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The economic efficiency of ore fields development technology combination

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Abstract
The economic and mathematical models for determining the effectiveness of metals extraction technologies combination at the stages of mining production are formulated.
Keywords: TECHNOLOGY COMBINATION, METAL LEACHING, MODEL, EFFICIENCY, ECOLOGY

With the development of modern scientific and technical revolution the problem of metals providing to industry is escalating. The stocks of ore deposits are naturally decreasing, the metals content in ores decreases and the metal production cost increases. At the same time no more than 5-10% of weight of minerals, which are extracted from the subsoil is used as the finished product [1, 12-14].

The perspective direction of the mineral resource base hardening by reduction of ore extraction and processing tailings is a combination of traditional and innovative methods of metals extraction with solution of adjacent problems of global significance: the mineral resource base hardening and land degradation prevention. This direction is implemented by the use of technologies with metals leaching [2].

The economic efficiency of deposits development depends on the combination of the parameters of new and traditional mining technologies of commercial and non-commercial reserves. The essence of the combining is that the rich ores are wind up for processing at the plant in the traditional way, while the poor and sub-standard ores are leached in underground blocks and stockpiles on the surface (Fig. 1) [3,15-16].

Tailings utilization, which is possible only after the metals extraction from them to the level of sanitary requirements, is provided by influence of both mechanical and chemical energy (Fig. 2) [4, 17].

Combining of technologies in time and space is possible during the development phase (Fig. 3) [5].

The effectiveness of ore field development at the first stage [6]

$$\sum_{1}^{t} П_1 = \sum_{1}^{t_1} A_1 (B_1 - c_1) \big/ (1+E)^{t_1 - 1}, \quad A_1 = f(R_c) = (R_e - R_{p+nc}), \tag{1}$$

where $П_1$ – is the income, UAH; A_1 – is the enterprise production capacity, t/year; B_1 – is the recoverable ore value, UAH/unit; c_1 – is the cost of production and processing, UAH/unit; E – is the discounting coefficient, fr.unit; R_c – is the commercial ores reserves, t; R_e – is the estimated field reserves, t; R_{p+nc} – are the poor and non-commercial ores reserves.

The effectiveness of ore field development at the second stage:

$$\sum_{1}^{t} П_2 = \frac{1}{(1+E)^{\Delta t}} \sum_{1}^{t_2} A_2 (B_2 - c_2) \big/ (1+E)^{t_2 - 1}, \quad A_2 = f(R_{p+nc}) = (R_e - R_c). \tag{2}$$

