Metal extraction in the case of non-waste disposal of enrichment tailings

Vladimir Golik

Professor, D.Sc,
North Caucasus Mining Metallurgical Institute (State Technical University),
Russia

Vitaly Komashchenko

Professor, D.Sc,
Belgorod State National Research University,
Russia

Vladimir Morkun

Professor, Vice-Rector for research, D.Sc,
Kryvyi Rih National University,
Ukraine

Olga Burdzieva

Candidate of Geographical Sciences,
Geophysical Institute of Vladikavkaz Scientific Center of RAS,
Russia

Abstract
New patterns of metal extraction from tailings of non-ferrous and ferrous metallurgy, depending on variable parameters of ore processing were identified. It is proved that mechanochemical activation allows extracting of metals from the tailings to the level of sanitary requirements. An ecological-economic-mathematical model to estimate the recommended technology of metal extraction from processing tailings of non-ferrous and ferrous metals is proposed.
Keywords: LEACHING, DISINTEGRATOR, MECHANOCHEMISTRY, EXTRACTION, TAILINGS, ECOLOGY

Extraction of minerals is characterized by progressive increase in mining operations due to the dynamic development of the needs of the world population. Accumulation of wastes from mining and mineral processing with intensive chemical impact on the environment by toxic components, among which the most dangerous are heavy metals, is the essential consequence of mining production. Disposal of hazardous and at the same time, valuable raw materials with bringing the residual content at least up to the background level can be the radical measure of global hazard reducing. The prevailing concept of waste processing of mineral raw materials comes from the fact that they are unusable and dangerous resources, the use of which can provide ecological and economic benefits. The applied methods of mining and processing of ores are characterized by the loss of the valuable components in the tails in all process stages (Fig. 1). Capabilities of most traditional technologies are limited by using only one mechanical energy. The use of chemical leaching methods with use of chemical energy also raises not much the possibility of extracting metals, requiring a longer time [1]. The practice of extracting metals from tailings is relatively uneventful. In the plant “Electrozinc, North Ossetia” the metals - from clinker or residue after milling me- tallurgical production wastes were removed according to the scheme (Fig. 2). The previous extraction experience of metals from tailings indicates that in this process secondary tailings are formed. The content of hazardous components in these tailings does not allow them to be disposed without limitations [2]

