Rational design of bottom blocks for development of ore deposits systems with caving of ore and enclosing rocks

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Abstract. The assessment of the geological conditions of development of existing ore deposits was made. For testing ore deposits in difficult mining and geological conditions, the authors proposed the system of development, accompanied by collapse of the mechanical ore with the use of feeders of active action that could be manufactured directly in the mine in accordance with the specific conditions of occurrence of minerals. The paper demonstrates the technology of manufacture of load-bearing structures of the feeder directly in the mine at the scene of the breaking of the first layer of ore, as well as the dynamics of the ore and the choice of parameters of concrete feeders. A new design of the bottom block was proposed, the idea of technical solution of which consists in the fact that it is offered to undergo the production of the smallest possible cross section, which is determined only by the dimensions of the conveyors to deliver ore. And before the explosion of fans of production wells, it is necessary to produce local collapse of the roof production to increase its height at the place of production of ore by blasting wellheads in two or three rows.

1. Introduction
Most of the large enterprises of Siberia and the Far East have been mining ore at depths of over 500 m, which resulted in a significant deterioration of the geological conditions of their working. For example, in the deposits of Norilsk region at the depth of up to 1.5 km, of Mountain Shoria (900 m) and Far East (1000 m), the mining strikes with energy up to 10^7-10^9 J were registered. There is an increase in the destruction of mines, the buckling of pillars, increasing the difficulties in ensuring the safety of mining operations. One of the possible solutions to the problem of mining ore deposits in difficult mining and geological conditions – the use of high-performance, secure systems development with collapse and flat bottom treatment blocks [1-10].

For wide introduction of the above-mentioned technology with caving ore and enclosing rocks, prom devices (feeders of various designs and fencing-mobile roof supports) are created, without which it is impossible to effectively implement the main process technology systems with caving of ore and enclosing rocks of the ore. The main disadvantage of most existing designs is the significant complexity of installation of the exhaust device and inability to effectively manage the flow process ore from the exhaust holes.

It is necessary to note a significant variability of mining-geological characteristics of inclined ore deposits, when such indicators as power and angle of incidence can vary even within the same excavation unit, which makes it difficult to select and set the parameters for the output devices.
Therefore, the problem of creating prom devices, maximally adapted to mining and geological conditions of occurrence of inclined ore deposits, which greatly improve the efficiency of their practice, is extremely important.

2. Development of a rational design of the feeder of the ore

Based on the analysis of operating experience of various output devices, it can be argued that, to the greatest extent, such mobile feeder of active actions, which could be manufactured in underground conditions, taking into account real mining conditions, would correspond to mining and geological conditions of mining of ore deposits at greater depths. Besides, the design of these feeders would allow one to maximally simply and reliably carry out remote control of such devices.

The basic idea of this solution is the manufacture of load-bearing structures directly in the mine (in the development mining on the site of the breaking of the first ore layer after sinking to the bottom face of the cutting rising one), which will allow one to intensify the ore production process by reducing the time required for the preparatory-final operations. In general, the technology of manufacturing such adaptive feeder can be as follows.

First, a temporary formwork of the hull feeder is manufactured. Then the rebar is set in it. The hardening mixture is pour (e.g., concrete mixture) in it and a channel for placement of the drive cylinders is formed. In the channel of the frame hydrocylinders are placed; they are fixed and a hydraulic system and remote control sensors are installed. Of particular interest are the technological options of the active method of release, allowing one to obtain the greatest living section of the outlet openings, compared to other existing methods of production of milled ore, which will improve the quality of ore by reducing losses of ore in the ridges between the repulsing layers of ore. The dynamics of the expiry of the ore when influencing the ore massif (pile of ore in the exhaust mining) by the working body of such ferroconcrete feeder is shown in Figure 1.

In the process of operation, the working body of ferroconcrete feeder 4 makes a reciprocating movement. At the exit from under the floor 5, the working body of the feeder feeds the ore to a transport device. According to the theory of soil mechanics, in the bulk body, a stress state is induced, which is caused by passive resistance. The amount of penetration of the feeder in bulk of blasted ore $L_3$ is defined as the distance from the plane face of the slaughter to the place of penetration of the working body of the feeder and can be calculated by the formula:

$$L_3 = \frac{H_c - H_f}{\tan \psi},$$

where $\psi = 45^0 - \rho / 2$, $\rho$ - angle of internal friction of loosened ore.

