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IMPROVEMENT OF THE TECHNOLOGY DEVELOPMENT OF ROCKS SURFACE MINERS MILLING TYPE

Introduction. For the domestic mining industry, increasing the competitiveness of production by reducing the cost of production and optimizing all possible links of technological processes is an important issue.

In connection with the trend of increasing the cost and demand for energy, as well as reducing the results of rational use of energy resources, there is an urgent need to improve the efficiency of surface mining of mineral deposits through the use of non-blasting rock mining technologies. A promising way to solve this problem is the introduction of the technology of layer-by-layer milling of rocks by surface miners into the working conditions of iron ore pits, which contributes to the development of half-rocky rocks and rocky rocks without drilling and blasting.

Based on the analysis of the practice of mining enterprises, the achievement of a sufficiently high organizational and technical level of production is possible with the development of advanced technologies with the use of highly productive mining equipment, which improves the technical and economic indicators of enterprise production.

Solving the problem of increasing the effective use of excavation and loading equipment and reducing the cost of raw materials requires the development of technological schemes. Which take into account to study in detail the cost patterns of the two technological processes: the preparation of rocks for excavation and excavation and loading work. Thus, to identify the factors influencing operations included in the technological process of mining production, which will determine the level and dynamics of costs for the development of iron ore deposits on the above induced technological processes, as well as to identify the nature of the optimal values of these factors of influence.

The most expensive mining process is the preparation of rocks for excavation. Part of the cost of preparing the rocks for excavation reaches 50% of the total cost of mining processes.

The traditional technology of opencast mining is the development of semi-rock and rock rocks with the implementation of a complex of drilling and blasting operations to prepare the rock mass to be excavated by an explosion. After that, the rocks are

withdrawn from the bottom of the step of entry of the ledge by an excavator and are loaded into the vehicle with the subsequent movement to the appropriate destination [1].

In most cases, the conduct of development of mineral deposits occurs with the conduct of blasting operations to obtain crushed rocks of considerable strength [2, 3]. In this case, the disadvantages of the existing technology of mining the rock mass is the need for a complex of drilling and blasting operations, which has a number of negative aspects inherent in a mass explosion. Namely, it leads to a temporary cessation of the career, due to the need to divert people and move the mining and transport equipment to a sufficient safe distance from the place of the mass explosion. It should also be noted about the insufficient level of impact on the particle size distribution of the pieces, the softening of the rock mass by an explosion, which in turn is characterized by the release of oversize and a negative impact on the environment, significant emissions of harmful substances into the atmosphere. And also there is a non-controlling violation of the surface and integrity of the rock mass, which in turn negatively affects the stability of the pit walls.

Analyzed the existing experience of domestic and foreign surface mining of iron ore showed that the use of traditional drilling and blasting to soften the rock mass in the current working conditions of iron ore mines creates certain difficulties. This in turn leads to a decrease in the likelihood of obtaining the required design performance of mining enterprises in the face of the need to reduce the cost of iron ore.

In turn, the mining and geological and mining conditions for the development of steeply dipping iron ore deposits deteriorate with increasing depth of the pits. It also leads to a decrease in the utilization rate of excavation and loading equipment during a shift, because the number of working ledges and the degree of concentration in the working area increase. At the same time, in order to intensify production indicators with an increase in the number of pieces of excavation equipment, their total productivity increases.

In this case, the concentration of excavation and loading equipment on the sections of the working horizons is determined by examining the optimal length of the length of the work front and its informed choice. As a result of analytical and experimental studies, the optimum length of the work front for surface miners is established, which is recommended in the subsequent study of technological schemes to obtain the highest performance indicators of the work of milling type surface miners.

Every year new strengthened requirements and measures for the implementation of blasting operations are being put forward. Therefore, there is a need to switch to non-blasting development of rocks, it becomes possible with the use of milling type mining machines.

The technology of layer-by-layer milling of the rock mass with surface miners, carries out mining of rocks without carrying out a complex of drilling and blasting operations, therefore, it finds more and more implementations in open pit mining. The development of rock and semi-rock rocks with a mechanical method of their softening is essentially effective when using high-performance surface miners.

