INCREASING THE ECONOMIC EFFICIENCY OF MINING COMPLEX STRUCTURAL GOLD DEPOSITS

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ABSTRACT. At present the deterioration of geological and engineering conditions of the ore deposits, entails increase of losses of minerals, increasing the mineral production and processing costs. With consideration of the specified limiting conditions, the net present value of deposit mining will be achieved with minimal economic loss resulting from the mineral losses and dilution. According to the results of the research, conclusions were made that the economic loss related to the losses and dilution, increase in direct proportion to the increase of bench heights; the mode of horizon preparation significantly influences the value of losses and dilution and the economic losses related to them; the value of losses and dilution increases with increase of the bench height, and the current stripping ratio reduces. In order to determine the optimal bench height, joint consideration of the losses and dilution with the current stripping ratio, is required. The conducted technical and economic calculations result in recommending the bench height in an ore zone to be 5 m while maintaining the rock bench height of 20 meters.

Keywords: Losses, dilution, loss-rationing, separate excavation

УВЕЛИЧАВАНЕ НА ИКОНОМИЧЕСКАТА ЕФЕКТИВНОСТ ПРИ РАЗРАБОТВАНЕ НА КОМПЛЕКСНИ ЗЛАТОСЪДЪРЖАЩИ НАХОДИЩА

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РЕЗЮМЕ. Понастоящем се наблюдава тенденция към влошаване на геоложките и инженерни условия при разработването на рудни находища, което води до увеличаване на загубите и обедняване на полезните изкопаеми, увеличаване на разходите за производство и преработка на минерали. Като се вземат предвид определените ограничителни условия, максималната нетна настояща стойност на добива от дадено находище ще бъде постигната с минимални икономически загуби, произтичащи от загубите и обедняването на рудата. В резултат на изследването може да се заключи, че икономическите загуби, свързани със загубите и обедняването на руда, нарастват пряко пропорционално на увеличаването на височината на стъпалата. Начинът на подготовка на хоризонта значително влияе върху стойността на загубите и обедняването и свързаните с тях икономически загуби; стойността на загубите и обедняването се увеличава с увеличаване на височината на стъпалото, а текущият коефициент на откривка намалява. За да се определи оптималната височина на стъпалото, е необходимо съвместно отчитане на загубите и обедняването със сегашния коефициент на откривка. Проведените технически и икономически изчисления водят до препоръчване височината на стъпалото в рудна зона да бъде 5 m, като се поддържа височината на стъпало на скалата от 20 метра.

Ключови думи: загуби, обедняване, съотношение на загубите, отделен добив

Introduction

One of the most important problems in the rational use of mineral resources is the improvement of existing methods for the complete extraction of minerals from the interior. The effectiveness of monitoring the compliance of the quantity and quality of recoverable reserves determined by the standards depends both on the reliability of the data and on the accounting methodology used. The indicators controlling the quantitative side of the process of mining of mineral resources are the absolute and relative losses of balance reserves, as well as the absolute and relative magnitude of the amount of clogging rocks in the mined ore.

Types of losses of mineral resources

The losses of mineral resources are divided into the following types: (i) in redeemed ledges (sides) of the quarry; (ii) in unfinished areas; (iii) in the soil and roof of the deposit; (iv) with separate excavation; (v) in the process of drilling and blasting works; (vi) in the internal dumps during the re-excavation; (vii) when loaded into transport vessels due to spillage; (viii) in the process of transportation; (ix) when stored in temporary warehouses; (x) at reloading points; (xi) at landslides of sides and ledges.

In a specific production environment, certain types of losses can be absent or new ones added to this list. For example, in coal deposits due to spontaneous combustion of certain coals, in the case of improper mining operations, coal losses from fires occur. In the case of draperies, there are losses in interstep and inter-path ladders, etc.

In addition to quantitative losses, mining often leads to depletion of minerals. The total amount of the diluting mountain mass is determined by the clogging of the conditioned minerals with an empty rock or substandard grades, and by the blending of valuable varieties with less valuable ones during drilling and blasting operations, and also as a result of local caving of the ledges. Insolvency leads not only to a decrease in the content of useful components in mined minerals, but also to a deterioration in recovery rates at concentrating mills and metallurgical plants.

Production of blasting

The normalization of losses and dilution includes the issues of operational testing, the organisation of drilling and blasting and excavation, the selection of effective blasting schemes with separation of ores and rocks, using schemes for initiating borehole charges, taking into account the position of ore bodies in the space aimed at achieving maximum preservation of the initial, geological structure or minimising the displacement of contacts of ore bodies and rocks during their joint blasting and subsequent excavation shipment.

