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The Main Directions of Processing of Mixed Copper Ores

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ABSTRACT

Mixed ores stockpiled in dumps at most copper deposits are the most difficult to process and are characterized by low levels of copper recovery.

In the Zhezkazgan region, one of the typical promising man-made objects, favorable for the speedy involvement in efficient processing, is the dump of stockpiled mixed copper ores from the development of the Taskora deposit. In the dump there are about 2 million tons of oxidized ores of the upper horizon of the deposit mined during stripping operations with an average copper content of 1.01% and copper reserves of 20 thousand tons. The low extraction of copper, which does not exceed 52% during the flotation enrichment of the ore, determined its conditional assignment to off-balance, with a copper content corresponding to the accepted standards.

Introduction

Features of the material composition of off-balance ores, in which ore mineralization is represented by sulfide and oxidized copper minerals in approximately equal amounts, do not allow processing them only by flotation or heap leaching without losing about half of the copper.

Oxidized and mixed ores of the main copper deposits are practically located on the upper horizons. At the initial stages of open-pit mining, such ores are mined in significant quantities during stripping operations and stored in dumps. Such deposits include Zhezgazganskoye, Udokanskoye, Kalmakyrskoye, Boshchekulskoye, Inspiration, Kananea, Anaconda, Katanga, Lakeshore, etc.

Oxidized and mixed ores are enriched much worse than sulfide ones, especially those containing copper in silicate form, and can be processed by flotation, leaching, according to combined schemes that combine enrichment, leaching, pyro- and hydrometallurgy methods. The determining feature of the floatability of ores is the degree of their oxidation, with an increase in which the content of difficult-to-float copper minerals increases: sulfates (brochantite, antlerite, chalcanthite), silicates (chrysocolla) and phosphates (turquoise), as well as the tendency of ores to sludge.

Methods

Flotation is used for non-refractory oxidized and mixed copper ores for efficient separation of sulfide and oxidized minerals from the rock, separation of copper and iron sulfides, additional recovery of precious metals and other valuable components into separate products or concentrates. The difference in the flotation properties of copper sulfides and oxides and the different nature of their intergrowths and dissemination, the tendency of oxidized copper minerals to overgrinding led to the use of separate flotation of sulfide and oxidized copper minerals at processing plants. Collective flotation of copper and iron sulfides is carried out using ethyl (Nchanga), isopropyl (Bancroft, Nchanga deposits), butyl (Kamoto deposit) or amyl (Sakaton, Christmas deposits) xanthates. Moreover, the higher the degree of oxidation of the surface of sulfides and the worse their floatability, the longer the apolar chain of the collector used. Sometimes xanthates are used in combination with dithiophosphate (Sakaton, Nchanga deposits) or with mercaptobenzothiazole derivatives (Christmas deposit). The pH value during bulk flotation should not exceed 8,5 to ensure efficient flotation of copper and iron sulfide into concentrate at low collector flow rates.

To extract copper from the leaching solution, cementation, extraction, sorption, and electrolysis are used. Of the combined methods for processing sulfide-oxidized copper ores, the most widely used is the process developed by V. Ya. iron and cement copper flotation. According to the combined scheme "leaching - cementation - flotation", crushed ore or enrichment products are subjected to leaching with weak solutions of sulfuric acid in vats with mixers. The slurry with dissolved copper first enters the cementing vats, where spongy iron or crushed iron chips are added, and then to the flotation machines.

