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DEVELOPMENT OF TECHNOLOGY FOR EXTRACTION OF PRECIOUS METALS FROM COMPLEX ENRICHMENTS OBTAINED FROM IT AND PROCESSING OF DIFFICULT-TO-ENRICH ORES

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Abstract: In connection with the decline in the quality of reserves of many types of mineral wealth, there is a need to develop mining techniques and technologies that allow for effective development of deposits having increasingly hard mining conditions. In the ores of non-ferrous, rare and noble metals, the concentration of ore minerals in small classes of loosened ore mass is often observed. The paper analyzes the nature of the distribution of gold, tungsten, lead and some other useful components in the original ores, and presents methods for the treatment and primary processing of the ore mass with the separation of enriched classes. The use of the mining complex when excavating the rock mass will provide a reduction in the cost price, which will allow the complexstructured areas of the deposits to be involved in the development, composed of low-grade and off-balance ores.

Keywords: mining, selective excavation, enriched classes, ore screening, mining complex, lump separation, batch sorting.

Currently, in the mining industry there is a tendency of reduced quality of reserves of most types of mineral wealth, because previously explored near-surface conditional reserves are almost completely mined out[1]. At the same time, the demand for metals in the world is steadily increasing, so according to, the extraction of metals in the world from 1987 to 2014 increased several times: iron – from 502 to 1,966 million tons, manganese – from 12.5 to 48, 9 million tons, copper – from 6,387 to 18,228 thousand tons, lead – from 2,275 to 5,634 thousand tons. With the development of scientific and technological progress in mining and ore dressing, it became possible to develop deposits that were previously considered unprofitable, which became an important

[1] L.A. Samatova, E.D. Shepeta, Mining Information and Analytical bulletin, 4, 187- 199 (2013)

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factor in the growth of reserves of almost the entire spectrum of minerals. In this connection, there was a decrease in the requirements for the minimal content of the useful component in ore, as well as for the geological and technological characteristics of extracted materials. So the minimal industrial content of metal in ore from 1987 to 2014 decreased significantly: for iron – from 40 to 30%; manganese – from 32 to 22%; copper – from 0.7 to 0.4%; lead – from 1.1 to 0.6%[2].

A feature of non-ferrous, rare and noble metal ores is their concentration in minerals ranging in size from the first micrometers to millimeter values. At the same time, grains of ore minerals in ordinary and poor ores are closely intergrown with brittle vein minerals, therefore, during explosive and mechanical disintegration, the effect of accumulation of valuable components in ore siftings is manifested. Deposits of noble metals are characterized by a wide range of their concentration in small (0.n-n m3) volumes of ore, therefore, for such objects it is advisable to use a combination of highly selective mechanical extraction from the rock ore in natural bedding and large-volume selective extraction after explosive loosening of the rock ore.

Studies on the nature of gold and silver distribution in the lost ore screenings during the underground mining of the Irokinda mine showed that in the –6 mm grades the gold content is 7–29 g/t, silver – 7–44 ppm, and in screened ore size +6 mm gold is less than 3 g/t, silver – 5 g/t[3]. In this case, the layer of enriched ore siftings, accumulating in the clearing space of the mine in cracks and uneven workings, is removed using vacuum installations.

An increased content of the useful component is characteristic for fine fractions of tungsten ores. The study of a technological sample of a lean ore from one of the tungsten deposits of Primorsk Territory showed that with an average content of the useful component in the original rock ore of 0.24%, the content in the -100+50 mm class was 0.18%, in the -50+20 mm class – 0.25%, in the –20+5 mm class – 0.30%, on average for classes –100+5 mm – 0.21%[4]. In screened ore of –5 mm, the metal content was 0.45%, which is 2.2 times higher than the average grade for –100+5 mm. At the underground BomGorkhonsky mine, the average content of tungsten trioxide is 0.65%, and the content of the useful component in the screened ore is on average 1.1%.

Technological samples of the bottom-hole lead-zinc ore of the Uchkulach deposit (Uzbekistan) showed that in the ore delivered from the bottom without reloading, there is a clear tendency to enrichment with lead of fine grades. This allows, directly at the screening stage, to separate the fine class of –25 mm and feed it to the concentrate, as it contains 2-3 times more lead than ores of the +25 mm class[5]. Therefore, one of the most important conditions necessary for the effective use of this technology is to

[2] L.V. Oganesyan, Mineral resources of Russia. Economics and Management, 2, 48-52 (2019)
[3] M. D. Adams, Gold Ore Processing: Project Development and Operations. 2nd ed. (Amsterdam: Elsevier, 2016)
[4] N. N. Hidayah, S. Z. Abidin, Minerals Engineering, 121, 146–157 (2018)
[5] L. Sinclair, J. Thompson, Hydrometallurgy, 157, 306-324 (2015)

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minimize the amount of ore reloading after its extraction from the mine face and before sorting.

