

IMPACT OF MINING DEPTH ON UNIT CAPACITY

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Abstract

Based on the selected options of room-and-pillar systems, there are distinguished the main criteria and technical-and-economic indices having an impact on the rationality of mining systems' use when decreasing the depth of room work conductance.

Keywords: room-and-pillar system; economic-mathematic modeling (EMM); technical and economic indices (TEI).

1. Introduction

Issues of parameters' optimization in the mining industry of Russia were extensively researched by Galaev, Agoshkov, Boki, Imenitov, Shevyakov, Gorodetskiy, Shestakov, Pushkarev, Drobot, and Bich [4-13].

Herewith, it is universally acknowledged that efficiency of ore production to a large extent depends on establishing of rational technological parameters and intensity of mining.

Research technique used for solution of these tasks is, as a rule, complex, and includes different methods of logic analysis, physical modeling, analogies, technical and economic analysis, analytical comparison of options, directed search for optimal decisions and use of the mathematical tool of graph theory, linear and dynamic programming, reliability, etc.

As the experience of many works shows, nowadays, the use is widely made of economic-mathematic modeling methods allowing to represent complex relations of a rather large amount of technical, organizational and cost factors having an effect on the selection of rational parameters of a mining system.

A mining system of any mine includes the performance of preliminary break-off of ore, its breaking, drawing, and delivery, and must ensure the safety of works, maximum extraction of a commercial mineral, minimum expenses on mining and processing.

Development of a system mathematic model must be preceded by a study of qualitative and quantitative phenomena peculiar to the system. Therefore, during the system analysis and mathematic description, it is very important to divide the whole totality of the phenomena into subsystems characterizing separate technological processes.

During this work, economic-mathematic modeling is used as the main technique for determining optimal process parameters of mining units. With the purpose to ensure the reliability of obtained results and wide possibilities of the technique's practical application, the developed models of mine works scheduling were made up: on the basis of used at Northern Urals bauxite mines (NUBM) technical-and-economic indices and scheduling algorithms, predicted conditions of development and their effect on process parameters of mining operations [1].

One of the important requirements to the technique presupposed that the economic-mathematic model (EMM) structure should be very flexible in terms of a simple adaptation to possible technical, organizational and cost variations, as well as in terms of different scheduling tasks solution and issues of parameters' optimization.

Main items of the approach to the elaboration of mining processes' EMM result from the character of the set research task – substantiation of development of a room work front.

