Zero waste as an economic criterion of efficiency of the mining enterprise's activity

ZERO WASTE AS AN ECONOMIC CRITERION OF EFFICIENCY OF THE MINING ENTERPRISE'S ACTIVITY

CERO DESECHO COMO CRITERIO ECONÓMICO DE LA EFICIENCIA DE LA ACTIVIDAD DE LA EMPRESA MINERA

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abstract

The current stage of development of the Russian economy is positioned as a deep transformation of commodity production according to the radical improvement of technology development. The addition of potential of chemical energy to the predominantly mining mechanical energy opens up new prospects to be involved in the operation of still inaccessible mineral resources. This process requires the development of other economic efficiency criteria. The proposed criterion for the mining enterprise's evaluation effectiveness is a priority condition of non-waste production. Environmental damage due to improper use (waste) is differentiated based on the amount and cost of lost metal and mineral ingredients at local, regional, global and hierarchical levels. The damage components and economic efficiency can be determined based on the extent of utilization, costs and technological level of production.

Keywords: Exploitation Deposit, Environment, Technology Assessment, Efficiency Criteria, Waste Management, Technology Correctness.

La etapa actual de desarrollo de la economía rusa se posiciona como una transformación profunda de la producción de productos básicos de acuerdo con la mejora radical del desarrollo tecnológico. La adición de potencial de energía química a la energía mecánica predominantemente minera abre nuevas perspectivas para involucrarse en la operación de recursos minerales aún inaccesibles. Este proceso requiere el desarrollo de otros criterios de eficiencia económica. El criterio propuesto para la efectividad de la evaluación de la empresa minera es una condición prioritaria de la producción sin residuos. El daño ambiental debido al uso indebido (desperdicio) se diferencia en función de la cantidad y el costo de la pérdida de ingredientes metálicos y minerales a nivel local, regional, global y jerárquico. Los componentes del daño y la eficiencia económica pueden determinarse en función del grado de utilización, los costos y el nivel tecnológico de producción.

Palabras clave: Depósito de explotación, Medio ambiente, Evaluación tecnológica, Criterios de eficiencia, Gestión de residuos, Corrección tecnológica.

Introduction

In estimation of the economic efficiency of commercial products' production technologies using criteria that do not always evaluate the time features, there may be priority of different criteria only even in economy sector .

After reforms in the Russian economy, there are prevalent transition themes in the economy and peculiarities of economy development in conditions of globalization and economic tensions, the enterprises' volatility of monetary funds and, in recent years, change in the technological basis of the economy.

Thus, the following should be considered for the mining sector of the economic problems of economy priority: the state of mineral deposits, the concentration of property, raw materials economy, depending on world prices for raw materials, volatility and risks, the deficit of foreign investment, etc.

After the protracted crisis of the mining industry at the end of the last century, with some progress the issues of volatility of the economic environment and limited financial and economic resources were raised, as well as rationalization of using the resource determinants of regional development and their modernization factors.

In the modern development of the Russian economy, the issues of creating a favorable institutional and infrastructure environment for the development of the regional economy are realized.

The regional and sub-regional economic systems' clustering is increasingly used as a tool for the development of the regional economy. Its prospects are associated with the economic entities integration processes within the regions to strengthen the industrial structure of regional economy. The industrial enterprises united in a cluster are stabilized in the market volatility conditions due to their flexible structure, synergetic effect, cost saving, as well as knowledge and information exchange and other factors.

The current development level of the Russian economy is characterized by the reindustrialization status, as well as deep commodity production transformation according to radical development of technologies adequate to the challenges of modernity.

The development of new technologies involves solving the technologies convergence problem.

Concerning the production of raw materials for most industries, convergence refers to the convergence of mining and chemical technology. Adding the chemical energy potential to the predominantly mining mechanical energy leads to new prospects for the operational involvement of still inaccessible mineral resources. This process

necessitates the development of other economic efficiency criteria. The cost of production, profit, costs and other indicators are regarded as criteria in assessing the feasibility of mining technologies. Gross output, depreciation and energy are considered to be higher assessment levels. For the regional level and a large enterprise, cost, profit, reduced costs, unit capital costs, etc. are considered to be sufficient indicators

With a payback period of up to seven years, the efficiency of capital investments is estimated by the coefficient E, the value of which is considered equal to 0.15. These costs are used to provide the same number of production options:

$$C_{ac} = C + E_n K$$

where C_{ac} is the amount of annual costs for the option; and C is unit cost of production.

If the technology products differ in quality, the reduced costs with basic value is used:

$$C_{ac} = \left(C + E_n \cdot K_y \right) \frac{P_b}{P_a}$$

where P_b and P_a are recoverable value of the baseline and alternative options, respectively.

Profit is determined by the following equation:

$$P_r = \frac{1 - P}{1 - R} \left(V_o - C_e \right)$$

Where P and R stand for loss and attenuation, respectively;

V_o is the value of mined ores;

C_e represents extraction costs.

