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SUBSTANTIATION OF THE TECHNOLOGICAL PARAMETERS OF BUCKET-WHEEL EXCAVATOR FORWARD TRENCH WHEN MINING TITANIUM DEPOSITS

Purpose. To justify the parameters of the technological scheme of working out an advanced overburden bench by a bucket-wheel excavator, to reduce the cost of overburden work at Pit 7 of Vilnohirsk Mining and Metallurgical Plant.

Methodology. Setting the parameters of the technological scheme of the bucket-wheel excavator was performed by the graphic-analytical method, which involves taking into account the technical characteristics of the mining machine, the physical and mechanical properties of the mining rocks and the stable slope angle of the advanced overburden bench. The substantiation of the effectiveness of application of the technological scheme with a forward trench was made by the technical and economic calculation of the specific costs on overburden works.

Findings. The possibility of increasing the height of the overburden bench when using a technological scheme with a forward trench was evaluated. Reasonable parameters of the forward trench, in which the bucket-wheel excavator can develop a forward pit bench with a capacity of 40 m with a stable slope angle of 30°. This allows reducing the amount of mining haulage equipment and reducing overburden costs by up to 50 %.

Originality. The minimum slope angle of the overburden slope at the maximum digging height of the ERShR-1600-40/7 excavator, which is equal to 40° at a slope height of 40 m, was established. The dependence of the resulting slope angle of on the re-excavation coefficient of the mining rock mass was established. This makes it possible to assert that when this angle is increased the re-excavation rate will decrease. It was established that at the applying technological scheme with a forward trench in the conditions of Vilnohirsk MMP, the coefficient of overburden re-excavation will be $k = 0.09$.

Practical value. A technological scheme for the development of an advanced overburden bench by the bucket-wheel excavator with a forward trench allows increasing its developed bench height. This makes it possible to reduce the operational cost for overburden works by refuse from haulage mining system with dump trucks.

Keywords: *overburden rocks, bucket-wheel excavator, advanced bench, slope angle, forward trench*

Introduction. Titanium is a strategic raw material large reserves of which Ukraine possesses. The main deposits are represented by rutile-zircon-ilmenite placer deposits, which are developed by the surface mining method [1].

Today, the demand for titanium raw materials is growing, however, in the conditions of market competition, mining enterprises must improve the technologies of deposit development in order to reduce the cost of ore mining and processing.

One of the largest enterprises in Ukraine for the development of titanium raw materials is Vilnohirsk Mining and Metallurgical Plant (Vilnohirsk MMP), which has been operating for more than 40 years.

The main costs for the mining of a mineral deposits are spent on overburden works and their share is about 70 % of the overall cost on deposit development [2]. Excavation works at Vilnohirsk MMP are carried out with by the powerful complexes of continuous and cyclical action [3]. A large share of overburden costs accounts for cyclic equipment; this is due to the use of BelAZ-7547 dump trucks that run on diesel fuel, which is expensive in comparison with electricity. Therefore, the reduction of overburden costs is an urgent topicality. To solve this problem, it is necessary to consider the possibility of improving the existing technological scheme of overburden with the use of continuous action complexes.

Increasing the efficiency of the powerful complexes of continuous action use is a multi-faceted task, which was comprehensively solved by scientists and equipment manufacturers. Thus, the study on the connected equipment parameters for the EG-1600 excavator based on the technical and economic evaluation of the options that differ in the standard size of the cantilever pile driver has been conducted by different scientists. The detailed development of the technological scheme of overburden works and establishment in the connection with NKMZ parameters of the face spreader at the work in a complex with the EG-1600 excavator was carried out in relation to the Nikopol manganese deposits. A lot of attention was paid to the research related to the substantiation of the standard range of bucket wheel excavators.

In research of UkrNDIproekt the aim consists in developing a new typical series of continuous machine complexes, the bench height and bucket wheel excavator parameters was also based on the assessment of possible mining face heights and the establishment of rational combinations of theoretical productivity and digging height. A mathematical model of the pit was developed to optimize its parameters and equipment parameters. The mathematical model made it possible to justify the structure of complex mechanization and the parameters of the mining system based on their relationship with the bucket wheel excavator's theoretical productivity, the capacity of the pit, and the total capacity of the overburden. Thus, the task of establishing such main working parameters of the bucket wheel excavator as the theoretical productivity and the digging height, which is accepted, was solved. Regarding the manganese ore pits parameters in Ukraine, recommendations are also given on the maximum heights of bench, which are developed without dividing them into sub-benches.