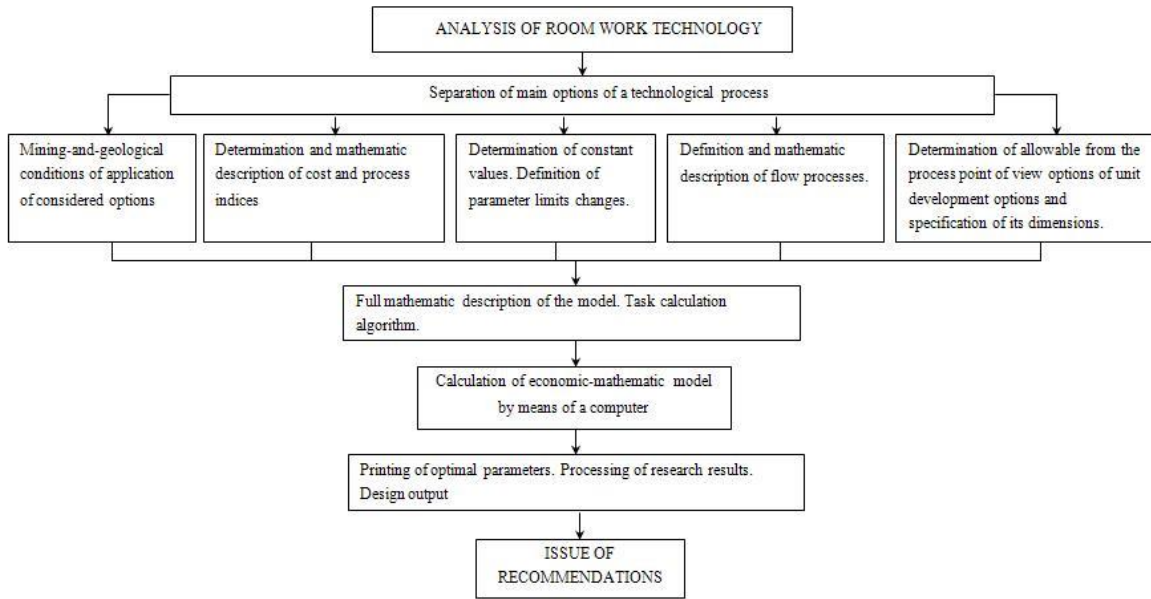


Fig 1. Flow diagram of effective development limits

It is expedient to avoid the use of large bodies of data, reliable determination of which for future periods of development is either very laborious or even impossible. For this reason, we included into the composition of initial parameters only the data which in the fullest measure represents the specifics of the main conditions of particular mine sections development. Some data was determined on the basis of a comparison with the actual indices obtained under similar conditions and including different development trends.

The use was also made of the widely applied at the enterprise system of specific and average weighted technical and economic indices which made it possible to take into account the impact of the main mining- and-geological and mine technical factors when planning expansion for a long period.

With the purpose to fully describe all technological processes at the production unit, the use was made of a combination of different techniques for determination of parameters that to the fullest extent made allowance for peculiarities of the determined values and included empirical data and results of analytical research [2].

By an optimization criterion for optimum design tasks, it is necessary to understand an assigned estimated figure, in the role of which there can be taken any resources at the society's disposal: labor, energy, mineral, material, financial and others. However, the roundup index, which most fully corresponds to the main aim of the social economy development and represents the main equivalent of the maximum society satisfaction, shall be the social labor costs. Consequently, in this case, the general criterion of optimization is the flat cost of commercial mineral production.

In compliance with the main principles of operations study, the considered mathematic model is a system consisting of the main target function (flat cost of production of 1 ton of ore), partial criteria (unit efficiency and level of ore extraction), variable parameters with limits and interval of their change, technological limitations and intermediate values.

In general, the task can be put down in the following way:

$$C_{prod} = C_{backfill} + C_{dev.op.} + C_{item} + C_{disec}, \text{ RUB/t} \quad (1)$$

where: $C_{backfill}$ is the flat cost of the backfill, RUB/t; $C_{dev.op.}$ is the flat cost of mining and development, RUB/t; C_{item} is the flat cost of production by items, RUB/t; $C_{disec.}$ is the diseconomy from ore losses in pillars, RUB/t.

A systematic approach to optimization requires a certain identity of the target function and general criteria of optimality. This ensures indestructibility of centralization, purposefulness and general criterion interests.

Along with the production flat cost, determining factors for selection of an optimal mining system during the transition to deep levels are technical-and-economic parameters.

Unit capacity, accepted as a criterion, as well as the determined amount of output product, depends on the ore body thickness and the room width. In accordance with general principles of the economic-mathematic modeling, the latter must also necessarily contain a criterion determining the quality of the output product. In this work – it's extraction ratio K_{extr} .

In order to solve the task of defining the optimal limits of use of room-and-pillar systems different options, the following flow diagrams were selected: room-and-pillar system with leaving of ore- and chain pillars arranged along the strike of an ore body (Fig. 2); room-and-pillar system with development of a working excavation (Fig. 3); room-and-pillar system with leaving of a combined support of a concrete-ore-concrete type (Fig. 4); room-and-pillar system with leaving of a combined support of an ore-concrete-ore type (Fig. 5).

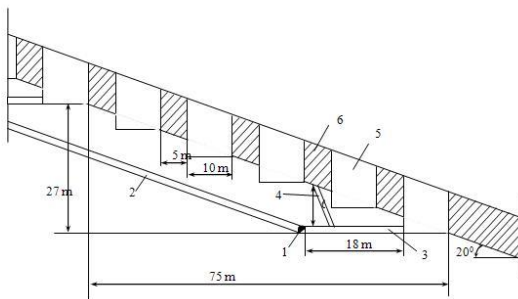


Fig. 2 Room-and-pillar system with arrangement of chain pillars along the strike.
1 – haulage gate, 2 – transport ramp, 3 – haulage crosscut, 4 – ore chute, 5 – room, 6 – pillar.

