Metal deposits combined development experience

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Abstract
The environmental humanization trends of mining engineering in technologically advanced countries are defined. The results of pioneer experiments on the extraction of metals using combined mechanochemical treatment in the disintegrator are given. The economic and mathematical models for effectiveness determination of combined technology and simulation of metal extraction results are formulated on a specific example.
Keywords: ENVIRONMENT PROTECTION, MINING TECHNOLOGY, IN-SITU LEACHING, MECHANOCHEMISTRY

Introduction

Mining operations each year violate about 150 thousand hectares of land, about 40% of them - agricultural land. Production of 1 million tons of iron ore violates 650 hectares of land, coal - up to 40 hectares, chemical raw materials - up to 100 hectares, 1 million m^3 of building materials - up to 600 hectares, 1 ton of nonferrous metals accounts at least 100-150 tons of waste during mining and over 50-60 tons during processing. During production of 1 ton of rare, precious and radioactive metals are formed up to 5 - 10 thousand tons of wastes, and during processing 10-100 thousand tons. [1]. The thousands of tons of complex ores are discharged in water. Metal mines form metal scattering halos, according to metal content comparable with the reserves in the bowels [2].Involvement in the exploitation of the poor fields with difficult operating conditions, and the backlog of enrichment opportunities from mining capabilities increases the number of production and processing tailings. The systems of state management of subsoil in developed countries are trying to protect the subsoil from the mismanagement by subsoil users and provide effective development of environmental technologies [3]. The current state of metal production is characterized by the regulations [4]: traditional enrichment processes do not provide full disclosure of minerals and do not decrease hazard of chemical contamination during storage of tailings; combined use of new energy types is promising direction in extraction of metals from tailings. Involving in processing the chemicalization sources of environment ecosystem simultaneously solves two problems of global significance: the hardening of the mineral resource base of mining companies and conservation from degradation unique recreational regions of the Earth.

The peculiarity of the situation is that the non-ferrous ores, precious and rare metals are complex and the use of tailings without extraction of the remaining metals is economically and ecologically incorrect [5]. Another feature is that the base metals such as gold, uranium, copper, zinc and others are easy-open, what increases the possibility of a relatively new leaching technology. In solving the technological and ecological problems the experience of the Russian, Kazakh and Ukrainian miners on production of metals combining traditional and new technologies can be useful [6-8]. With undeniable merits, especially the preservation of the array from the destruction with high-quality of extracted ores, technologies with stowing require the hoisting to the surface for processing not only all ore, but also diluting rocks. The condition for application of these technologies is provision of reacting particles sizes, uniformity of arrays and associated filtration capacity of ores [9-12].

New and traditional mining technologies of balance and off-balance reserves are combined to improve the economic efficiency. Strategy of environmental technologies is based on the following provisions: unreasonableness of technologies is expressed in the loss of natural resources; degradation of ecosystems is the result of unreasonable technologies, so the value of profit from the sale of commercial products must be reduced by the amount of compensation for damage to the environment.

The final aim of environmental protection concept is waste-free mining production with full utilization of the components produced from mined raw materials. It includes: mitigation of ore dilution by rocks when stowing voids by hardening mixtures; maximum use of reserves when leaching poor and low-grade ores; hydrometallurgical processing of ores with extraction of all valuable components.

Disposal of tailing resources is possible only after the extraction of the metals to the level of sanitary requirements. Such requirements are met by the new technology with impact on mineral resources at the same time by mechanical and chemical energy in the activators of disintegrator type [13, 14].

The influence zone height of mining operations on the array is determined by the size and the ratio of the structural rock blocks and stress:

$$h = \frac{l}{V} \qquad (1)$$

where V - is the coefficient of rock stability; l - is arch span, m;

$$V = 2\frac{d_2}{d_1}\frac{R^2_{comp}}{R^1_{comp}} \qquad (2)$$

where d_2, d_1 - are the vertical and horizontal dimensions of rock blocks, m; R^1_{comp}, R^2_{comp} - are the compressive strength of rocks in the direction of arch thrust and in the direction of the rock mass.

An array is safe, while ensuring conditions:

$$H > h = \frac{l}{2V} = \frac{l}{4\frac{d_2}{d_1}\frac{R''_{comp}}{R'_{comp}}} \qquad (3)$$

Dimensions of pillar ensuring its safety within the influence area of voids:

$$b = \frac{l\gamma\left(H - 2/3h\right)}{\sigma_{comp} - \gamma H K_s}, \qquad (4)$$

where b- the width of the pillar, m; l - Maximum arch span, m; γ - bulk weight of rocks; H- the depth of works, m; h - the height of the impact zone of mining operations on the array, m; σ_{comp}- compressive strength of rocks, MPa; K_s- the safety factor.