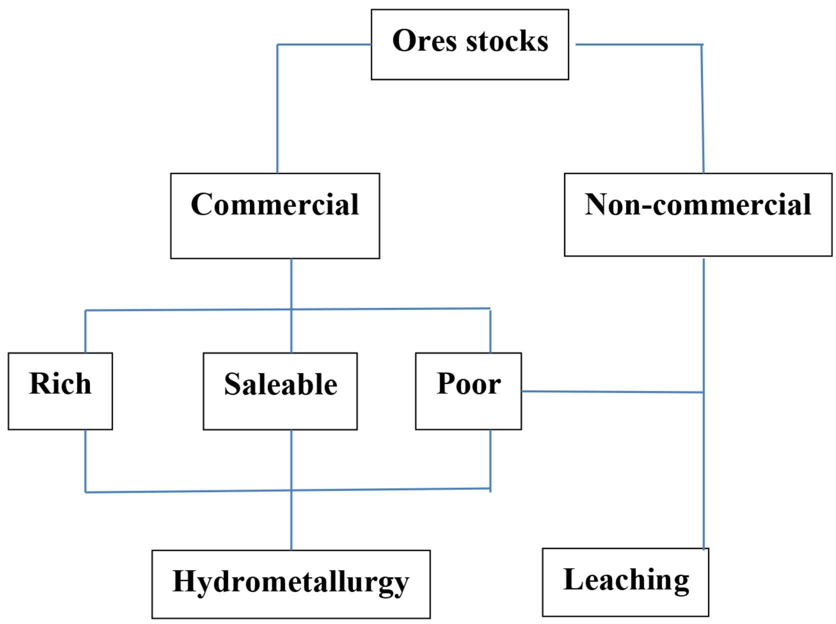

Figure 1. The scheme of technologies combining

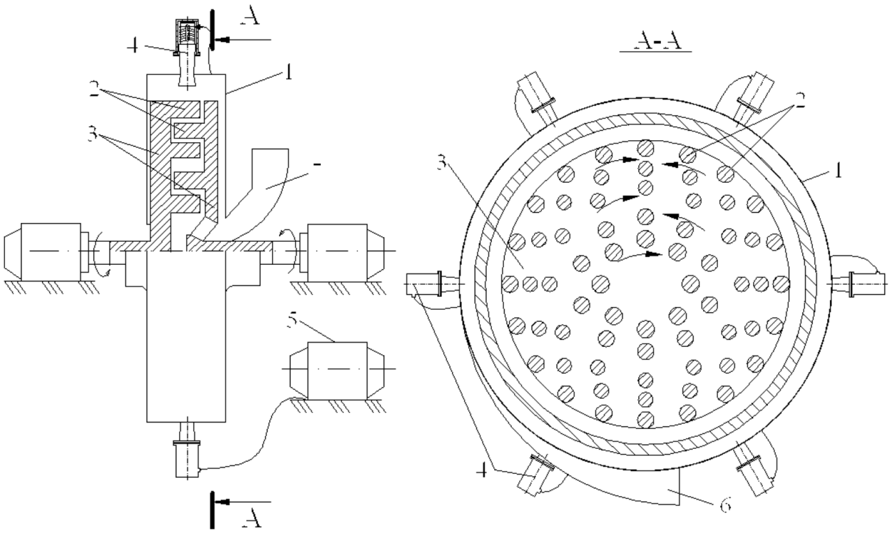

Figure 2. The scheme of disintegrator: 1 – housing; 2 – pins; 3 – discs 4 – nozzles; 5 – pump, 6 – discharge; 7 – feeding cone

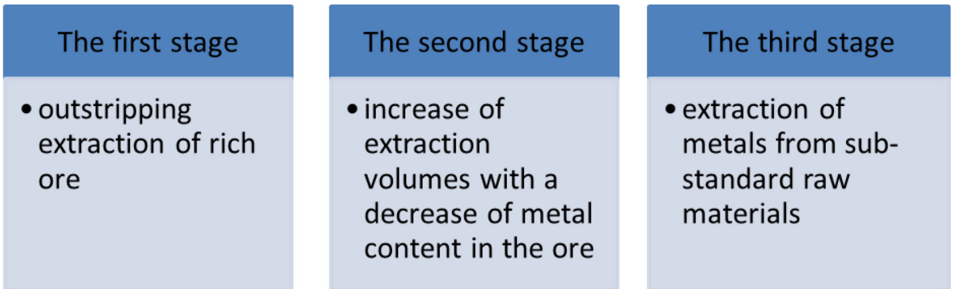

Figure 3. The stages of ore fields development

The effectiveness of ore field development at the third stage

$$\sum_{1}^{t} \Pi_3 = \frac{1}{(1+E)^{\Delta t}} \sum_{1}^{t_3} A_3 (B_3 - c_3) \big/ (1+E)^{t_3 - 1}, \qquad (3)$$

$$A_3 = f(R_{nc+t}) = (R_e - R_c),$$

where R_{nc+t} – are the non-commercial ores reserves and beneficiation tailings.

The sale of goods from waste cheapens the main production: metals and non-metals in the form of salts and oxides; secondary tails with the ingredients content below the MRL; desalinated water for heating, cooling, systems etc.; gaseous products: chlorine, hydrogen and oxygen.