Concentration of ore minerals and aggregates containing them in fine classes of disintegrated ore mass is often observed, especially for ores characterized by disseminated and finely disseminated sulfide mineralization associated with quartz. The presence of an increased content of the useful component in screened ore is also typical for some non-metallic minerals. Thus, in the poor apatite-nepheline ores of the Oleniy Ruchei deposit with an average content of the useful component of 5.4%, in the +20 mm grades, the content of phosphorus pentoxide P2O5 was 3.66%, in the ore screening -10 mm – 7.22%[6]. In the ordinary ore of the deposit with an average grade of the useful component in the technological sample of 10.1%, in the grades of +20 mm, the content of the useful component was only 5.48%, and in screened ore with a size of –10 mm, the apatite content was 18.05%.

To increase the productivity of single-bucket excavators, design schemes of mining complexes are proposed that allow converting the cyclic process of scooping up rock mass with a bucket into a continuous process of loading it into a vehicle by means of a conveyor. A common disadvantage of technological schemes with mining and loading into dump trucks of rock mass with single-bucket excavators and mining complexes is that the substandard ore, together with the fine fraction enriched with a useful component, will be delivered to the warehouse of temporarily substandard ore, and in essence, to the dump. The paper proposes a technical and technological solution that provides an increase in the efficiency of a mining and processing enterprise during open-cut mining of deposits, the ores of which, after disintegration, are characterized by the enrichment of small classes, due to the separation of small classes of substandard ore in the mine face directly during mining, its subsequent sorting and processing, and also increasing productivity and expanding functionality of mining equipment.

Based on the data of operational exploration and technological testing, a digital model of the mining block is formed, loaded into the on-board automated control system of the mining complex 1, which carries out selective mining of the rock mass prepared for excavation. Taking into account the position of the contours and zones of localization of technological types of rock mass, the mining complex 1 with working equipment 2 of the hydraulic excavator “front shovel” type is performing extraction. The bucket 3 is unloaded into a rotary conveyor 4, which, by means of blades 5, moves the rock mass to the unloading window 6 and dumps it onto the dump conveyor 7, with which the dump truck is loaded.

When moving substandard ore by the rotary conveyor 4, the ore screening is sieved through vibrating screens 8, collected in the storage 9 and by means of the

[6] H. Jang, E. Topal, Y. Kawamura, Applied Soft Computing Journal, 32, 1-12 (2015)

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pneumatic system 10 is moved into the container 11 of the vehicle. In case of excavation of conditioned ore or waste rock, vibrating gratings 8 are blocked from below with dampers, and the entire volume of rock mass is directed to the unloading window 6. Waste rocks and oversized product of substandard ore are transported by dump trucks, respectively, to the waste rock dump and warehouse of temporarily substandard ore. Conditioned ore is transported to the in-pit crushing and screening plant, where, after crushing by screens, it is divided into size classes with the separation of ore screenings. After that, the grades of conditioned ore are separately fed to the lump separation module, also located in the quarry, with the separation of the pre-enriched product (primary concentrate) and empty inclusions, which will be sent from the open pit to the concentrator and to the waste rock dump, respectively.

CONCLUSION

The proposed technical and technological solution with the use of the mining complex will ensure an increase in the recovery factor of mineral raw stock in the development of complex-structured deposits, the ores of which are characterized by natural enrichment of small classes, due to the separation and subsequent processing of ore screenings of substandard ores, which, using traditional mining technologies, would be delivered to the storage site for temporarily substandard ore. The mining complex, based on the data of the digital model of the production block being developed, provides selective extraction of ores of different conditions. The bucket of the mining complex is unloaded into a rotary conveyor, which moves the rock mass to the dump conveyor, with the help of which the dump truck is loaded, thus, the cyclic process of mining the rock mass is converted into a continuous process of loading the vehicle. The technology provides the formation of different-quality flows of ore mass for separate processing with lump separation and batch sorting to obtain a pre-enriched product. It is advisable to process the obtained ore screenings using the activation leaching technology, which allows the extraction of valuable components at the level of 73-95%, or using flotation after preliminary regrinding of the material. An increase in the productivity of mining the rock mass, as well as its intrapit primary processing, will ensure a decrease in the cost of work, enabling to involve in the development some complex structural sections of deposits, composed of poor and offbalance ores.

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