The arch span of the self-blocking of rocks:

$$l = 2d_1\left(\frac{10R_{comp}}{K_s H_\gamma} l\right) \qquad (5)$$

Wher e l - span of limit self-blocking arch, m; d_1- horizontal size of the structure block of rocks, m; R_{comp}- resistance to compression in the direction of rock weight, kg/cm^2; 10 - conversion factor from kg/cm^2 into ton/m^2; γ - bulk weight of rocks, ton/m^3; H- the depth of the arch foots, m; K- the safety factor.

The effectiveness of deposit development in the first stage [15]:

$$\sum_{1}^{t} P_1 = \sum_{1}^{t_1} A_1(v_1 - c_1)/(1+E)^{t_1-1},$$
$$A_1 = f(R_b) = (R_e - R_{l+o}), \quad (6)$$

where P_1- profit, rubles; A_1 - production capacity of enterprise, tons/year; v_1- enriched ore value, rubles/unit; c_1 - the cost of production and processing, rubles/unit; E - the discount rate, fraction units; R_b - balance ore reserves, tons; R_e - estimated reserves, tons; R_{l+o} reserves of low-grade and off-balance ores.

The effectiveness of field development in the second stage:

$$\sum_{1}^{l} P_2 = \frac{1}{(1+E)^{\Delta t}} \sum_{1}^{t_2} A_2(v_2 - c_2)/(1+E)^{t_2-1}$$
$$A_2 = f(R_{l+0}) = (R_e - R_b), \quad (7)$$

where P_2 - profit, rub; A_2 - production capacity of enterprise, tons/year; v_2- enriched ore value, rub/unit; c_2 – the cost of production and processing, rub/unit; E - the discount rate of costs and profit, fraction units; R_b - balance ore reserves, tons; R_e - estimated reserves, tons; R_{l+o} reserves of low-grade and off-balance ores.

The effectiveness of field development in the third stage:

$$\sum_{1}^{t} P_3 = \frac{1}{(1+E)^{\Delta t}} \sum_{1}^{t_3} A_3(v_3 - c_3)/(1+E)^{t_3-1},$$
$$A_3 = f(R_{o+t}) = (R_e - R_b), \quad (8)$$

where P_3 - profit, rub; A_3 - production capacity of enterprise, tons/year; v_3- enriched ore value, rub/unit; c_3 – the cost of production and processing, rub/unit; E - the discount rate, fraction units; R_b - balance ore reserves, tons; R_e - estimated reserves, tons; R_{o+t} off-balance ores and tailing reserves.

To compare the effectiveness of variants the analysis of production function in the modern models of economic growth for conditions: from raw material in the metallurgical plant will extracted 40% of metal with extraction ratio of 0.93. From 50% of balance reserves that remain for in-situ leaching with extraction ratio of 0.8, and taking into account solution processing losses, 39% of the metal will be obtained. For the content of the metal in off-balance ores 1 gram/ton in the final product 2.3% of the metal will be extracted, and through extraction ratio will be 0.88 [16,17].

Extraction of metals from low-grade ores and tailings using leaching can be implemented at all stages of the deposit development (Fig. 1).

Conclusion

The materials-products of mechanochemical processing that recyclable without sanitation limitations form practically unlimited raw materials source not only for the mining industry, but also for allied industries. Involvement in the production of substandard reserves is strengthening the national resource security of the countries, avoiding dependence on the world market of metals. Combining traditional development technologies with the leaching technologies of metals is unused reserve for economic recovery of mining enterprises.

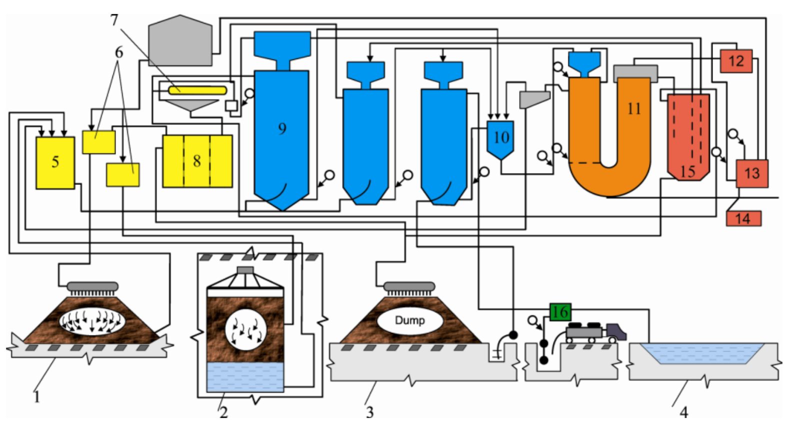

Figure 1. Technology of metals leaching from ores: 1 - heap leaching bing; 2-block of in-situ leaching; 3-dump; 4-pond; 5,6,7,8- storage tanks; 9.10 -technological devices; 11-sorption-desorption column; 12-15- auxiliary equipment

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