Floating trench traverses the ore zone with drilling and blasting operations. The width of the split trench is determined by the parameters of the applied technological equipment, as well as by the number and consistency of the contour of ore bodies. In gross blasting, all three sizes of the blast block (width, length and height) or some of them are set regardless of the position of contacts with different types of rock on the basis of technological considerations.

Separate blasting should be used when it is possible to perform a simultaneous or selective blasting of ore bodies and rocks. The multi-row co-rapidly delayed gross blasting of the block can be carried out on a selected face, in a clamped medium and with a retaining wall.

The advantage of multi-row explosion of charges on the open front with a uniform initiation of charges is to ensure the quality of rock crushing. The disadvantage is the material breach of the initial settings lay down deposits of ore bodies.

Multiple explosion in the clamped medium provides a more complete preservation of the parameters of occurrence of ore bodies after the explosion due to the lower rock openness after the explosion (Kp = 1.05 ÷ 1.2), but for the same reason increases the energy intensity of the excavation and the duration of the excavator cycle (Trubetskoi, 2001). Explosion in a jammed environment requires the use of commutation schemes with longitudinal cutting. What is characteristic for the drilling and explosive preparation of rock mass is the thickening of the well grid by 10-15%, which limits the minimum width of the blast block.

In the case of a multiple-row explosion without a retaining wall, the disintegration coefficient of the blasted rocks varies along the width of the blast block: for the first row of wells, it is the largest and reaches 1.6, for the second and third rows the value of Kp in comparison with its value in single-shot blasting decreases by 8-10%, for the fourth to fifth rows − by 12-15%, for the sixth to eighth series − by 20-30%. The explosion of rocks in a clamped medium (with a retaining wall) leads to a decrease in the opening ratio. The horizontal power of the buffer of the previously infiltrated rock mass should be taken within 10-15 m with a bench height of 10 m.

Organisation of technological processes

The complex structure of mineralisation sets increased requirements for the organisation of all technological processes of mining. Separate excavation in the form of exploded rocks can be simple or complex. In this case, the extraction of valuable ores is carried out under the following basic conditions:

- he explosion of rock and ore is mainly carried out by the gross method;
- he position of the contact "ore-rock" and grades of ores is determined by the geological service with the setting of reference points on the collapse of the blasted rock mass;
- he excavation of rock mass in a complex face is always carried out from the hanging side of the ore body to the bed, with the least loss and dilution of ores. The elimination of ore bodies from the recumbent side of the deposit to the hanging one is unadvisable;
- epending on the conditions of the occurrence, the development of a mining ledge should be envisaged in two 5-meter steps and a 5-meter-high damming subdivision. To increase the level of selective excavation in the development of low-power ore bodies, a 5-meter long canopy can be worked up by two layers 5 m;
- n accordance with the accepted technology of gross explosion, all three sizes of the blast block (width, length and height) or some of them are set regardless of the position of the contacts and the number of ore bodies on the basis of the required volume of the finished blown rock mass;
- he part of the camber is initially shipped along the roof of the ledge, with the passage of the first step on the rock from the side of the hanging side of the ore body.

The sorting is carried out only on the width of the face with a complex split notch. In case of a complex separate seizure, the quality of the mined minerals is achieved by the correct choice of the method, the thorough preparation of the face for the explosion, and the installation of the excavator as close as possible.

Losses and dilution of minerals with a simple separate excavation occur when the roof of the mining ledge is scraped, because of the mismatch between the tractor's scooping of the excavator bucket with the contacts of the deposit and the surrounding rocks, and also during loading.

The methods of complex sorting are: separate scooping, managed collapsing and their combination. With the method of complex sorting with separate scooping of ore and rock, it is advisable to separate the face into 4-5 m tall sub-steppes, and each lead should be worked by layers 2-2.5 m high (Arsentiev, 2002).

Combined methods used in the faces with complex intermittency of ore and rock are combinations of separate scooping with controlled caving or one of these methods with simple segregation or simple sorting methods (by isolating subterranean strata in individual sites, trench excavation of individual sections of the collapse), as well as sorting by fractions, the allocation of diverse and diverse grades of minerals and waste rock with temporary segregated storage in cone-shaped stacks in the bottomhole space.

Opening and preparation of production blocks is carried out on the blown up mountain mass, when dividing a ledge 10 m in height into two 5 m steps, depending on the choice of the technological scheme.