The research studies of UkrNDIproekt and NKMZ paid a lot of attention to the establishment of rational combinations between the length of the rotor boom, the diameter of the bucket wheel and other design parameters of the excavator working equipment. However, the initial position of these studies was orientated to the standard size of the excavator. From the results of these studies, the following should be noted: recommendations on the minimum bench of the bucket wheel boom for an excavator with a digging height of 40 m, recommendations on the optimal calculated heights of bench for complexes with a capacity of 5,000 and 12,500 m^3/h when the excavator works on one bench; conclusions about the expediency of reducing the bucket wheel diameter from the point of view of reducing dynamic phenomena at the development of hard rocks.

Evaluating the conducted research, we should note that most of the works performed in the complex with machine-building plants are devoted to the design and development of continuous complexes individually for the conditions of each deposit. However, solving the problem of increasing the efficiency of the already existing complexes that work in the pit, due to the modernization of the equipment, is very costly and inefficient.

Therefore, in order to solve the problem of increasing the efficiency of bucket wheel complexes and reducing costs for overburden, it is necessary to consider the possibility of improving the existing technological scheme of overburden.

Literature review. The substantiation of the technological scheme of the operation of powerful bucket-wheel excavator complexes and the determination the parameters of mining systems for various technical and geological conditions of deposits is a large and complex problem [4], to the solution of which the efforts a lot of research organizations and mining enterprises have been directed [5].

One of the most important technological scheme parameters of the bucket-wheel excavator is the height of the bench being developed. With a large number of deposits, the height of the overburden developed by one bucket-wheel excavator shows the effectiveness of the use of a complex of mining haulage equipment. Therefore, many studies have considered the issue of increasing the height of the bench.

Thus, in the study [6], the authors proposed a technological scheme for the development of high benches with a division into sub-benches and the operation of a bucket-wheel excavator on two horizons in turn. This made it possible to significantly increase the bench height and increase the efficiency of using the bucket-wheel complex in time. However, such a scheme requires a complex organization of mining operations and can be applied only when using crawler-type of bucket-wheel excavators.

One of the studies directed on the increasing the bench height of bucket-wheel excavators was conducted at Pokrovsk Mining and Processing Plant [7]. They considered the possibility of combining the advanced and main opening bench into one, which is developed by one bucket-wheel excavator. However, the technical parameters of the excavator are insufficient for working out the combined bench. Therefore, to ensure the necessary height of the bench, a dragline excavator was installed on the roof, which moved part of the overburden under the slope of the lower part of the bench [8]. Thus, instead of two bucket-wheel complexes, there remained one, which worked in a complex with a dragline excavator. However, these studies did not take into account the physical and mechanical properties of mining rocks and the stable slope angle of the bench, which does not allow the application of this technological scheme in the development of soft unstable rocks.

Research in field of bench stable profile formation by the bucket-wheel excavators makes it possible to state that when a mining machine with a pressure boom is working, it is possible to form a bench slope of at least 25–30° at the maximum possible digging height of the excavator. And when using a pressureless boom, the minimum bench slope angle at the maximum digging height of the excavator will be 38–45° [9]. These studies make it possible to analyse the slope angles during the operation of different types of bucket-wheel excavators.

Evaluating the conducted research, it should be determined that for improving the technological scheme of overburden, it is necessary to consider the possibility of increasing the height of the advanced overburden bench that developed by the bucket-wheel excavator. For this, it is necessary to take into account the technical parameters of the excavator and the properties of the mining rocks being developed.

Also, for the possibility of increasing the height of the bench, attention should be paid to the combination of the operation of a bucket-wheel excavator with various types of mining and haulage equipment.

Results. The research directed to selection of the technological scheme of the opening carry out for condition of the Vilnohirsk Mining and Metallurgical Plant, which is developing the Eastern section of the Malyshevskyi deposit by surface mining method. The Eastern part of this deposit is mined through Pit No. 7, where the average length of the mining front works is 1000 m.