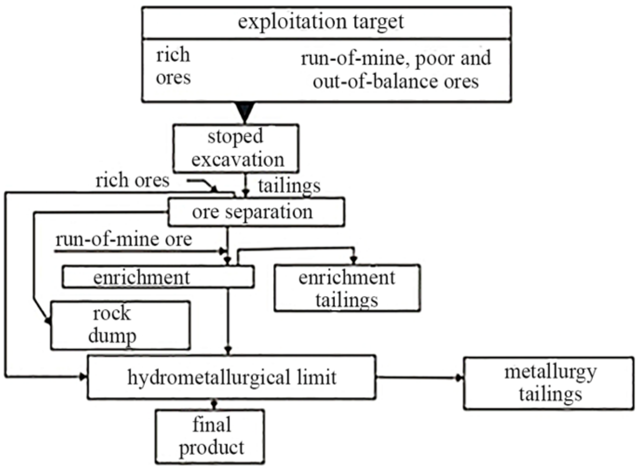

Figure 1. The traditional scheme of mining and processing of metal ores

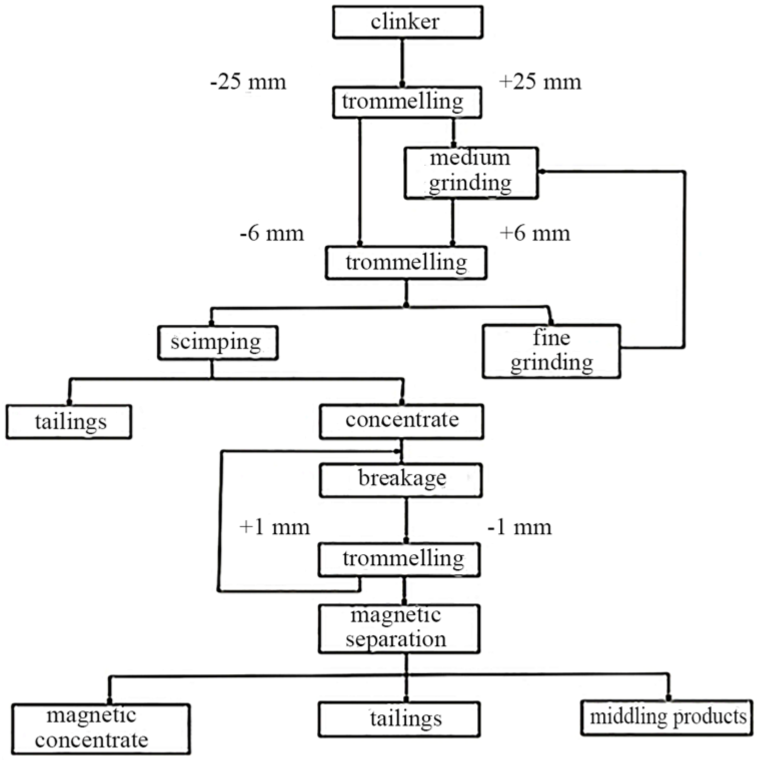

Figure 2. Technological scheme for processing clinker

Currently, humanity is faced with the need to transition from a selective disposal of the most valuable components of the waste to the organization of non-waste use of mineral raw materials. The accumulation of substandard raw metal-emerging materials on the surface is a global problem [3-6]. The new technology is based on the phenomenon of matter activation by high mechanical energy that was investigated in the works of Lenin Prize laureate Johannes Hint [7]. Mechanical activation is increasing of the catalytic properties of matter by grinding in a vibrating mill (R. Shreder), the acceleration of chemical reactions (G. Heineke); increase in strength (I. Hint), etc. Disintegrator in the global mining practice was firstly used on an industrial scale in the field “Shokpak” (North Kazakhstan). [8-10] Disintegrator mount DU-65 was equipped with universal hub, making it possible to use 4- and 3-row rotors and engines of power 200 - 250 kW (Fig. 3).

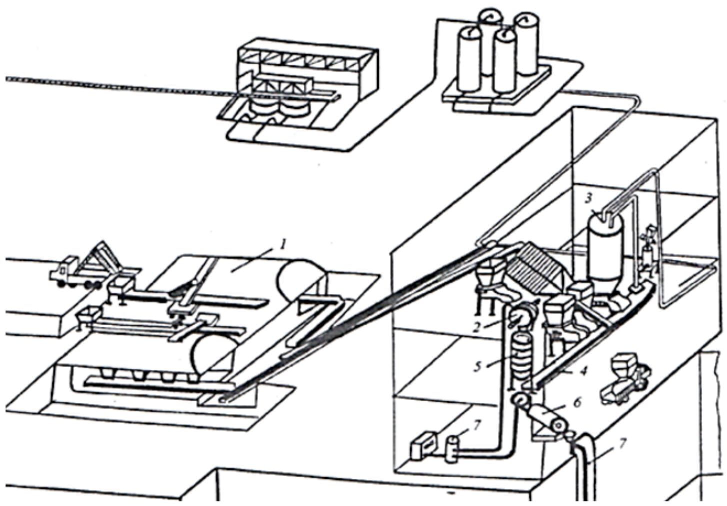

Figure 3. Stowing complex with disintegrator

1 - warehouse of metallurgical slag; 2 - disintegrator; 3 – capacity for cement; 4 - conveyor; 5- vibration mill; 6-mixer; 7-stowing well

Disintegrator was providing up to 55% yield of active class, and in combination with a vibration mill - up to 70%, which allowed activated slag to compete with trademark cement. Mount was located in a separate building with a footprint of 7.5 meters on three levels. The material was delivered to the top mark and passed through the sieve with mesh of 20 mm into the mount. The grinded products from disintegrator were delivered into the hopper - damper and sent into the manufacturing chain. For wet grinding scheme water was filed in disintegrator, and the activation products were fed in a form of slurry. Increment activity effect reached 40% compared with the base case. Later disintegrator is used for combined activation of the process of metals extraction which simultaneously is mechanical and chemical. For this purpose disintegrator chamber is fed by a reagent. The feature of the process is that under the influence of high energy the reagent is pressed into microcracks and extracts metals into the solution almost instantly (Fig. 4) [11, 12].