To reduce losses and dilution, it is advisable to use a technologic scheme with backhoe type excavators. Figure 1 shows an example of the excavation of two ore bodies using a PC-400 excavator. The technology includes sequential mining of the rocks by the fork of the hanging side, then the ore. Managed collapse is produced by working the bottom of the face in an order that depends on the location of the useful

object in the collapse. In the lower part of the face, in a staggered manner, trough-shaped notches are formed, into which the rock mass from the top of the face is brought down, it is shipped and then the protrusions between the recesses are worked.

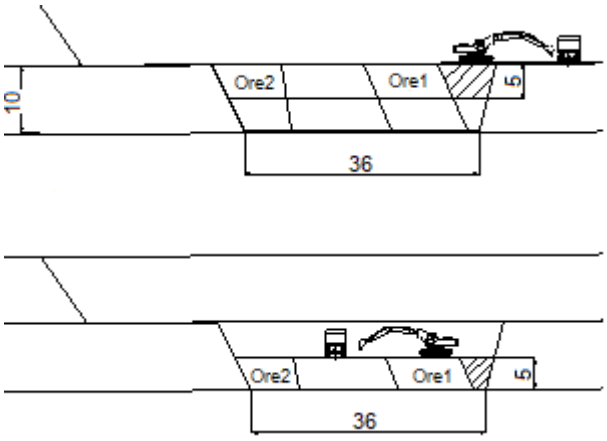

Fig. 1. Scheme of development of the sub-stages excavator PC-400

Planning of mining operations

At the current planning stage, quality indicators and quantities of extracted ore are determined using operational exploration data and subsequently, after blasting the block, they are specified taking into account the collapse of the blasted rock mass and excavating ditches for its development. The boundary of ore grades is defined as the distance between drilling and blasting wells along the slurry, at which operational exploration is carried out in proportion to the gold content in adjacent wells by the formula.

$$\Delta = L\,(C_2 - C_b) / (C_2 - C_1), \qquad (1)$$

where:

C_1 and C_2 are the contents of two adjacent wells, respectively; C_b is the specified airborne content;

L is the distance between the wells.

Based on the forecast results of the ores' grades for the disintegration of the blown up mass, excavating moves are planned and a passport of the mining excavator is developed. In the excavator passport, in addition to the known parameters and the order of organisation of work, the axis of the excavator stroke, the order of excavation and loading of ores of various qualities should be shown.

To achieve minimum losses and dilution of ores, it is necessary that the excavation of the contact zones of the ore body is carried out with the formation of a slope of the face in accordance with the drop in contact of the ore body. The most unfavourable conditions of excavation with an inconsistent incidence of contact and profile of the slope of the face should be avoided in every way when planning excavating moves.

The angle of the slope of the working face, on which the possibility of qualitative excavation in contact zones depends, is determined by the physical and mechanical properties and the granulometric characteristics of the blasted rock mass. The sequence of constructing the contours of the excavating cavity is as follows: n the plan for the collapse of the blown up block, the contours of grades of ore are displayed, taking into account the displacement of their boundaries after the explosion; xcavation starts are planned for block development; ections are plotted along the characteristic cross-sections of contact zones, on which the rational position of the excavating contour is carried out.

Schemes for constructing excavation contours on sections and determining the amount of removal of the excavation contour from the contour of the ore body to the surface are determined from the height of the upper triangle of losses of the normative variant of the development of the contact zone.

For the normative losses and dilution of the mineral such a level is taken that is technically possible and economically justified with the current state of the technology of mining and processing of ores in the enterprise.

With the high value of minerals, it is necessary to pay close attention to the magnitude of losses and dilution, which decrease with the decreasing height of the ledge. However, a decrease in the height of the ledge leads to a smoothing of the slope of the working bead and, consequently, to an increase in the current stripping ratio.

Thus, the rational height of the ledge can only be found by a joint examination of losses, dilution and the current stripping ratio.

Conclusions

To achieve the minimum values of loss and dilution of ores, it is necessary the excavation of the contact zones of the ore body to be carried out by: multiple explosion in a clamped medium, which provides a more complete preservation of the parameters of occurrence of ore bodies after the explosion due to a lower rock release rate after explosion (Kr = 1.05 ÷ 1.2); the method of complex sorting with separate scooping of ore and rock, with the division of the face into 4-5 m high, and the development of each approach to be carried out by layers 2-2.5 m high; formation of the slope of the face according to the drop in the contact of the ore body.

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