The advanced bench, with a capacity up to 30 m, in the section of Pit No. 7 "Pivnich", is worked by a bucket-wheel excavator complex, which consists of an excavator ERShR-1600-40/7, a loader PG-5000/60, a mining face and two transverse and dump belt conveyors, a PVP-6600 reloader and a ZP-6600 dumper, with rocks spreading in an internal dump in two benches. The design volume of overburden performed by the bucket-wheel excavator complex is 5 million m^3.

The overburden bench on the second overburden bench is worked out by an excavator EKG-10 with loading into dump trucks and removal of the rock to the internal dump along the inter-ore zone between two deposits. The average annual volume of overburden is carried out by the excavator EKG-10 up to 1.5 million m^3.

In order to reduce overburden costs in the conditions of Pit No. 7 "Pivnich", the possibility of combining the leading and second overburden benches into one was considered, which is developed by the excavator ERShR-1600-40/7.

The possible height of the bench for a bucket-wheel excavator with a given theoretical productivity depends on the initial value of the excavator linear parameters and the physical and mechanical properties of the mining rocks. Since a bucket-wheel excavator already in operation is being considered, in order to increase the height of the front overburden bench, it is necessary to consider the property of mining rocks which includes their stability.

Overburden rocks in Pit No. 7 "Pivnich" are represented by quaternary loams and red-brown clays, which belong to the class of unstable rocks.

When setting the parameters of the technological scheme of the excavator complexes, the graphic-analytical method is

most often used. This provides for the graphic construction of the excavator excavation taking into account its technical parameters and the physical and mechanical properties of the mined rocks being developed.

Taking into account the physical and mechanical properties of overburden mining rocks [10], the stable slope angle of the leading overburden bench should not exceed 30° [11]. Therefore, in order to determine the maximum possible bench height at a stable angle of slope, the profile of the pit bucket-wheel excavator was built using the graphic-analytical method. During the construction, the following are taken into account: digging radius, chip height, boom angle and bucket wheel radius.

The mining face of overburden rocks profile at the implementation of bucket-wheel excavator ERShR-1600-40/7 when forming a stable slope angle of the overburden bench is presented in Fig. 1.

After the construction is completed, it can be stated that when using the ERShR-1600-40/7 bucket-wheel excavator and its operation with horizontal chip with 10 m high, the maximum possible height of the overburden bench is 30 m at a stable slope angle of 30°. However, the technical parameters of the bucket-wheel excavator allow it to address a bench with a height of 40 m. Therefore, in order to determine the slope angle of the bench at the maximum digging height of the excavator, a mining face profile was built for these conditions. The face profile of the ERShR-1600-40/7 with the maximum possible height of the bench is presented in Fig. 2.

From the mining face profile shown in Fig. 2, we can see that when bench of 40-m high is worked out, the slope angle of it will be 40°, which is unstable for the conditions of the Malyshevskyi titan-zirconium ore deposit. Therefore, the use of this technology for working out an overburden bench of a greater capacity by a bucket wheel excavator is not permissible from the point of rocks massive stability.

The technical parameters of ERShR-1600-40/7 do not allow it to form a bench with a height of 40 m with a slope angle of 30°. Therefore, a new technological scheme with a forward trench has been developed, which will allow reaching a bench height of 40 m at a slope angle of 30° (Fig. 3).

The essence of the proposed technological scheme consists in the preliminary building of a trench with 10 m depth by an excavator ESh-10/70, with the storage of mining rock on the slope of the bench. Excavator ERShR-1600-40/7 with a maximum scooping height of 40 m develops the face with four horizontal chips, which, when passing the first one, opens the site of the forward trench, which makes it possible to establish a stable slope angle of 30°.

The use of a technological scheme with a forward trench will not allow ensuring a stable slope angle directly through the face for long period. At the same time, there is a possibility of the landslide formation of the rocks mass in the pit at the angle of the collapse prism [12]. However, it must be taken into account that the overburden face is constantly moving, so the rock subjected to landslides has a short life.

The operation of ERShR-1600-40/7 at the maximum height of scooping has several peculiarities. In order to prevent the formation of overhanging visors of mining rock, it is necessary to work out the by the horizontal chips in a row from the top to the bottom. Taking into account the height of the horizontal chip of 10 m and the construction of the rigid boom of the excavator, working out the overburden face will be performed in four stages, with a gradual displacement of the excavator back from position I to position IV (Fig. 3).

