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Effective Exploitation of Ore Deposits in the Market Economy

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Abstract: The study is devoted to the issues of regulation of production process flexible development at mining enterprises in the conditions of market economy formation. The mechanism of managing the economic activity of a mining enterprise based on the regulation of ore mining indicators is formulated taking into account the ability to flexibly react to internal and external factors. It is substantiated that the optimization of volumes in the release of mining enterprise products within the framework of the mechanism of flexible adaptation to the market conditions is ensured by the use of innovative technologies for mining ore reserves with ensuring profit.

Key words: Flexible development, mining enterprise, market, economy, management mechanism, ore mining, optimization, reserves, profit

INTRODUCTION

The economic aspect of effective marketing of mineral raw materials and products of its processing is the study of production and the market demand. The price of metal is the fundamental factor in determining the value of the ore mass for mining enterprises. Reduction in domestic market demand forced companies within the industry to be oriented to export deliveries which resulted in repurpose of the range of exported metal to those grades that have the highest consumer properties (Golik *et al*., 2016a-d). Tough competition with leading Foreign companies, the anti-dumping barriers, high requirements for certification, labeling, packaging, delivery times, environmental and health standards in trade with EU countries are deterrents to expand exports (Golik *et al*., 2015a-d, 2016a-d; Ermishina, 2011; Lyashenko and Golik, 2004).

When forming a strategy of behavior, enterprises in a market economy are guided by a change in the market situation of supply and demand for metals which is the basis for price policy and the development of further behavior in an unstable environment (Lyashenko and Golik, 2004, 2006; Golik *et al*., 2015a-d; Logachev and Golik, 2009).

MATERIALS AND METHODS

A mathematical and statistical analysis of price changes in the world metal market was conducted to forecast pricing in mining enterprises and during the analysis, the character and trend of development of the economic phenomenon under study was established (Golik *et al*., 2015a-d; Lyashenko *et al*., 2008).

The forecasting method was based on the assumption that the parameters are preserved until the end of the forecast period provided that the function sufficiently describes the features of the phenomenon under study, with the macroeconomic conditions affecting the growth rates remaining unchanged (Lyashenko *et al*., 2008; Komashchenko *et al*., 2016; Luzin and Golik, 2004; Muratovna *et al*., 2016).

RESULTS AND DISCUSSION

Mining enterprises produce a mono-product. Cross-elasticity of demand between oligopolist products and other goods is negligible:

$$e_{i,j} = \frac{dq_i}{dp_j} \cdot \frac{p_j}{q_i} \to 0$$

Where:

$e_{i,j}$ = A coefficient of elasticity of demand for the oligopolist product
i, j = Enterprises producing homogeneous products
p_j and q_i = The price and output volumes of i-th and j-th enterprises

Mining enterprises are tied to mineral deposits and represent a very capital intensive production. The standard time for construction is 5-10 years. To carry out

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mining operations, it is necessary to have state licenses, a system of special taxes, for example, on the right to use subsoil resources and to reproduce mineral resources. The mining industry technologically represents many isolated markets. Consumers of the products are metallurgical plants, the number of which is limited. In the conditions of oligopoly, mining enterprises can maximize profits only by changing production volumes as the price of metal is regulated by the London Metal Exchange.

The ore value is a function of the content of the useful component in it which varies according to the Weibull distribution law. To select the optimal ratios of ore production volumes (Q), its value (P) and the Marginal Revenue (MR) of a mining enterprise, calculations were made based on the initial data of the loss-making Sadonsky enterprise. The Revenue (TR) is compared for different volumes of ore output (Q) with costs (STC) corresponding to each of the volumes. The option is considered optimal if the difference between gross income and gross costs is minimal.

Under these conditions, the amount of ore extraction is determined which ensures the maximum profit of the mine and the amount of additional capacity input when re-mining technogenic reserves. Due to the saving of expenses for mining operations, the growth rates of the variable part of incomes in the cost structure are reduced.