Mining enterprises need new solutions for the introduction of an improved traditional technology that:

will allow to review the feasibility of the established final depth of mining of iron ore deposits;

improve technical and economic performance of iron ore open pits;

reduce the cost of production of 1 ton of ore;

reduce the harmful impact of its activities on the environment;

increase the safety of open pit mining.

Increasing the depth of an open pit development complicates and increases the cost of mining operations, as a result of which it is economically feasible to switch to non-blasting development of the rock massif by surface miners.

A lot of research has been done in the field of technology of developing rocks of considerable strength with a mechanical method of preparing them for excavation. Among those that are progressive non-blasting technology of development of rock and semi-rock rocks is the most effective when using high-performance milling combines. The essence of the work, which is to perform the grinding, removal and load of rocks in a vehicle in one cycle.

The following mining equipment is used to implement the non-blasting development of rocks: baking powder on the basis of heavy and super-heavy bulldozers, impressive sizes of single-bucket hydraulic excavators, hydraulic hammers, milling type mining combines, switch type combine harvesters [4, 5].

The idea of the work is the improvement of the technological scheme of the work of highly productive surface miners and the justification of their joint work with existing mining equipment. The efficiency of using the non-blasting technology of layer-by-layer milling is increased due to obtaining successful adaptation of the mining harvesters to the existing technology of mining.

The analysis of scientific works in this direction has shown that there is a need to modernize the excavation and loading operations using milling type mining machines, taking into account the factors influencing their work efficiency and expediency of use in deep pits.

The range of application of mining harvesters for mining the rock massif expands due to the lack of execution of a massive explosion. So, as every year there is a tendency to tougher tightening of requirements and measures for the implementation of blasting operations [6].

The effectiveness of the use of non-blasting layer-by-layer milling technology is considered taking into account the main factors that influence it:

speed and thickness of milling of the rock layer;

physical and mechanical properties of rocks;

the width and length of the active work front.

The technology of layer-by-layer development of rock and semi-rock rocks by surface miners has the disadvantages associated with the use of a set of traditional technological schemes, which are intended for the development of mines of small depth. Technological schemes for the development of the rock mass by combines stratified milling, even partially not improved for the adaptation and rational work of combines in such specific conditions of development of iron ore deposits.

High-performance mining equipment performs layer-by-layer mining of the ledge for its entire height with the open mining of mineral deposits, allows for efficient non-blasting mining of rocks with an uniaxial compression strength of 120÷140 MPa [7].

The disadvantage of the technology of layer-by-layer milling of rocks of the ledge in the development of rock mass according to the above work [7] is that the layered mining of the ledge occurs mountain combine without touching the rocks of the prism of possible collapse. As a result, a pillar is formed on the edge of the ledge represented by prism rocks of possible collapse. In this case, the milling combine stops its work until the pillars are worked out by other means, as a result, the milling type harvester performs a large number of idle movements. And also increases the downtime of mining and transportation equipment.

The implementation of the technology of layer-by-layer milling of rocks of the working platform of the ledge is carried out by mountain combines according to two main technological schemes of their movement:

scheme of movement of combines with a turn at the end of the waste rock strip;

the shuttle pattern with combines returning idling to the starting position of the next rock band [8,9].

Analysis of the work and materials of research carried out in this direction suggests that the combine method of mining the rock massif is one of the least energy-consuming, ecological and economic in appropriate working conditions. And they require a review of the established patterns of operation of milling combines between the technological parameters of mining equipment and the parameters of the elements of the development system. This will show the reality of solving the problem of creating and improving the technology of developing semi-rock and rock rocks by introducing high-performance and high-performance excavation-loading equipment without conducting a set of drilling and blasting operations when mining iron ore deposits.

Despite significant shortcomings drilling and blasting, they are the primary means of weakening the half rock and rock. This can be explained by absence of real alternative method of grinding rock mass. In fact made the only effective way, which meets the requirements of the traditional technology of conducting works.