Taking into account the proposed technological scheme for the operation of a bucket-wheel excavator with a forward trench, it is planned to change the existing haulage system for the development of Pit No. 7 "Pivnich" (Fig. 4, *a*). In this case, it was proposed to use the EKG-10 excavator and dump trucks on the second overburden bench, to a combined development system with the use of the ESh-10/70 excavator for mining a forward trench.

Considering the high productivity of the ERShR-1600-40/7 bucket-wheel excavator, which has an output of more than 20 million m^3 per year [13], it will be able to work with an additional volume of 1.5 million m^3 [14]. The load on

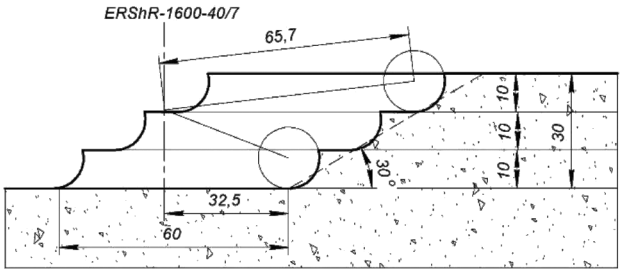

Fig. 1. Excavator mining face profile ERShR-1600-40/7 when working out the overburden bench with a height of 30 m

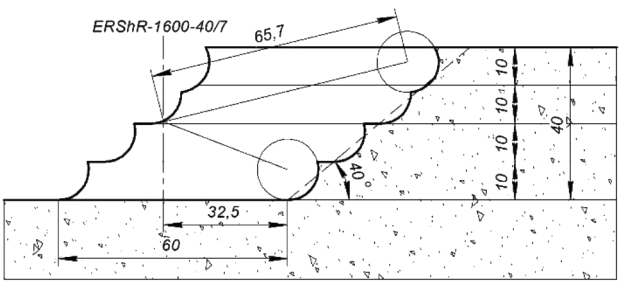

Fig. 2. Mine face profile of the excavator ERShR-1600-40/7 when working out the overburden bench with a height of 40 m

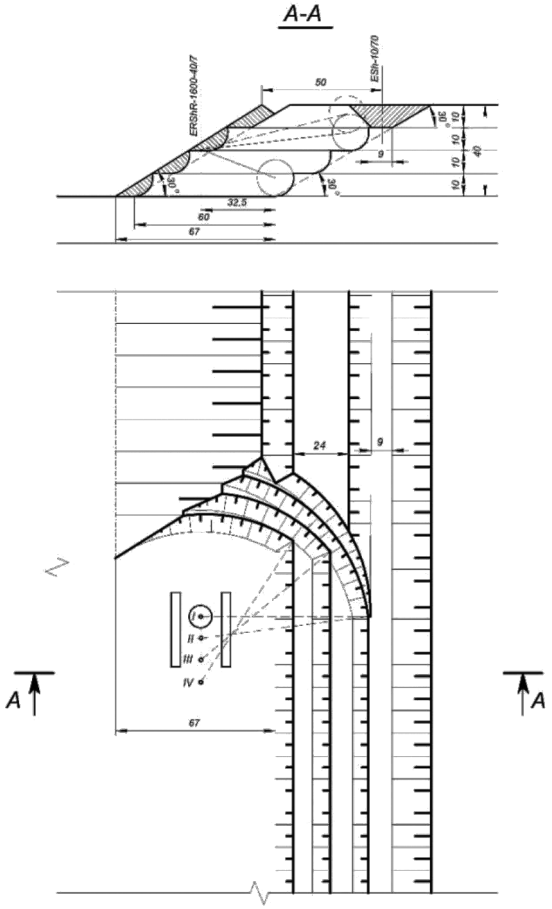

Fig. 3. Technological diagram of the ERShR-1600-40/70 operation during the development of an overburden bench with a height of 40 m with a forward trench