Example: The extraction of ores in volume of 100 thousand tons is carried out by traditional technologies and the average cost per ton of ore was 291.7 rub. Starting from 100 thousand tons, the areas of metal-bearing stowage are involved in re-operation, the cost of which is 254.9 rub. per ton. The marginal revenue with an increase in output will decrease and will be:

$$MR = 234.2\text{-}100\frac{261.6\text{-}234.2}{20} = 97.2(234.2)$$

With this demand and costs, the enterprise can make a profit either by increasing the volume of output or by increasing the value of extracted ore. The optimal volume of output Q* is that at which the profit is maximum:

$$\max P(Q^*) = TR(Q^*)\text{-}TC(Q^*)$$

The condition of the first order for profit maximization is:

$$\frac{dp(Q)}{dQ} = \frac{dTR(Q)}{d(Q)} - \frac{dTC(Q)}{dQ} = 0$$

Since, dTR/dQ = MR(Q) and dTC/dQ = MC(Q), the first-order condition is the marginal revenue equality to marginal costs:

$$MR(Q^*) = MC(Q^*)$$

It can be seen from the diagram that the marginal costs laid within the range of 20-136 thousand tons decrease and then increase. In the study from 40-140 thousand tons, the marginal cost curve crosses the marginal revenue curve with their minimum value which corresponds to the price (i.e., point A) and crosses the line ATC in the point B. The areas of the rectangle OP* AQ* correspond to the total revenue and the total costs correspond to the areas of the rectangle OC*BQ*. The shaded rectangle represents the minimum negative profit (C*DAB). The method of least squares determines the dependencies of economic indicators:

$$\begin{cases} Q = F(MR) = F(MC) = 137 \\ F(MC) = 0.015Q^2\text{-}3.547Q+275.3 \\ F(ATC) = 0.03Q^2\text{-}8.83Q+871.7 \\ F(P) = -0.0052Q^2+0.261Q+276.85 \\ F(MR) = -0.0123Q^2\text{-}0.24Q+335.37 \end{cases}$$

The mining volume that minimizes the losses of the mining enterprise:

$$\begin{cases} MR = -0.0123Q^2\text{-}0.24Q+335.4 \\ \underline{MC = 0.015Q^2\text{-}3.547Q+275.3} \end{cases}$$

$$F(M, MC) = -0.0273Q^2+3.307Q+60.07$$

$$Q = \frac{-b-\sqrt{b^2\text{-}4ac}}{2a} = \frac{-3.307-\sqrt{10.96+6.559}}{-2\cdot 0.0273} = 136 \text{ thousand tons}$$

The calculated point of cournot corresponds to the optimal volume of ore extraction which ensures minimization of the company's losses. Forecasting the behavior of the mining industry is characterized by the direction of its adaptation process in a market economy, taking into account the maximum use of domestic resources. The economic goal of the target function is the optimization of financial results ensuring stable operation of the enterprise.

A necessary requirement is an indicator of the completeness of subsoil use which is the general criterion for the effectiveness of mine development. However, in practice it is necessary to leave a part of the reserves in the form of off-balance reserves or in various kinds of solid blocks.

Table 1: Criteria for the efficiency of metal deposits

In a planned economy	In a market economy
The volume and quality of marketable products under different conditions of inventory calculation	Volume and quality of commercial products
Annual production costs of marketable products	The price of marketable products in the domestic and world markets
The size of the investment to create the infrastructure of the enterprise	The rate of return after taxes
Expected value of profit from sales of marketable products	Costs of production, taking into account the costs of protecting the natural environment
The level of profitability to production assets or to the cost of commodity output	Payback period for investments
The reduced production costs	Multiplicity of return on investment

Considering that the division of stocks into balance and off-balance reserves depends on the level of engineering and technology development, off-balance reserves are considered losses reduced by re-mining.

To optimize the production of off-balance ores, the optimal content of metals in off-balance ores and lateral rocks is established. It is established that an increase in the contour of balance reserves with a content of 3.65-0.44% in them and a decrease in the average metal content from 3.65-1.22% ensures a 4.9 fold increase in inventories and in 1.6 times as to metals.

