON-3 diffractometer. This research method has proven to be an effective tool

a *b*

Fig. 3. General view of the sampled limestone from the Oleshiv deposit:

a – for studying beneficiation processes; b – for testing compressive strength (Sample 1) for identifying the crystalline phases of minerals, and is characterized by high resolution, providing a clear display of diffraction peaks [30]. Monochromatized Co-K-α radiation is used for the analysis, which allows for high accuracy and detail in detecting minerals in the composition of limestone samples.

The ultimate compressive strength of selected rock samples from the Oleshiv deposit (3 samples) is determined in laboratory conditions using a specialized test press KL 200/CE-Tecnotest. This method helps to assess the strength of a material under high pressure by modeling the conditions that may occur when crushing this rock.

The KL 200/CE-Tecnotest press uses a hydraulic loading to compress the samples, allowing for precise control the value and rate of loading. This approach makes it possible to measure compressive strength with high accuracy and reproducibility of results. Prior to testing, the rock samples were prepared for testing, including their standard shaping into cubes with dimensions of 0.05 m, to ensure uniform conditions for each test process. A visualization of the process of testing formed limestone samples on the KL 200/CE-Tecnotest press is shown in Fig. 4.

Methodology for studying energy absorption during the processing of non-metallic mineral raw materials. According to Prof. Yu. I. Anistratov's definition, "Part of the energy consumed to perform mining operations and spent on changing the state is absorbed by the rock in the production process, as it were, is called technological energy absorption. This part represents the energy consumption to overcome rock resistance in technological processes, as opposed to the actual consumption, which is taken into account by the efficiency of the machines". When processing non-metallic mineral raw materials, significant volumes of energy are used to perform various processes, depending on the chosen technological scheme. The main processing stages of limestone from the Oleshiv deposit include its crushing, transportation and screening to separate fractions. Therefore, taking into account the selected equipment for limestone processing, the authors of the paper studied the energy absorption rates based on the use of a number of dependences:

- energy absorption during the crushing process, J/kg

$$E_c = \frac{\sigma_c^2}{2E} \lg \frac{d_{aver}}{d},$$

where σ_c is the medium compressive strength, kg/cm^2; E – is the elasticity modulus, N/m^2; d_{aver} – is an average diameter of a piece of mineral fed for crushing, mm ($d_{aver} = B/6.5$; B – is the excavator bucket width, mm); d – is the diameter of the piece after crushing in the crusher, mm;

- the energy absorption of active screening is associated with overcoming the inertia forces of rest and resistance to rock mass movement through the screen, J/kg

$$E_s = \frac{v_s^2}{2g} + F_s l,$$

Fig. 4. Visualization of the process of testing formed limestone samples on the KL 200/CE-Tecnotest press

where v_s is the velocity of rock mass movement through the screen, m/s; F_s – is the resistance to the rock mass movement through the screen, N; l – is the screen length, m;

- energy absorption in the process of moving between individual processing operations depends on the conveyor resistance, J/kg

$$E_{\bar{t}} = \frac{v^2}{2g} + \omega_o l_{t.} + H,$$

where v is the conveyor movement velocity (0.8–3.15 m/s); ω_o – is the main resistance to movement, N; l_t – is the total length of conveying at a factory, m; H – is the total lifting height of the mineral in the process of moving it at a factory, m.

Research results. In accordance with the provisions specified in the methodology for selecting equipment for this research, the authors have developed a water-sludge scheme for the complex processing of limestone from the Oleshiv deposit (Fig. 5). To calculate this scheme, the production line capacity for dry material is assumed to be 250 tons/hour.

The analysis of this scheme indicates that it provides for the production of 7 fractions of limestone and 1 fraction of clay-sand raw materials, which is performed by crushing and partially dry and wet screening, which ensures the highest yield of the useful component (limestone) with high quality of the final product. The results of research on the content and quality of beneficiated limestone in beneficiation products are shown in Table.