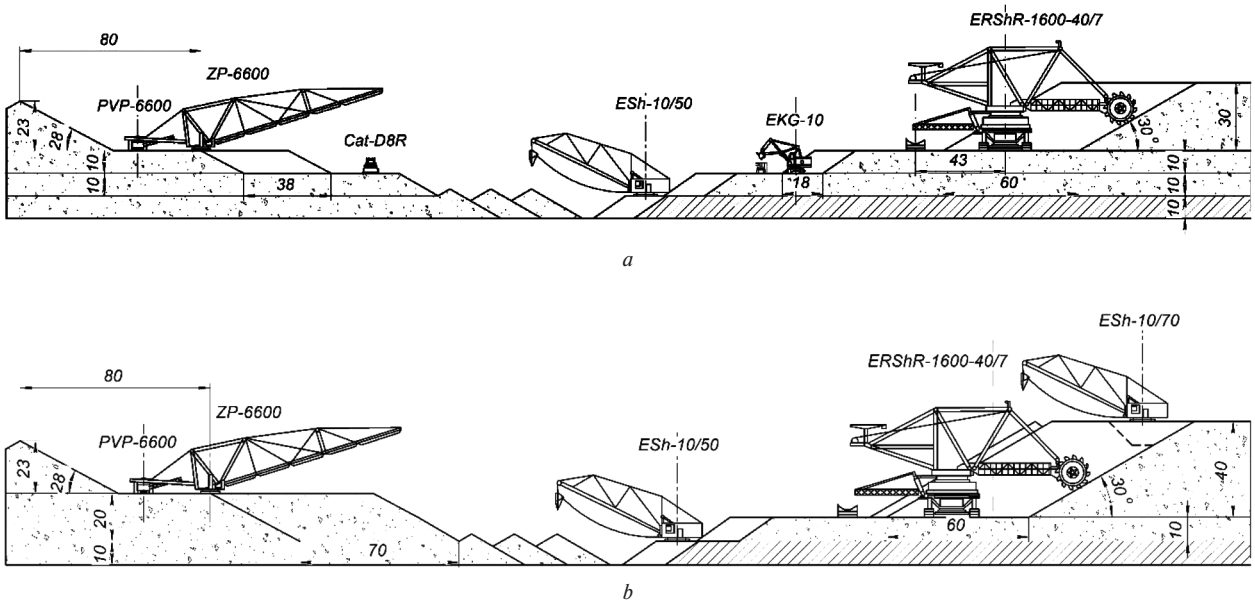

Fig. 4. Mining system of Pit No. 7 "Pivnich":
a – the existing haulage mining system; b – the proposed combined mining system

the main and face conveyor will increase by 30 %; however, with the existing technological scheme, the conveyor load in time is about 40 % [15], that is why its productivity will allow haulage of an additional rocks volume.

At the proposed technological scheme, the overburden is removed by the bucket-wheel excavator complex [16] and stored in an internal dump [17] in two benches with a total height of 43 m (Fig. 4, *b*).

The evaluation of the overburden technology effectiveness in the conditions of Vilnohirsk MMP shows that using a forward trench it is possible to increase the height of the front bench with a stable slope angle.

In addition to increasing, the bench height the width of the face width has a significant effect on the efficiency of using the bucket-wheel excavator and its productivity. When increasing the face width to the maximum value, the productivity of the excavator decreases by 3–5 %, due to increasing time of auxiliary operations and boom manoeuvring. However, the decrease in productivity is not significant, so the maximum increase in the face width is reasonable. Despite the proposed technological scheme with a forward trench, it is necessary to take into account the maximum unloading radius of the ESh-10/70 excavator and the maximum height of the embankment it forms. After completing the graphic construction, it was determined that the maximum width of the bucket-wheel excavator's face with the proposed technological scheme will be 60 m.

It should be noted that the shape and cross-sectional area of the forward trench has a significant influence on the slope angle of the bench. The conducted research showed that the most favourable from the position of ensuring the permissible slope angle and the minimum volume of re-excavation work is the trapezoidal shape of the forward trench with side slope angles of 45 and 30°, respectively.

The graphic construction of the technological scheme makes it possible to establish the influence of the cross-sectional area of the trench on the resulting slope angle of the bench. Due to the graphic modelling, sections of the leading overburden bench were constructed, and the area of the forward trench was determined at different widths below.

According to the obtained data, the dependence of the volume of the trench on the slope angle of the bench $Vp.g.=f(\alpha)$ was established (Fig. 5).

From the obtained results that are shown in the graph (Fig. 5), we can see that the volume of the forward trench decreases when the slope angle of the overburden bench increases. This indicates that the weaker the overburden rocks and the smaller the slope angle of the bench are, the larger forward trench are needed.