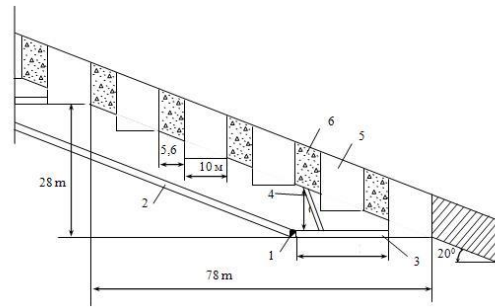


Fig. 3 Room-and-pillar system with development of a working excavation.
1 – haulage gate, 2 – transport ramp, 3 – haulage crosscut, 4 – ore chute, 5 – room, 6 – pillar.

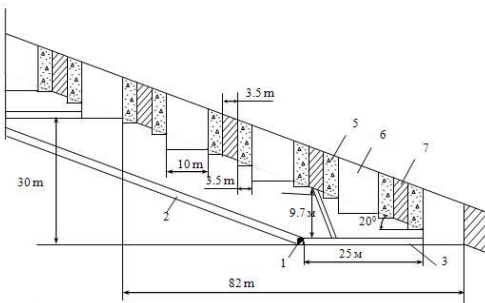


Fig. 4. room-and-pillar system with leaving of a combined support of a concrete-ore-concrete type.
1 – haulage gate, 2 – transport ramp, 3 – haulage crosscut, 4 – ore chute, 5 – batch I room, 6 – batch II room, 7 – pillar.

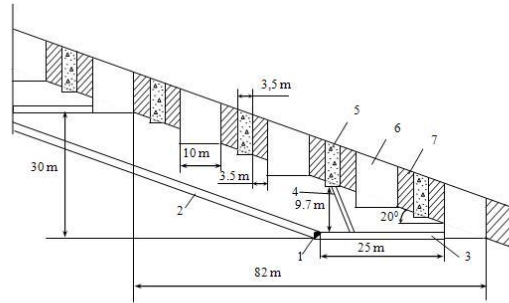


Fig. 5. Room-and-pillar system with leaving of a combined support of an ore-concrete-ore type.
1 – haulage gate, 2 – transport ramp, 3 – haulage crosscut, 4 – ore chute, 5 – batch I room, 6 – batch II room, 7 – pillar.

Based on these options of mining systems, values of ore reserves distribution by work stages were introduced into the economic-mathematic model, and a unit capacity was calculated (see Figure 6).

Reliability of these values can be compared with available for other similar mines data on labor productivity of a face worker as one of the main production indices, but only for small depths (up to 800 m). The comparative assessment shows no significant difference.

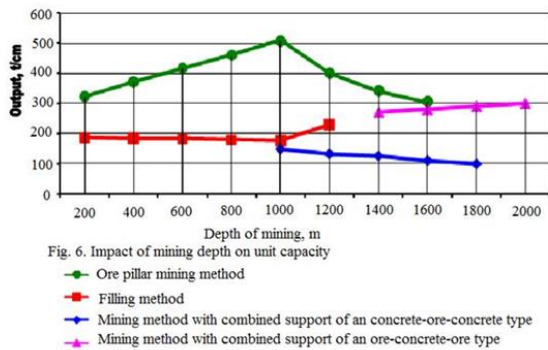


Fig. 6. Impact of mining depth on unit capacity
 — Ore pillar mining method
 — Filling method
 — Mining method with combined support of a concrete-ore-concrete type
 — Mining method with combined support of an ore-concrete-ore type

Along with this data, a comparison was made with the use of available economic information of the mine proper for the second quarter of 2010 [3]. The flat cost of the commercial mineral production constitutes:

- during room-and-pillar development – 164.5 RUB/t,
- during production with the development of a working excavation – 186.3 RUB/t.

It is necessary to point out that mining works at (NUBM) mines are already performed at the depths of 1000 m. This data is also totally confirmed by the calculated values of the mining cost when using these mining methods.

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