Analysis of the data from Table shows that the limestone content in the fractions ranges from 4.78 to 21.91 %. It should be especially noted that the implementation of the developed complex beneficiation scheme with the use of preliminary dry extraction of marketable fractions of flux limestone (items 1–3 in Table) resulted in an increase in their content compared to traditional beneficiation methods. This opens up new oppor-

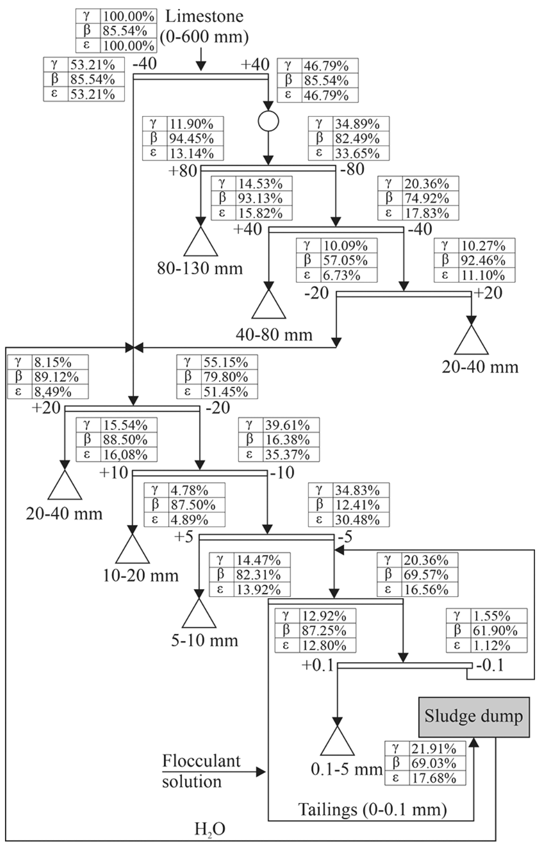

Fig. 5. Water-sludge scheme for beneficiation of limestone from the Oleshiv deposit (γ – *is the product yield from input feedstock, %;* β – *is a useful component content, %;* ε – *is a useful component extraction, %*)

Table

Data on limestone content in beneficiation products depending on the fraction type

No.	Fraction type	Yield, %	CaO + MgO, %	$SiO_2 + Al_2O_3$, %
1	Fraction 80–130 mm	11.90	53.57	2.89
2	Fraction 40–80 mm	14.53	53.64	3.56
3	Fraction 20–40 mm	10.27	52.90	3.66
4	Washed out fraction 20–40 mm	8.15	52.56	3.78
5	Washed out fraction 10–20 mm	15.54	52.09	4.09
6	Washed out fraction 5–10 mm	4.78	52.48	4.34
7	Washed out fraction 0.1–5 mm	12.92	52.18	5.38
8	Washed out fraction 0–0.1 mm	21.91	34.65	28.10
9	Input raw materials	100	47.90	14.46

tunities for further expansion and improvement of limestone beneficiation processes, as well as for optimizing the economic efficiency of mining production.

Movement of clay-sand raw materials in the 0–20 mm fraction and its combination with the preliminary extraction of the 0–40 mm fraction before crushing allowed to maximize the yield of the finished product, and intensive clay washing maximized the yield of washed out products (items 4–7, Table 1). Limestone beneficiation tailings (item 8, Table 1) are also a separate marketable product that can be sold for brick production. At the same time, analysis of the mineralogical composition of limestone indicates that the degree of its purity during the process of processing in fractions increases from 86 % (input raw materials) to 87–95 % (fractions). Fig. 6 shows the mineralogical change in limestone concentration in the 80–130 and 20–40 mm fractions.

Analysis of the X-ray phase test results of the obtained beneficiated limestone fractions indicates that the best parameter of the main calcite component ($CaCO_3$) is inherent in the 80–130 mm fraction (95 %) of the total composition. The content of dolomite mineral in limestone composition varies from 4 to 7 % in fractions, with the highest content observed in the washed-out fraction of 0.1–5 mm. An indeterminate phase of 2 % is also present in all samples and may contain quartz minerals. In addition, the fractions also contain kaolinite minerals (3–10 %), which were extracted into beneficiation tailings. Each of the X-ray diffraction patterns clearly illustrates the mineralogical composition of the samples, emphasizing the importance of identifying constituent minerals for understanding the properties of limestone and its potential for processing processes to yield marketable products.

When determining the compressive strength of the selected limestone samples, the study has revealed that the strength parameter varies significantly, ranging from 135 to 156 kg/cm^2. These data indicate a variety of structural properties of limestones, which may be due to differences in mineralogical composition, degree of crystallization, as well as the content and nature of impurity inclusions in each sample. Subsequent research by the authors of the paper, taking into account the determined strength characteristics of limestone, has found the main parameters related to energy absorption during its crushing, transportation and screening.