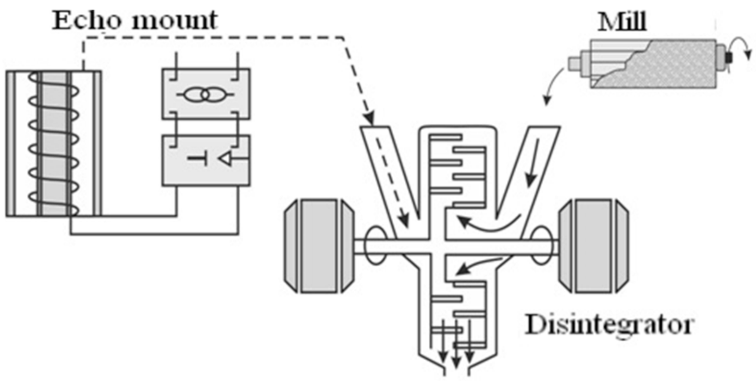

Figure 4. Combined product activation process of electro-chemical processing in a disintegrator

The best degrees of extraction are provided by a multiple leaching in a disintegrator. With the initial iron content in a test sample equal to 8% a single leaching extracts about 1% of iron and after three times passing of tailings through the disintegrator into a solution - 3% of iron. It is possible to reach a safe (of health requirements) level of iron content by the further increase of processing cycles. The content in the secondary tailings does not exceed acceptable values for unrestricted use of material. In both cases a mechanochemical activation in a single treatment increases the extraction of metals into the solution and has a reserve of increase at processing cycles' increase. Ecological effect of tailings utilization is the exclusion of the necessity of their storage on the earth's surface with the land return for economic use [13-14]. Model of tailings usage efficiency is

$$P = \sum_{r=1}^{R}\sum_{o=1}^{O}\sum_{p=1}^{P}\sum_{t=1}^{T}\sum_{f=1}^{F}\sum_{n=1}^{N}\left\{\left(M_{eu}C_{mu} + Q_u C_{qu}\right)\right\} - \sum_{z=1}^{Z}\left[K\left(1+E_{nu}\right)+E_q+E_x\right] -$$

$$-\left[\left(M_e C_m + QC_q\right)+Q_g C_g\right]K_s K_u K_t K_b K_g K_{vr} K_r \to \max$$

where P – the products of tailings utilization; O - tailings types; R - refining processing of tailings; T - processing time; F - phases of the storage existence; N – the stage of tailings use; M_{eu} - the quantity of metals from tailings; C_{mu} - the price of metals; Q_u - the number of reduced effects; C_{qu} - the price of utilized materials; E_q- the coefficient of interest rate on the loan for utilization; E_x - the coefficient of interest rate on loans for the metals' production; E_{nu}- the coefficient of interest rate on environmental restoration; M_e - the number of lost metals; C_m - the price of lost metals; Q - the number of lost effects; C_q - the price of lost valuable components; Q_g - the number of effects of environment destruction; C_g - compensation costs of global destruction factors; K - management costs; K_c - the cost of storage management; K_s - coefficient of self-organization of tailings; K_u - leakage coefficient of leaching products; K_t - range coefficient of solutions leak; K_b - coefficient of influence on the biosphere; K_g - coefficient of pollution impact on neighboring regions; K_{vr} - the coefficient of the implementation of the hazard over time; K_r - coefficient of the risk of the environment from the unrecorded factors.

Mechanochemical activation of ore tailings is a real step towards a complex solution of simultaneously two problems of global importance: metals' providing and waste management [15].

Conclusions

Traditional technologies of enrichment are restricted by the extraction limits the result of which are the tailings the further metal extraction from which is impossible with the help of the known methods. Metals are leached from the tailings of the ores of non-ferrous and ferrous metals at the activation of raw material in the disintegrators. Modernization of traditional enrichment processes can be carried out by usage of combined treatment processes through the usage of activation energy.

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