The available information on the effective use of milling-type mining combines in foreign pits indicates that high technical and economic indicators of the mining enterprise have been achieved. Attention is focused on a detailed study and solving problems of studying the physical and mechanical properties of rocks and working conditions of mining equipment. Obviously, every year mining harvesters work out semi-rock and rock rocks with a more significant strength indicator, that is, it is achieved economically feasible mining of rocks with a coefficient of strength within $f = 15 \div 20$ on the M.M Protodyakonov.

At present, there is the possibility of creating and introducing new technologies with the use of modern high-performance mining equipment in the development of iron ore deposits, creating significant competition for drilling and blasting. In turn, the use of the combine method of loosening the rock massif improves the performance of mining and transportation equipment. This is achieved by the fact that the proposed technological scheme for the development of a ledge by the milling type mining combines, which includes layer-by-layer mining of rocks with a direct load, the softening of rocks in a motor vehicle by introducing additional operations to work off the working platform of the entire width.

A flow chart is presented that takes into account all the theoretical and experimental aspects of foreign research on the improvement and implementation of non-blasting open pit mining technology with the intensification of its adaptation to the traditional technology of rock mass development in iron ore pits.

A promising and relevant direction in improving the technology of opencast mining is the use of progressive milling combines for the transition to a non-blasting technology to develop semi-rock and rock rocks of the iron ore deposit.

Modern quarry miners meet the requirements of efficient operation of mining enterprises, is a new technological level in the conduct of the surface development of iron ore deposits. They successfully work in various mining pits. The main tasks of solving the possibility of the effective use of the technology of layer-by-layer milling of rocks on the use of mine harvesters and the rational parameters of his work are as follows:

determining the operational performance of mining combines depending on the structure and strength properties of the rocks of the massif;

quality and assessment of the completeness of mining in the desired mining, geological and mining conditions of its work;

the establishment of the field of application of mining combines to ensure the rational efficiency of the use of layered milling technology;

substantiation of the effectiveness of the transition to the non-blasting technology of open source technology, which reduces the harmful effects on the environment.

The use of technology of layer-by-layer milling of rocks by surface miners requires substantiation of the main criterion for determining the expediency of rational use of mining combines, taking into account the costs of mining.

In this regard, an important and most promising direction in the existing mining-geological and mining-technical conditions of mining enterprises is the possibility of a real increase in the technical and economic indicators of enterprises through the transition to a non-blasting technology for the development of iron ore deposits, including the search for new and innovative solutions.

After analyzing literary sources and scientific work in this direction, we can conclude that the issue of improving and applying the non-blasting technology of layer-by-layer milling of half-rocky rocks and rocky rocks has not been fully explored, because there are different approaches to this issue and, accordingly, with different results. Based on the above, it is necessary to continue the study to obtain an effective non-blasting technology for the development of rock and semi-rock rocks by milling combines. Including the study of factors affecting the rational use of this excavating and loading equipment in terms of their work in the traditional technology of surface mining of minerals, taking into account modern advances in the field of mining.

The improved technological scheme allows to improve the technical and economic performance of excavation and loading equipment and means of transport by improving the organization of their work in the development of rock mass. Thus, for iron ore pits, the use of an improved technological scheme makes it possible to effectively develop half-rocky rocks and rocky rocks using milling-type mining combines.

Regarding the technological aspect of the implementation of the technology of layer-by-layer milling of rocks, it should be noted that this technological scheme allows combines to effectively adapt to the existing technology. The harvester develops the rock mass with the parameters of the elements of the development system already formed by the existing technology and during the operation the harvester partially adjusts the parameters of the elements of the development system for its rational work.

Research results. To increase the efficiency of opencast mining technology in the conditions of operation of Krivbass's iron ore pits through the use of an improved technology of layer-by-layer milling of a ledge to its full height without drilling and blasting operations. In order to realize in the future a priority technological scheme for the operation of open pit miners in the development of the rock mass in the existing technology for mining iron ore deposits.

The article contains a comprehensive research method that covers the scientific generalization and systematization of the theoretical analysis of the practical application of layered milling technology in the development of iron ore deposits.