The use of the specific profit indicator without considering the value of products leads to large calculation errors. When using closing costs instead of the selling price, differential rent is a special type of conditional profit:

$$D = P_o - C_e$$

where C_o stands for the value of ores.

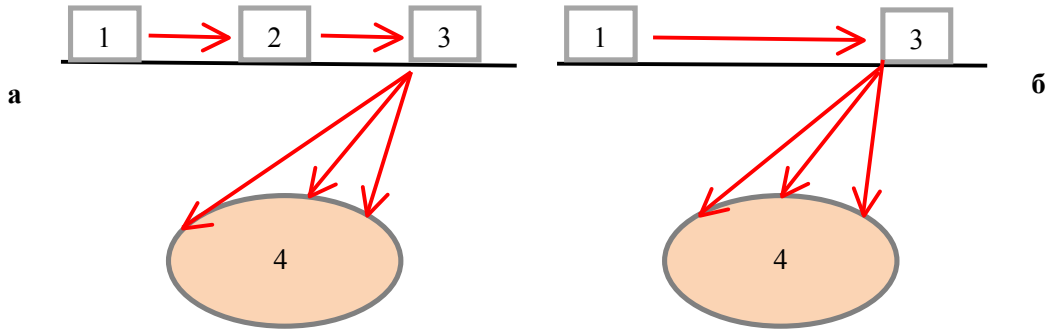$$C_e = 0.01 \bar{e} \cdot (1 - P) \cdot \mathcal{E} \cdot 3_3$$

where $\bar{e}$ represents metal content of ore; 3_3 is the closing costs per unit of concentrate; and stands for extraction metals from ore.

$$D = \frac{1-P}{1-R}\left(V_o - C_e\right)$$

These criteria are applied through considering the factor of time by discounting or adjusting the factor $K_в$:

$$D = \left(V_o{}' - C_e\right) \times K_e$$

The general drawback of the known criteria for the efficiency of mining technologies is that they do not fully consider the possibility of utilization of mining waste and ore enrichment. Therefore, progressive operation includes the direction of dumping the ore tailings in mined-out space without extracting their lost during the primary processing of valuable and scarce metals (Fig.1).

Fig. 1. Options for the use of enrichment tailings for the hardening mixtures preparation: a - with the extraction of residual metals; б - without the extraction of residual metals; 1- ore-concentration plant; 2- the plant extracting irreducible metals; 3- stowage complex; 4- goaf

The proposed efficiency criterion of the enterprise is based on the fact that since there is no possibility to assess the damage caused by waste, it is necessary to exclude technologically it. In assessing the impact of mining damage caused by unused raw materials is differentially considered for the different phases of the existence of the mining enterprise:

$$\sum_{t=1}^{t} Y_э = \sum_{t=1}^{t}\left(Y_p \cdot n + Y_э \cdot m + Y_л \cdot p\right)$$

where Y_p, $Y_э$, $Y_л$ respectively stand for damage during exploration, operation and liquidation of mines and factories; n, m, p-specific weights of phases by volume of waste storage.

In the exploration stage, the damage is calculated as follows:

$$Y_p = \sum_{t=1}^{t}\sum_{n=1}^{n}\sum_{k=1}^{k} M_e \cdot V_м + \sum_{t=1}^{t}\sum_{r=1}^{r}\sum_{f=1}^{f} Q P_q \rightarrow max$$

$$Q = Q_н - Q_б$$

where t is the waste storage time; n represents the amount of leachable components; k stands for number of self-organization effects in dumps. In this equation, M_e shows the number of metals released into the environment; $P_м$ is the price of useful components; and r represents the number of direct factors of environmental violations; f stands for the number of environmental violations indirect factors. Q illustrates the number of useful effects lost; Vq shows the cost of lost effects; and $Q_н$, and $Q_б$ respectively are the number of lost resources at the disposal of the waste and without it.

Damage during occurrence operation

$$Y_{экс.} = \sum_{t=1}^{t}\sum_{n=1}^{n}\sum_{k=1}^{k}\left(M_e V_м \cdot M_{ey} V_{му}\right) + \sum_{t=1}^{t}\sum_{r=1}^{r}\sum_{f=1}^{f}\left(Q P_q - Q_y P_{qy}\right) \rightarrow max$$

where M_{ey} represents the amount of waste disposal metals; $V_{му}$ is metal price; Q_y stands for the amount of restored useful effects; and V_{qy} is the price of utilized useful effects.

When an enterprise is liquidated only with reclamation and without any waste disposal, the danger to the environment increases due to the manifestation of new factors (globality, living matter mutations, rupture of the ozone layer, and so on).

Damage to the liquidation of the company is calculated by the following equation:

$$Y_{p.x} = \sum_{t=1}^{t}\left(\sum_{n=1}^{n}\sum_{k=1}^{k} M_e V_м + \sum_{r=1}^{r}\sum_{f=1}^{f} Q P_{iq} + \sum_{q=1}^{q} Q_г P_г\right) \rightarrow max$$

where q is the number of factors influencing waste; $Q_г$ represents the number of the environmental destruction effects; $P_г$ stands for the price of compensation for the environmental destruction.