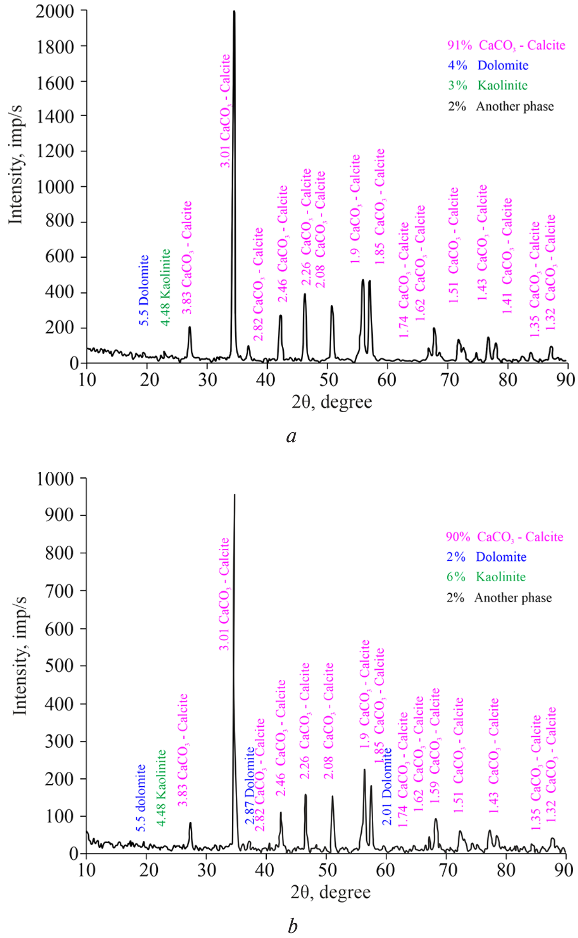

Fig. 6. X-ray diffraction patterns of limestone samples by fractions:

a – 80–130 mm; b – 20–40 mm

In the process of transportation and screening, the ultimate strength parameter is virtually absent, so the main process that consumes most energy and has a higher energy absorption rate is crushing. It is during crushing that the process of energy absorption occurs, which is transferred from the working body to the raw material. The harder the rock, the more effort is required to crush it and the more energy is used. In accordance with the previously found strength parameters using formula (1), the dynamics of energy absorption fluctuations in the process of crushing limestone from the Oleshiv deposit is studied. The change in energy absorption dynamics is shown in Fig. 6.

The determined energy absorption dependence during crushing of limestone from the Oleshiv deposit with a compressive strength from 135 to 156 kg/cm^2 is as follows, kJ/kg

$$E_c = 0.14\sigma_c^2,$$

where σ_c – is the ultimate compressive strength of Oleshiv limestone, Pa.

Analyzing the energy consumption parameters in the processes of limestone processing, it is possible to note significant differences in the energy consumed by different technological operations. Energy absorption rates when crushing limestone with a jaw crusher according to the beneficiation scheme, depending on its compressive strength, vary from 10.8 to 14.7 kJ/kg. This indicates the high energy intensity of this processing stage. Unlike crushing, energy consumption during screening is insignificant. For our conditions, the energy absorption rate for dry screening is 0.035 kJ/kg, and for wet screening – 0.036 kJ/kg. The total transportation parameters are 0.9 kJ/kg.

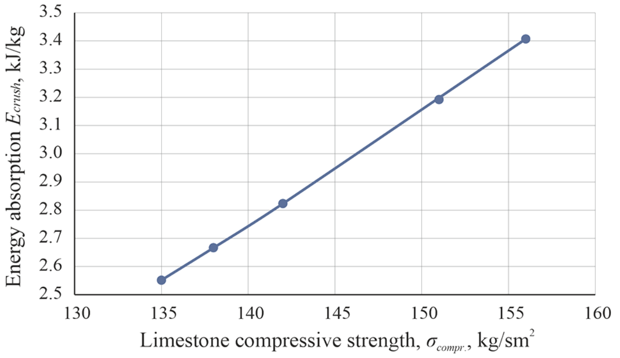

Fig. 7. Change in energy absorption dynamics during limestone crushing

The total share of energy spent on screening and transportation is 8.25 % of the total energy consumption for processing. This emphasizes that both of these processes together form only a small part of total energy consumption. Therefore, the main recommendations for optimizing energy consumption should be directed to crushing processes. Under such conditions, it is necessary to implement more efficient technologies and equipment, which can significantly reduce the total energy consumption. Transportation costs can be reduced by optimizing logistics chains and using energy-efficient vehicles. Despite the low energy parameters of the screening process, further reduction of energy consumption is possible by using modern screens with improved technical characteristics and greater energy efficiency.