The technology of development of iron ore deposits as a whole meets all modern requirements for opencast mining. It is flexible due to separate technological processes, typical use of milling combines for mining the rock mass. A large number of tests and efforts have been carried out to make it part of the traditional technology of open mining of mineral deposits. However, the existing technological schemes need to be refined in order to adapt to the existing technology for developing the rock mass in iron ore pits [10].

Layer-by-layer milling of half-rocky rocks and rocky rocks leads to a large amount of downtime of mining equipment and idle passages, which leads to its low efficiency and to a significant increase in the cost of mining.

The study of technological schemes shows that it is possible to obtain a positive result of solving the above problems when making non-standard technological solutions. The improved technological scheme of work of mining combines in existing deep pits allows the development of the formulated parameters of the elements of the development system of the existing technology, which increases the efficiency of the development of the field with milling combines when introducing new approaches and manipulations in the technological scheme of their work.

The technological scheme developed by the authors of the article for the development of a ledge using milling-type mining machines is implemented as follows. The mining harvester 1 processes the rock layer with a direct load of them with its conveyor system to the dump truck 2 (Fig. 1).

The combine 1 runs a layer of rocks only between the prism of a possible collapse of the ledge and the lower eaves above the underlying ledge, and then it molds the layer of rock with successive strips 3 parallel to the upper eaves of the ledge 4, thus not exceeding the threshold of the prism of possible collapse 8, which is clearly observed on the section A–A (Fig. 2).

After passing the required number of lanes, the mining combine 1 creates a sufficient width of the working platform for starting the milling combine 6, which successively strips 5 removes a layer of rocks along the line of the prism of a possible collapse of 8 with a direct load of rocks in the dump truck.

When a mining combine of milling type 6 completed the working of a layer of rocks of the entire thickness of the layer of rocks between the upper eaves of the ledge 4 and the prism line of a possible collapse of the ledge 8, as evidently observed in the section B-B (Fig. 3), to work has the ability to proceed to the milling combine 1.