The height of the discharging window AB will be:

$$H_c = \frac{L_3}{\cos \psi}.$$

The essence of adaptation of the above-mentioned technical devices to specific technological parameters of mining places demands on their design. For example, the form of an overlapping visor must be geometrically similar to the outlet mining cross section with the preset coefficient of similarity to reduce the effort of moving the working body of the feeder. From the standpoint of production technology, the above-mentioned parameters of the structure of the bottom of the purification unit with the use of adaptive concrete feeder are optimal. The reduction in $L_3$ will reduce the height of the discharging outlet.

With a deeper penetration of the feeder, resistance of the soil to the movement of the working body of feeder 4 will increase dramatically, which will lead to violation of the process of forming the window release. To reduce the dependence of the formation process of the windows release on a possible hyperadmissible increase of feeder penetration, more sophisticated designs of such devices for ore production have been developed to date.
Figure 1. A diagram explaining the output dynamics of the ore and the choice of parameters of ferroconcrete feeders

1 – output; 2 – repulsed ore; 3 – concrete feeder; 4 – the working body of the feeder; 5 – arched ceiling of the working body of the feeder; 6 – breed of the waste layer; \( H_B \) – the height of the development; \( H_p \) – the height of the feeder; \( H_c \) – the height of the living (active) section outlet; \( L_3 \) – ore milled pile penetration of the feeder

3. Development of a rational design of the bottom purification unit

Economic benefits, in addition to reducing the loss and dilution, can be obtained due to a significant reduction of the cost of excavation of workings as well by reducing their cross-section, as the dimensions of the details of the adaptive feeder, delivered to the face, will be much less than those of currently used structures (including node self-propelled equipment). Thus, the essence of the proposed design of the unit bottom, which will determine the economic efficiency of adaptive feeders, expressed
in reducing cross sections of mine workings.

The idea of the technical solution consists in the fact that it is offered to pass the mining production of the smallest possible cross section, which is determined only by the dimensions of the conveyors, intended for ore delivery (Figure 2). Before the explosion of fans of production wells, it is necessary to produce local collapse of the mining roof to increase its height at the place of ore production by blasting the mouth of the wells (2-3 wells in 2-3 series).

**Figure 2.** The bottom of the stope unit with the adaptive feeder of pushing type
1 - output; 2 - treatment; 3 - feeder; 4 - the working body of the feeder; 5 - the overlap of the working body; 6-expanded portion output.

This object is achieved owing to the fact that the bottom of the stope unit includes drill-supplying production 1, conjugated with control space 2, feeder 3 with working body 4, made in the form of a pushing element, mounted on the ground of the drill-supplying production under the working excavation and deepened in a ore pile at distance $L$ from a conjugation of drill-supplying mining with working excavation, determined from the ratio:

$$L = K(H - H_p)g(45^\circ - \varphi/2),$$

where $K$ - empirical coefficient, depending on the depth of development equal to 1.0 - 1.2 m;
$H$ - height of the release, m;
$H_p$ - height of the working body of the feeder, m;
$\varphi$ - angle of internal friction of blasted ore.
At that, drill-supplying mining, adjacent to the working excavation, is performed with the extension to the side of the roof of drill-supplying mining, and the height of the extension of drill-supplying production is determined from the expression:

\[ h = tg(45^\circ - \varphi/2)L + H_p - H. \]

Technology of ore production with the proposed design of the bottom is similar to the above-mentioned one. Feeder 3 with its working body 4, outgoing from chamber 5 (Figure 2), moves the volume of blasted ore, limited by figure \(ABCD\), to extended production 6 at a distance proportional to the stroke length \(l\) of working body 4 of feeder 3. At that, the ore, located above plane BC, descends by the amount proportional to stroke length \(l\) of working body 4 of feeder 3. In this case, the value of BC defines the size of the output window, sufficient to ensure a uniform process of outflow of powdered ore without any lockups. In its turn, value \(BC\) is determined by height \(H\) of drill-supplying mining in the place of its fit to space 2. The volume of ore, displaced further by the working body of push type 4 of feeder 3, is loaded to the transport device (in Figure 1, it is not shown) and delivered to the place of further processing.

4. Conclusion

Introduction of technology of conducting remediation with the use of adaptive feeders and new bottom designs of sewage treatment units, allowing the smallest possible cross-section, allows one to improve significantly the efficiency of mining through the establishment of rational schemes for preparation of blocks, very handy for the quick testing of mineral reserves. When applying training regimens to concrete feeders, the bottoms of the blocks are less prone to fracture, which gives the opportunity to expand significantly the scope of the development system with ore caving and enclosing rocks. Technology of mining ore deposits, allowing one to create simple designs bottoms, helps to increase the height of the floor, owing to which the productivity of units and, accordingly, the production capacity of a mining enterprise can be increased significantly.

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