The conducted research studies make it possible to establish that for the conditions of Pit No. 7 "Pivnich" with the required slope angle of 30°, the volume of the forward trench will be 224 thousand m^3.

An important indicator of the application effectiveness of the overburden technological scheme at the bucket-wheel excavator using is the re-excavation coefficient of the mining mass. It is calculated according to the formula that considers area of forward trench cross-section and parameters of the bench

$$k = \frac{S_{tr}}{A \cdot H},$$

where S_{tr} is a cross-sectional area of the forward trench, m^2; A is the width of the overburden face, m; H is the height of the bench, m.

Taking into account the received data on the cross-sectional area of the forward trench and the slope parameters of the bench, the re-excavation coefficient was calculated for different volumes of this excavation. According to the obtained data, the dependence of the trench volume on the re-excavation coefficient $Vp.g.=f(k)$ was established (Fig. 6).

Analysing the data shown in the graph (Fig. 6), we can state that the re-excavation coefficient directly depends on the volume of the forward trench.

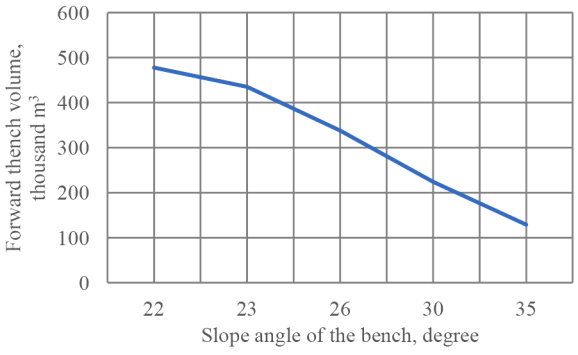

Fig. 5. Dependence of the forward trench volume on the slope angle of the bench

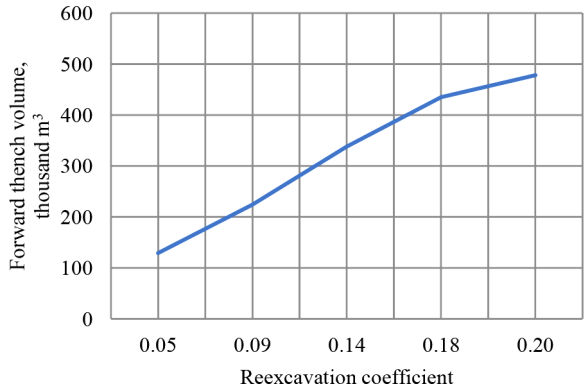

Fig. 6. Dependence of the forward trench volume on the re-excavation coefficient

Establishing the dependence of the trench volume on the slope angle of the bench and the re-excavation coefficient makes it possible to analyse the effect of changing the slope angle of the bench on the coefficient of re-excavation (Fig. 7).

The obtained research results (Fig. 7) show that the greater the slope angle of the bench is, the smaller the re-excavation coefficient of the overburden rocks will be. Therefore, we have an inversely proportional relationship that allows us to determine the re-excavation coefficient depending on the required slope angle of the slope when bucket-wheel excavator using.

The dependence of the re-excavation coefficient on the slope angle $k = f(\alpha)$ is described by an equation of the form

$$k = -\frac{\alpha - 37.1}{3.3}.$$

The reliability of this dependence is high, as evidenced by the coefficient of determination $R_2 = 0.948$. Thus, the obtained equation can be used for the preliminary calculation of the re-excavation coefficient.

For the conditions of the Vilnohirsk MMP, when applying the technological scheme for the overburden bench development with a forward trench, the re-excavation coefficient will be $k = 0.09$.

To substantiate the recommendation of the proposed method of overburden rocks development implementation it is necessary to conduct the economic assessment. The production program of the mining enterprise operation is based on the technology of deposit development, the provision of equipment and the enterprise's work schedule [18]. Based on these indicators, the specific consumption of 1 m^3 of overburden is formed when applying a technological scheme with a forward trench. The elements of the cost for overburden works include: basic salary (surcharges, allowances, bonuses); basic and auxiliary materials; fuel, depreciation of the equipment involved; electricity, etc.