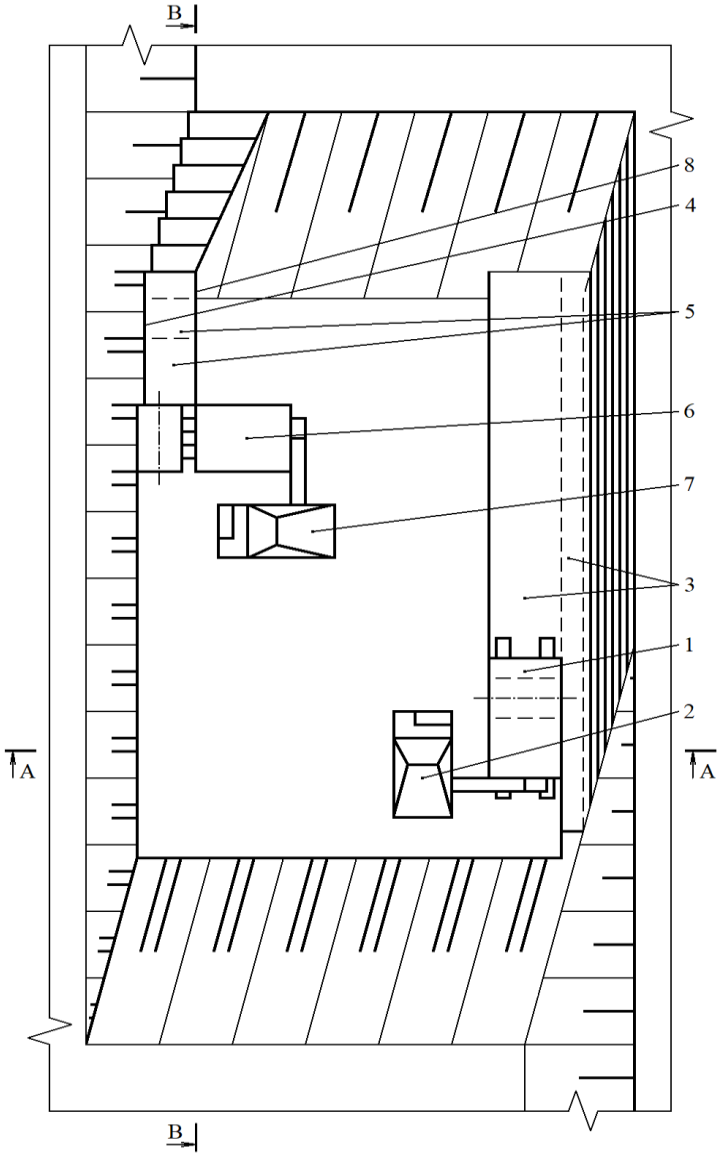

Figure 1. Technological scheme of the development of the ledge with the use of career combines milling type

Source: developed by the author

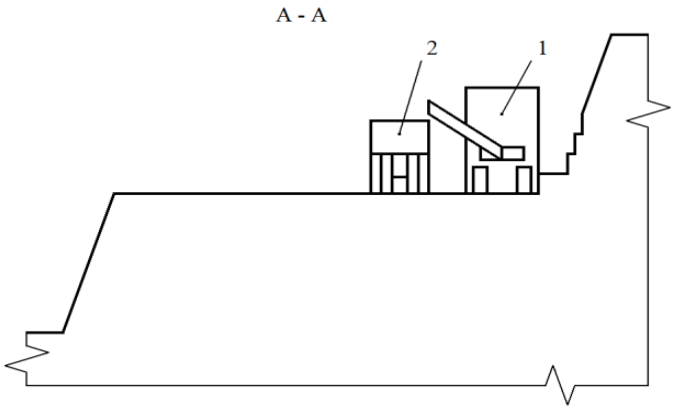

Figure 2. The section A-A of the technological scheme depicted in Fig. 1, on which the milling combine (1) performs the removal of the layer of rocks, not crossing the line of prisms of possible collapse with direct load in the dump (2)

Source: developed by the author

Then the mining combine 1 develops the next layer of rocks in successive parallel successive passages. At the same time, he, with his system of conveyors, performs a direct load of the rocks he has removed from them into a dump truck 2, which transports the loaded breed by combine 1 to its destination. The surface harvester 1 carries out the milling of the rocks in successive stripes, parallel to the upper crest of the ledge 4, not crossing the prism boundaries of a possible breakdown of the ledge. In accordance with the above-mentioned technological scheme of conducting the development of the ledge, the principle of the sequence of layer milling of the rocks of the working platform to the full working out of the ledge at its full height is repeated. Moreover, according to the presented technological scheme, in a coordinated operation, mill combiners perform a simultaneous layered exploration of the rock mass independently of each other.

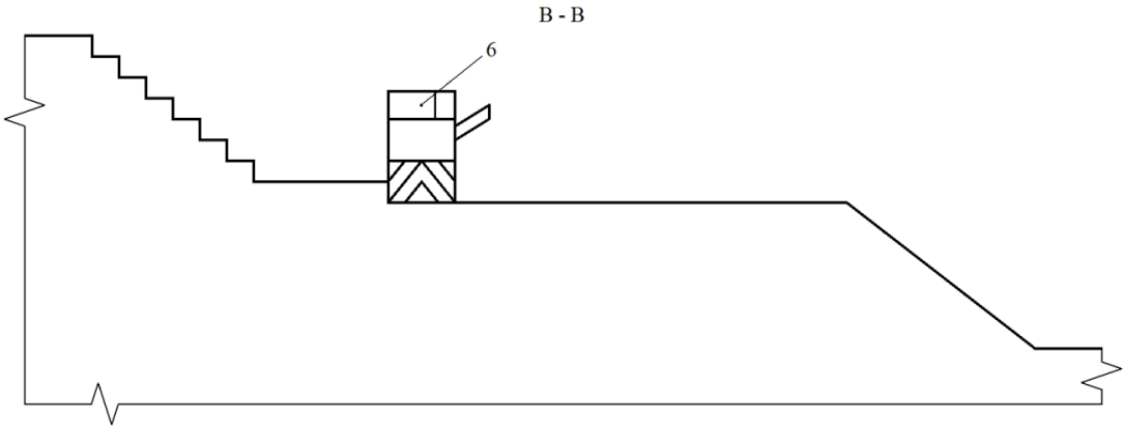

Figure. 3. The section of the B-B technological scheme depicted in Fig. 1, on which is practicing the working of the prisms of the possible milling with milling combine (6)