For the purpose of ranking independent variables on the strength of their influence on production volumes, a linear model was formed:

$$F_Q = -0.001088П(y)+0.0042TC-$$
$$0.02M-29.4\alpha_x-0.2145P$$
$$r^2 = 0.9811$$

Where:

- Q = Annual volume of ore mass extraction (thousand tons)
- P(y) = Profit (losses) based on the results of the production activity of the SLZMC thous.rub.
- TC = Total Cost of metal (thousand rubles)
- M = Total yield of Metal, t
- α_x = Cutoff grade of metal in the incremental part of technogenic reserves (%)
- P = Total recoverable ore value mass (rub./t)
- r^2 = Correlation coefficient

In competitive economy conditions where the value of mineral raw materials is determined by the demand and supply in markets, the economic value of deposits and conditions for calculating their reserves is determined by different criteria (Table 1).

The prevailing criteria are the rate of profit and the cost of production. Since, they are associated with fluctuations in prices in the mineral markets, this technique allows rejecting of reserves because of the unprofitableness of their extraction and processing or conversely includes passive reserves in development.

The cutoff grade of the metal in the ore (α_{min}) is reviewed every 5-6 years. To establish the relationship between α_{min} and the exponent of completeness of extraction of reserves, the balance of values equation is used which reflects the technological and economic aspects of mining the reserves and processing the extracted raw materials. It is advisable to supplement the balance with the reserves included in the re-mining of sub-standard ores:

$$BTs_b - PTs_{Пл} + BTs_{пр.п} + TTs_{ТМО} = DTs_{р.М}$$

Where:

- B = The value of the Balance reserves of the deposit
- P = Loss of ore when mining reserves with use of various technological systems
- B = The amount of rock mixed with the ore mined
- D = The amount of extracted ore mass
- T = The number of Technogenic formations included in the re-mining
- Ts_b, $Ts_п$, $Ts_{пр. Р}$, $Ts_{р.м.}$ $Ts_{ТММО}$ = Values of balance reserves losses, admixed rocks, extracted ore mass and technogenic waste (rub./t)

The innovation in the definition of minimum cutoff grade is to take into account changes in world prices which have a phase-frequency fluctuation:

$$\alpha_{min} = (\varepsilon_{\sim\ddagger}^{\ddagger})^{-1}\sum_{i=1}^{n} C_i(\ldots I_p\varepsilon_{\sim})^{-1} z_{\hbar^{\sim}\cdot} + z_{\cdot}\alpha_{\cdot}\varepsilon_{\sim\ddagger}^{\bullet} -$$
$$z_{\cdot p,\cdot}\alpha_{\cdot p,\cdot}\varepsilon_{\sim\ddagger}^{\bullet p,\bullet} - \text{ж}_{p^{\sim\sim}}\alpha_{p^{\sim\sim}}\varepsilon_{\sim\ddagger}^{p^{\sim\sim}}$$

Where:

- C_i = Production cost of the i-th kind of mineral raw material
- Ts = The price of the i-th kind of metal
- I_{mp} = Index of the price fluctuations trend for the i-th kind of metal
- $\varepsilon_{об}^{б}$, $\varepsilon_{об}^{П}$, $\varepsilon_{б}б^{пр.п}$, $\varepsilon_{б}б^{ММО}$ = Extraction of the i-th kind of metal during enrichment, respectively in balance reserves, lost ores, admixed rocks, technogenic ores
- $K_{коп}$, $K_п$, $K_{пр.п}$, $K_{ММО}$ = The coefficient of the amount of ore mined, losses, blended rocks and technogenic ores, respectively

In the diagram, the lines D1 and D2 correspond to the change in demand and the distance between them corresponds to the trend of fluctuations in world prices for non-ferrous metals. The cutoff grade is inversely proportional to the ore value. With the increase in prices from 260-280 rub., the cutoff grade should increase but in fact it will be:

$$F(\alpha_{min}) = \frac{1}{\eta_2 I_p} = 0.6\%$$

CONCLUSION

Optimization of economic indicators of the mining complex is achieved by marketing research of the conformity of product quality to the conditions, price fluctuations and the direction of the market development. The export-import orientation of the non-ferrous metals market is evidence of the need to take into account price changes. Extraction of additional income is possible if the scale of production changes, appropriate reserves are available and qualitative parameters of ores are regulated. Forecasting the behavior of mining enterprises in a market economy is based on the maximum use of domestic production resources and reducing the damage to the environment through the involvement of technogenic mineral formations in operation.

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