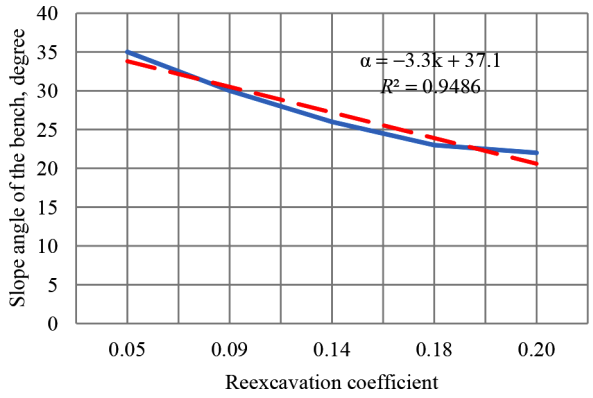

Fig. 7. Dependence of the slope angle of the bench on the re-excavation coefficient

The use of a new approach (overburden forward trench mining) makes it possible to more efficiently use the available resources at the enterprise, reduce the burden on the payroll fund, reduce the amount of equipment, which in turn has a positive effect on reducing the main costs that are included in the cost price.

The main criterion for choosing a rational scheme for the overburden benches development and operating parameters of bucket-wheel excavator complex machines is a system of interconnected factors that takes into account the optimal parameters for the formation of the extracted products cost. The system of costs per 1 m^3 of overburden was chosen as the basis of the calculation. The economic evaluation of interrelated factors should be understood as reducing the production cost. This reduction is achieved by saving resources and reducing the labour costs of dump truck drivers, because with the new mining scheme, the expediency of using the EKG-10 excavator with loading into dump trucks and rock removal to the internal dump decreases and becomes unnecessary. Because of this, the need to use such vehicles as BelAZ and a bulldozer is significantly reduced. The reduction of mining machines number will affect saving of spare parts together with components, warehouse costs, and also significantly improves the haulage scheme of the dump.

During the conducted research a special attention was paid to the saving of financial resources in terms of the wage fund formation, which is calculated for each profession separately, as well as to the fund of direct wages of all hourly workers – the calculation takes into account the use of the hourly bonus system of labour remuneration. It is also worth noting that the saving of financial resources allows reducing the burden on the wage fund and creates conditions for the introduction of additional payments in the form of bonuses for the rationality of the mining technology and the number of employees involved.

In addition, costs for auxiliary materials are reduced, which include technical kerosene, lubricants: industrial, cylinder, compressor, graphite, wiping. However, the main thing is the lack of operations of BelAZ-7548 dump trucks (45 t), which reduces fuel costs and subsequently affects the depreciation fund due to the fact that the less equipment is used, the faster it can be updated. Since the cost of the equipment will be transferred to the extracted products, the volume of which increases due to the extraction technology.

During the planning of depreciation deductions, the useful life of the equipment and its original cost are taken into account. Also, the special attention is paid to the methods for calculating depreciation. Traditionally, the enterprises use the straight-line, production and cumulative methods for calculating depreciation.

However, the choice of a particular method of depreciation is based on the useful life, the fair value of the equipment and the simplicity of the calculation. Therefore, it is proposed to use the straight-line method for calculating depreciation for all fixed assets involved in the new mineral extraction scheme. The existing scheme of cost structure formation was imperfect in terms of a large share of fuel use. The new scheme makes it possible to reduce the usage of fuel due to the refusal to operate the BelAZ vehicle and to optimize the structure of depreciation deductions.

Thus, the specific costs of 1 m^3 overburden rocks with the proposed technological scheme were calculated, which amounted to 29.35 UAH/m^3. The calculation of specific costs is given in Table.

From the technical documentation of the enterprise, it was established that the specific costs for 1 m^3 of overburden rocks with the existing technology for Pit No. 7 "Pivnich" of the Vilnohirsk MMP are 60.56 UAH/m^3.

After the cost of 1 m^3 of overburden for the proposed schemes was calculated, it was determined that when using a

Table

Specific costs for of 1 m^3 of overburden rock

Cost elements	Costs for the annual volume of overburden rocks (6.5 million m^3), thousand UAH
The basic salary	1,163
Additional salary (9 % of the basic salary)	105
Total salary	1,267
Charges for wages (22 % of wages)	279
Basic and auxiliary materials	3,772
Depreciation	126,261
Electricity	32,272
Total	163,852
The cost of overburden, m^3	0.025

forward trench, the cost will decrease by 31.21 UAH/m^3. Analysing the cost structure, we can say that with the existing technology, a large share of costs goes to fuel, 36 %, and with the proposed technology, the main share (77 %) is depreciation deductions. This is due to the lack of dump trucks and bulldozers that work on fuel.