Source: developed by the author

The analysis of the existing technological schemes for the development of the rock mass is made thanks to the processing of the relevant statistical data, based on the experience of conducting non-blasting mining of mineral deposits by milling combines, mining companies. In order to determine their effectiveness based on the surface mining of iron ore deposits. Also, a theoretical analysis of the practical possibility of destruction of rocks of considerable strength, depending on the characteristics of the rocks, namely the physic-mechanical properties.

On (Fig. 4) is a diagram of a sequence of layered working out of the ledge, which indicates the order of working out rocks in accordance with the serial number. That is, at first, there is an extraction of a layer of rocks 1, after which the removal of layer of rocks 2 is performed.

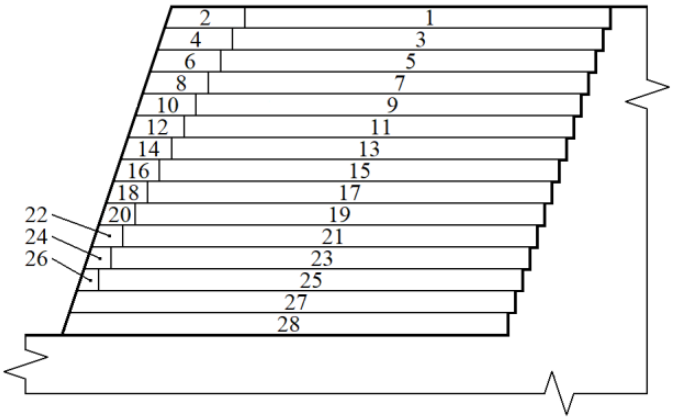

Figure 4. Scheme of the sequence of working out layers of rock mass with surface miners

Source: developed by the author

Subsequently, in the corresponding sequence of the above, the following layers of rocks are carried out: 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25 after which the following layers of rocks are worked out: 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26 respectively.

After removing the layer of rocks 26 the layers of rocks 27 and 28 are worked out until the full run of the ledge to its full height.

As a result of combine harvesting, the above-mentioned technological scheme increases the productivity of mining equipment.

In this technological scheme, as in some others, the advantages of using combine harvesters are enhanced by providing a significant front of work. Continuous operation of the milling combine with the minimum number of auxiliary operations and idling is ensured, which increases its productivity. In the case of the development of deep pits using transport systems for the development of fields using this technological scheme, favorable and rational conditions are created for the operation of layer-by-layer milling combines.

CONCLUSION

The development of a rock massif of iron ore deposits by mining combines of the milling type is possible without carrying out the complex of drilling and blasting operations. According to the proposed technological scheme of the layout design of the ledge, the working area of the entire width along with the prisms of possible collapse is worked out. Due to this, it is possible to perform layer-level removal of rocks of the horizontal or weak-down working platform of the ledge with given operational parameters of the elements of the development system. It allows to effectively adapt the milling combines to the existing technology of open development in the existing

mining and geological and mining conditions of the iron ore pits in the mining of rocks with a coefficient of strength up to f = 15, in the presence of a variety of inclusions with a significant strength coefficient in the rock massif f > 20 on the scale of M.M. Protodiakonov at given technological parameters of elements of the system of development and norms of the operating technology for the development of iron ore pits.

The presented method of developing the ledge without performing drilling and blasting operations while conducting an open exploration of iron ore deposit with the use of mill type mills with direct loading in an dump truck allows to improve the technical and economic performance of iron ore pits and reduce the cost of working out of iron ore deposits up to 46%.

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