Efficiency of non-waste natural and man-made resources usage in the region compared to the baseline option [7]

$$\sum_{t=1}^{t_c+t_p} \Pi_{prt} = \sum_{t=1}^{t_p} \Pi_{prt} \frac{1}{(1+E_{ir})} - \sum_{t=1}^{t_c} K_{ct} (1+E_{ir}), \qquad (4)$$

$$\text{for } \Pi_{prt} = A_t \left(C_{p_t} - V_{p_t} \right),$$

where Π_{prt} – is the income for the relative year; t_c and t_p – is the time for production modernization before the start of production granting, years; K_{ct} – is the costs for the modernization in t-th year, UAH.; A_t – is the enterprise production capacity with the modernized technology version in t-th year, t/year; E_{ir} – is the coefficient, which considering the interest rate on a credit for performing the preparatory works in t-th year, fr.unit; C_p – is the production costs in t-th year, UAH/t; V_p – is the production value in t-th year, UAH/t;

Resource efficiency (D) increases by the value of use of substandard raw materials, which involved in the production [8]:

$$D = \sum_{1}^{n} Q_i B_i = Q_P (C_p -) - V_p Q_l B_l - Q_r B_r - Q_w B_w , \qquad (5)$$

where Q_i – is the value of the i-th resource extracted or lost during processing; Q_p – is the reserves of raw materials, units; n – is the amount of resources; B_i – is the unit value of the i-th resource, UAH/unit; Q_l, Q_r, Q_w – are the resources of lands, rocks and water, which disturbed by enterprise; C_p – is the production costs, UAH/t; V_p – is the production value, UAH/t;

Profit from disposal of ore processing tailings considering prevented environmental damage

$$\Pi_x = \frac{\sum_{1}^{n_0}\left(C_{T.O} - Z_{O.O} - Z_{O.M.}\right)}{t_0} + C_p^0 + \frac{\sum_{1}^{n_M}\left(C_{T.M} - Z_{O.M} - Z_{M.M.}\right)}{t_M} + C_p^M \quad (6)$$

where $П_x$ – is the profit from tailings recycling, UAH/t; C_{mo} – is the distribution cost of associated products, UAH/t; Z_{oo} – is the cost of tailings processing, UAH/t; $Z_{ом}$ – is the costs for metallurgical repartition of concentrating tailings, UAH/t; n_0 – is the amount of recoverable components from concentrating tailings; Q_0 – mass of concentrating tailings, t; t_0 – is the processing time of concentrating tailings, year; C_p^0 – is the penalties for concentrating tailings storage, UAH/year; $C_{тм}$ – is the products realizable value of metallurgical tailings concentrating, UAH/t; $Z_{ом}$ – is the cost of metallurgical tailings beneficiation, UAH/t; $Z_{мм}$ – is the costs for metallurgy of metallurgical tailings, UAH/t; $n_м$ – is the amount of recoverable components from metallurgical tailings; $Q_м$ – is the mass of metallurgical tailings, t; $t_м$ – is the processing time of metallurgical tailings, years; $C_p^м$ – is the penalties for metallurgical tailings storage, UAH/year.

The effectiveness of the environmental protection is determined by the ratio of technological disasters consequences and the cost of their prevention [7, 9-11,18-20]

$$П_e = \sum_{n=1}^{П}\sum_{p=1}^{P}\sum_{c=1}^{C}\sum_{t=1}^{T}\left[\left(Q_a + Q_h + Q_l\right)\cdot\left(P_z \cdot C_к - P_0 \cdot C_0\right)\right]\cdot K_y \cdot K_П \cdot K_T \cdot K_H, \quad (7)$$

where $П_e$ – is the profit from the use of environmental protection technologies; Σ – is the number of agents of the environmental impact; T – is the time; n – is the number of environmental destruction factors; p – is the number of works on liquidation of disasters consequences; Q_a, Q_h Q_1 – are the amount of pollutants in the atmosphere, hydrosphere and lithosphere; $P_к$ – is the number of works on the compensation of environmental damage; $C_к$ – is the cost of the compensation for damage; P_0 – is the amount of works on environmental protection; C_0 – is the cost of works on environmental protection; K_y – is the gain of the environmental impact; $K_П$ – is the coefficient of pollutants influence on the biosphere; K_T – is the coefficient of prediction accuracy of disaster occurrence; K_H – is a risk quotient of disaster occurrence from the unaccounted factors.

Conclusions

The minerals recyclable by combining technologies form a powerful source of raw materials for the mining industry and related sectors of the economy. Involvement of sub-standard reserves in the production leads to a strengthening of the national resource security of countries, avoiding the dependence from world metal conjuncture. Combining is unused reserve of mining enterprises economic recovery.

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