The direction of unused resources reduction

includes their full utilization (Fig.2).

Hydrometallurgical company
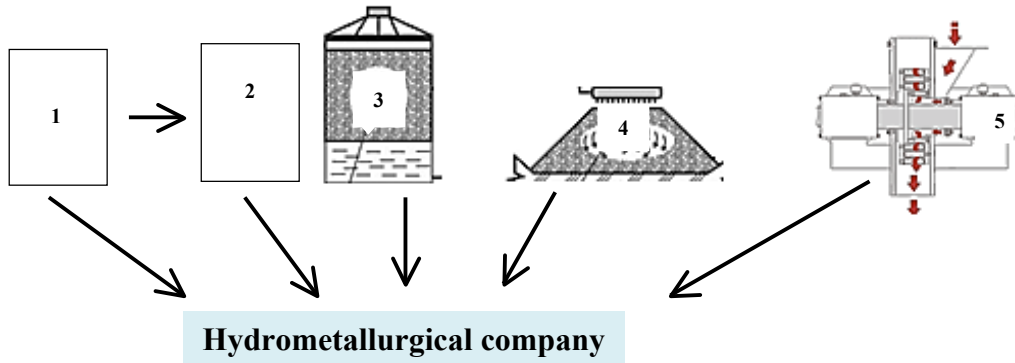
Fig. 2. Technology of metals' waste-free extraction from various grades of ores: 1- traditional development systems through arranging the hardening mixtures; 2- concentrating mill; 3- underground leaching unit; 4- leaching on the heap; 5- solvent extraction in the disintegrator

Technological solutions in the path of metal-containing waste utilization can include type design practice

Table 1. Type of solutions to nature conserved areas

Level	Types	Realization
Global	The changing geography of extraction	international contract
	Mining cooperation	International association
Regional	Cooperation of mining and processing enterprises	Inter-regional, intra-regional, and inter-sectoral
	Cooperation of utilizing complexes	
	Cooperation of users of recycled raw materials	
Local	Use of environmental and resource-saving production technologies	Bookmark hardening mixtures, options with leaching
	Use of environmental and resource-saving primary processing technologies	Combination of energy types for disintegration and collectivization
	Use of environmental and resource-saving waste management technologies	Electrochemical, geotechnology, disintegratory, etc.

The ecological and economic effect of the use of production and enrichment wastes for non-waste production is expressed by the model:

$$E = \sum_{t_0+1}^{t} \left(\frac{P \cdot V - 3_a}{1,08^{t-t_0}} \right) \cdot A$$

where P stands for the products obtained from recycling per weight unit.; V is the product price, per money unit.; 3_a–is the listed disposal costsper weight unit; t0 and t respectively are the start and end time; A illustrates the volume recycling wastes/Mathematical-economic model of the utilization efficiency of national economy tailings:

$$P = \sum_{p=lo}^{P}\sum_{o=ln}^{O}\sum_{n=lt}^{\Pi}\sum_{t=lf}^{T}\sum_{f=ln}^{F}\sum_{}^{N}\left\{\left(M_{ey}\cdot V_{My} + Q_y P_{qy}\right)\right\} - \sum_{s=1}^{3}\left[K\left(1+E_{Hy}\right)+E_q+E_x\right] - \left[\left(M_e\cdot V_M + Q\cdot P_q\right) + Q_r P_r\right]K_c K_y K_r K_6 K_r K_{Bp} K_q \rightarrow max$$

where: P is the utilization products; O stands for the waste type; P_q is the technological waste processes; T shows the waste recycling time; F is the existence phase of the mine and company; N represents the waste utilization stage; 3 is the cost of utilization waste; K is the capital investments for utilization organs: K c shows the dumps self-organization coefficient.

The model operates under restrictions:

$$\sum_{1}^{n}\left(M_{ey} + V_y\right) > 0; Q \cdot V_q + Q_r \cdot V_r < P$$

The probability of short-term effect:

$$r = \frac{K_{\text{б}}}{K_{\text{н}} + K_{\text{б}}}$$

where $K_{\text{б}}$ is the waste part of capital investment in utilization cost; $K_{\text{н}}$ represents the investment's used part.

The economic effect of production from waste products, including tailings enrichment scheme of environmentally friendly production is determined by the following equation:

$$E = \sum_{t_0+1}^{t}\left(\frac{P \cdot V - З_a}{1,08^{t-t_0}}\right) \cdot A$$

where P is the products' utilization, per weight unit.; V shows the product price, per money unit; t_0 and t stand for the start and end time, respectively; and A is the utilization volume.

Conclusions

1. Profit should be the criterion for the efficiency of the mining enterprise, if the production is waste-free.

2. The damage caused by the metal-containing waste is differentiated for the production stages based on the quantity and value of the wasted metal and mineral ingredients at local, regional and global hierarchical levels.

Conflict of Interest

The author confirms that the presented data do not contain any conflict of interest.

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