The proposed technology allows reducing the costs of 1 m^3 overburden rocks mining and getting the company an additional profit per year in million UAH

$$P = (60.65 - 29.35) \cdot 6{,}500{,}000 = 202.8.$$

The use of proposed technology with a forward trench will not only reduce costs for overburden, but also reduce the parameters of the pit excavations, due to the reduction of the number of overburden horizons and working spaces.

Conclusions. The conducted research allowed developing and proposing a technological scheme for working out the advanced overburden bench with a capacity of 40 m using a special forward trench. The possibility was justified of using the technological scheme of the excavator ERShR-1600-40/7 with a forward trench in the conditions of Pit No. 7 "Pivnich" of Vilnohirsk MMP.

Specific costs were calculated of overburden works for 1 m^3 of mining mass when applying the technological scheme with increased capacity of the forward bench, which amounted to 29.35 UAH. The dependence of the coefficient of re-excavation of the overburden rocks on the slope angle of the bench during the development of the forward trench has been established, which makes it possible to calculate the costs for the trench construction works.

The rational parameters of the forward trench were set that include the depth of the trench, which is 10 m, slope angles of 45 and 30°, width trench at the bottom (9 m), which makes it possible to develop a bench with a height of 40 m and a stable slope angle of 30°, for the conditions of Vilnohirsk MMP.

Economic efficiency from the implementation of the technological scheme of a bucket-wheel excavator operation with an increased capacity of the front bench at Pit No. 7 "Pivnich" will allow reducing the overburden work costs by 50 % compared to the existing technological scheme, and therefore, obtaining an additional profit in the amount of 202.8 million UAH per year.

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Обґрунтування технологічних параметрів випереджальної траншеї роторного екскаватора при розробці родовищ титану

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Мета. Обґрунтувати параметри технологічної схеми відпрацювання передового розкривного уступу роторним екскаватором, для зменшення собівартості розкриву в умовах кар'єру № 7 Вільногірського гірничо-металургійного комбінату.

Методика. Встановлення параметрів технологічної схеми роботи роторного екскаватора виконувалось графоаналітичним методом, що передбачає врахування технічних характеристик екскаватора, фізико-механічних властивостей гірничих порід і стійкого кута відкосу передового розкривного уступу. Обґрунтування ефективності застосування технологічної схеми з випереджувальною траншеєю виконано за рахунок техніко-економічного розрахунку питомих витрат на розкрив.

Результати. Оцінена можливість збільшення висоти розкривного уступу при застосуванні технологічної схеми з випереджувальною траншеєю. Обґрунтовані параметрі випереджувальної траншеї, за яких роторний екскаватор може відпрацьовувати передовий уступ потужністю 40 м зі стійким кутом укосу 30°. Це дозволяє зменшити кількість гірничотранспортного обладнання та знизити витрати на розкрив до 50 %.

Наукова новизна. Установлено мінімальний кут укосу розкривного уступу при максимальній висоті черпання екскаватора ЕРШР-1600-40/7, що дорівнює 40° при висоті уступу 40 м. Встановлена залежність результуючого кута укосу уступу від коефіцієнту переекскавації гірничої маси. Це дає змогу стверджувати, що при збільшенні цього кута коефіцієнт переекскавації буде зменшуватись. Встановлено, що при застосуванні технологічної схеми з випереджувальною траншеєю в умовах Вільногірського ГМК, коефіцієнт переекскавації розкривних порід складе $k = 0{,}09$.

Практична значимість. Розроблена технологічна схема розробки передового розкривного уступу роторного екскаватора з випереджувальною траншеєю, що дозволяє збільшити його висоту. Це дає можливість знизити витрати на розкрив за рахунок відмови від транспортної системи розробки із застосуванням автосамоскидів.

Ключові слова: *розкрив, роторний екскаватор, передовий уступ, кут укосу, випереджувальна траншея*

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