Conclusions. The implementation of a complex flux limestone beneficiation scheme, which includes preliminary dry extraction of marketable fractions, allows an increase in the amount of marketable fractions compared to traditional beneficiation methods, with a limestone yield in fractions from 4.78 to 21.91 %. Particularly important is the use of the process of moving clay-sand raw materials into 0–20 mm fractions and combining them with the preliminary extraction of the 0–40 mm fraction before crushing, which can help to maximize the yield of the finished product. Intensive clay washing additionally increases the yield of washed-out products, which generally improves the quality of the final product. This approach not only optimizes the resource use, but also reduces the environmental impact of the mining enterprise by reusing beneficiation tailings, for example, for brick production, which is an example of effective industrial waste management.

Mineralogical analysis of limestone shows that the degree of the product purity increases from 85.54, 87 to 94.0 %, depending on the fraction type, which confirms the high efficiency of the selected beneficiation scheme to achieve high quality limestone products. This not only helps to increase the competitiveness of products on the market, but also provides higher standards for further applications of limestone.

It has been found that the dynamics of fluctuations in energy consumption at enterprises engaged in mining of non-metallic raw materials is closely related to the physical-mechanical characteristics of the mineral. The analysis shows that such a property of rock as strength directly affects the amount of energy consumed during its crushing, which, in turn, increases the total energy consumption of the enterprise. In view of this, mining enterprises can implement targeted measures to optimize production processes, in particular, by choosing more suitable equipment and technologies for processing a particular type of rock. In addition, the development and application of innovative technologies capable of reducing energy consumption can be a key factor in improving efficiency and reducing costs, which will ultimately have a positive impact on the competitiveness of enterprises in this area.

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Оптимізація технології переробки сировини неоднорідних карбонатних родовищ

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Мета. Визначення якісних і кількісних характеристик комплексної переробки вапняків Олешівського родовища зі встановленням параметрів енергопоглинання у процесах переробки нерудної мінеральної сировини.

Методика. Авторами роботи було проведено відбір проб вапняків у трьох локаціях оголення покладу корисної копалини Олешівського родовища. Ступінь чистоти вапняку у товарній продукції за типами фракцій досліджувалась за допомогою рентгенівського дифрактометра ДРОН-3. Межа міцності вапняку на стиск була визначена в лабораторних умовах за допомогою спеціалізованого випробувального пресу KL 200/CE-Tecnotest. Показники енергопоглинання встановлювались за параметрами, що характеризують основні етапи переробки вапняку та включають його подрібнення, транспортування та грохочення.

Результати. Проаналізовані основні тенденції у сфері видобутку й переробки вапняків з виділенням раніше невирішених проблем. На прикладі переробки вапняків Олешівського родовища розроблена технологічна схема його збагачення; визначені якісно-кількісні показники процесу збагачення; досліджено мінеральний склад фракційного товарного продукту; встановлені параметри міцності вапняку на стиск, визначені показники енергопоглинання в процесах переробки для отримання готової продукції.

Наукова новизна. Встановлені закономірності зміни вмісту флюсового вапняку при його збагаченні з попереднім сухим вилученням товарних фракцій 80–130, 40–80 та 20–40 мм. Визначені закономірності розподілення виходу готового продукту з урахуванням переміщення глинисто-піскової сировини у фракції 0–20 мм та її об'єднанням з попередньо вилученою фракцією 0–40 мм перед подрібненням. На основі мінералогічного аналізу складу вапняку за типами фракцій встановлено, що ступінь його чистоти підвищується з 85,54 до 94,0 %. Визначені показники енергопоглинання при переробці вапняку з урахуванням фізико-механічних властивостей корисної копалини й параметрів роботи обладнання.

Практична значимість. Розроблена технологічна схема збагачення вапняків Олешівського родовища, що дозволяє отримувати сім фракцій вапняку та одну фракцію глинисто-піскової сировини. Ця схема оптимізована для максимального вилучення корисного компоненту, забезпечуючи при цьому високу якість кінцевого продукту. Визначена динаміка енергопоглинання при дроблені, транспортуванні та грохоченні вапняку, що актуалізує подальшу розробку рекомендацій для оптимізації енергоспоживання у процесах дроблення.

Ключові слова: *вапняк, переробка, енергопоглинання, міцність, Олешівське родовище*

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