Results and Discussion

The subsequent separation of valuable components from the obtained collective copper-pyrite concentrates is carried out in a lime medium at a pH higher for the depression of iron sulfides with the highest selectivity of the flotation process. The main industrial copper sulfide minerals - chalcopyrite, bornite and chalcocite - have good flotation properties, and preliminary sulfidization is used to enhance the floatability of oxidized copper minerals. Joint flotation of sulfide and oxidized copper minerals in the presence of a sulfidizing agent during the depression of iron sulfides with lime is carried out only at a low degree of oxidation and a variable content of oxidized copper in the ore, as, for example, at the Almalyk, Balkhash concentrators and at the Markopper factory. Due to the heterogeneity of the material composition of the processed ores, it is necessary to optimize the costs of lime in the range of 500-1500 g/t supplied to grinding, and sodium sulfide in the range of 300-1000 g/t supplied to the grinding cycle or main flotation. There are different modes of flotation of oxidized copper minerals from oxidized ores or from sulfide flotation tailings, depending on the degree of oxidation of copper minerals, the composition of host rocks, and other factors. Flotation of oxidized copper minerals with oxyhydryl collectors is used in the processing of ores with a silicate or clay rock component with a low content of carbonates and iron hydroxides. Fatty acids, their soaps, mixtures of solid and liquid fatty acids are used as oxyhydryl collectors. Flotation using carboxylic acids and other oxyhydryl collectors is generally inexpensive, but does not provide component selectivity: copper concentrates often contain more than 50% rock. In addition, when using modes with oxyhydryl collectors, only malachite is well extracted, cuprite is worse, and chrysocolla and other copper silicates are very bad. The most common method for beneficiation of ores with carbonate or highly ferruginous rock is the flotation of oxidized copper minerals with sulfhydryl collectors after sulfidization. The most common sulfidizers are sodium sulfide, sodium hydrosulfide, or a mixture thereof with sodium sulfide.

The consumption of the sulfidizing agent increases with the increase in the content of copper, sludge, and soluble salts in the ore and ranges from 0.2 to 2 kg/t at different factories. The collector is most often butyl or amyl xanthate, which is fed into the flotation after each loading of the sulfidizer. The collector's consumption is 0.1-0.2 kg/t and increases during the processing of rich and highly slimy ores. The regulation of the sulfidization process can be carried out by the magnitude of the electrochemical potentials of ion-selective and silver sulfide electrodes. The optimal value of the potential of the sulfide electrode during sulfidization and flotation of oxidized copper minerals is in the range of 400-600 mV at pH 9-10. The main losses of oxidized free copper are observed in thin classes, more often during the processing of highly sludge ores, therefore, a scheme with separate flotation of sands and sludge is used at a number of factories (Christmas, Mount Isa). The flotation of oxidized copper minerals with a mixture of sulfhydryl and oxyhydryl collectors after preliminary sulfidization is also used at a number of foreign factories, such as Bancroft, Nchanga, etc. For example, at the Bancroft factory, amyl xanthate and cottonseed oil are used as collectors, which at the same time it is a foaming agent. Sulfidization of sulfide flotation tailings is carried out with sodium hydrosulfide at a flow rate of 0.68-0.9 kg/t.

The resulting oxidized concentrate contains 16.5% copper with a recovery of 33%. The total recovery of copper in sulfide with a copper content of up to 60% and oxidized concentrates is 83%. The Nchanga factory uses a combination of amyl xanthate (35 g/t) and palm oil (40-75 g/t) as a collector, the addition of oil reduces the viscosity of palm oil and, acting as a foam modifier, increases its effectiveness. Sulfidizer - sodium hydrosulfide (1.1-1.3 kg/t) is fed to the beginning of the main flotation cycle. Analysis of the considered methods of flotation enrichment of oxidized and mixed copper ores indicates that they do not provide a high extraction of copper from chrysocolla and other silicates. When enriching ores, in which copper minerals are represented to a large extent by bound copper, flotation with sulfhydryl collectors is promising after the surface of oxidized minerals is reduced to metallic copper (formaldehyde).

Conclusions

In general, schemes and modes of flotation enrichment of oxidized and mixed copper ores can be justified and are used for sufficiently rich ores containing 4-5% copper. At present, there are practically no or very few such ores in promising deposits. For the processing of refractory oxidized and mixed ores, when copper is found in the form of silicates, aluminosilicates, phosphates, in water-soluble forms, as well as sorption associated with iron and manganese hydroxides, if it is impossible to selectively separate rock minerals from copper minerals by flotation, combined schemes with preliminary acid leaching. A large number of options for combined schemes have been developed, when the entire ore or only the most difficult part - middlings, tailings or sludge is subjected to leaching.

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