REPORTS OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
ISSN 2224-5227
Volume 5, Number 309 (2016), 55 – 62

M.Z. Bitimbayev, V.S. Shemyakin, S.V. Skopov

[1]Expert of "Kazakhmys Corporation" LLP, JSC "MMC "Kazakhaltyn"
[2] JSC "Scientific-Production Company "Technogen", Yekaterinburg
mbitimbayev@mail.ru, shemiyakin@mail.ru, sws54@mail.ru

X-RAY RADIOMETRIC ENRICHMENT OF COPPER AND COPPER ZINC ORES OF KAZAKHSTAN

Abstract. The quality of copper and copper-zinc ores in Kazakhstan is deteriorating from year to year. There were studies and pilot-scale tests on the different fields samples conducted in order to assess the fundamental possibility of using the X-ray radiometric separation for pre-enrichment of copper and copper-zinc ores in Kazakhstan. In preliminary studies the optimum material of X-ray tube anode was chosen, boundaries and analytical fields of X-ray characteristic registration of copper, zinc, iron and the scattered X-rays were determined, as well as the optimum of Pi analytical parameter (separation algorithm), which takes into account only copper and scattered radiation intensity values, was installed.

Pilot scale tests of copper and copper-zinc enrichment from different deposits in Kazakhstan were carried out on an industrial X-ray radiometric separator SRF2-300. It was determined that copper zinc ore of the Irtysh deposit and copper ore of the Shatyrkul Sayak deposit, as well as Jaman-Aibat and Zhezkazgan can be recommended for their enrichment on a stage of the raw materials ore preparation by X-ray radiometric separation method. The ores of these deposits have good contrast and good raw material prerequisites for their enrichment in a lumpy condition. X-ray radiometric separation method allows to obtain separation tailings which contains the major valuable components (Cu and Zn) below the cut-off grade. With the purpose to develop technological regulations and to design ore sorting complexes construction the basic technological pre-enrichment scheme has been developed.

Keywords: copper zinc and copper ore, X-ray radiometric separation, preliminary enrichment, X-ray emission spectra, the analytical parameter.

In the Republic of Kazakhstan more than 90 deposits of copper have been explored [1]. Extraction of copper ore in Kazakhstan is carried out by enterprises of LLP "Kazakhmys Corporation", LLP "Kazzinc", Aktobe Copper Company, "Maikainzoloto" and others. The share of the company "Kazakhmys Corporation" is about 85% of its copper in concentrate in Kazakhstan.

The main practical significance on copper and copper-zinc deposits is in sulphide ores. Oxidized ores have a very limited distribution. As a rule, the main ore minerals that compose the primary sulfide ores of copper-zinc deposits such as Irtyshskoe, Kosmurun and Akbastau are pyrite and chalcopyrite. In the upper levels there is sphalerite, galena, faded ore and melnicovite-pyrite. Gangue minerals are quartz, barite, chlorite, sericite and gypsum. Along with copper and zinc there are often in the ores gold, silver, cobalt, selenium, tellurium, molybdenum, and bismuth.

The mineral composition of sulfide ore of copper deposits such as Shatyrkul Sayak, Zhaman-Aibat and Zhezkazgan, is represented by chalcocite, bornite and chalcopyrite, to a lesser extent there are galena and sphalerite. Ore-bearing rocks are composed of assorted sandstones, gravelites, inter- and intraformational conglomerates, siltstones and mudstones. The main rock-forming minerals are chloritized feldspar, conventional feldspar, quartz, calcite, altered tuffs and microfelsites. Dilution of marketable copper or copper-zinc ore varies from 10 to 20%.

The quality of copper and copper-zinc ores in Kazakhstan is deteriorating with each passing year. In particular, the processing involved Zhezkazgansky ore deposits containing copper not more than 0.4-0.5%, which drastically reduces the efficiency of enrichment processes and increases production cost of copper. In this case, it may be the most promising methods of prior enrichment that allow at the initial stages of refining copper and copper-zinc ores to remove a significant amount of diluting breed and to improve the quality of the raw material supplied to the concentrators. One of these methods is the X-ray radiometric separation of rough material.

While the X-ray radiometric separation the analyzed thickness of material depends on the energy of the primary and secondary radiation (but the most by the characteristic X-ray of the analyzed elements) and is from 0.01 to 1.00 mm - only the surface layer works. Surface distribution is significant for minerals formed due to the circulation of ore-bearing solutions in cracks of rocks [2]. Sulfide minerals of copper and copper-zinc ores, mainly, have passed such formation process. These cracks are concentrated minerals, and at the same time, these cracks are the most weakened areas, which occurs when the splitting pillar mining. This feature defines the basic physical and methodical bases of the X-ray radiometric separation, as well as the technology requirements [3].

To assess the fundamental possibility of using the X-ray radiometric separation for pre-enrichment of copper and copper-zinc ores in Kazakhstan there were conducted research, test and pilot tests on samples of different deposits. Total weight of the samples was more than 50 tons. All received technological samples characterize the grade of commercial ores of its deposits. Fineness of initial samples (mostly) is not exceeding 300 mm. Selected material is representative of their fields, both in particle size, and on the chemical and mineralogical composition.

Ore preparation and preliminary studies on the X-ray radiometric separation were carried out under the program [4], which included:

- classification of received samples of copper or a copper-zinc ore by size classes with the release of grain size +300, -300+150, -150+100, -100+50, -50+30 and -30 mm (Fig. 1.);

Initial sample

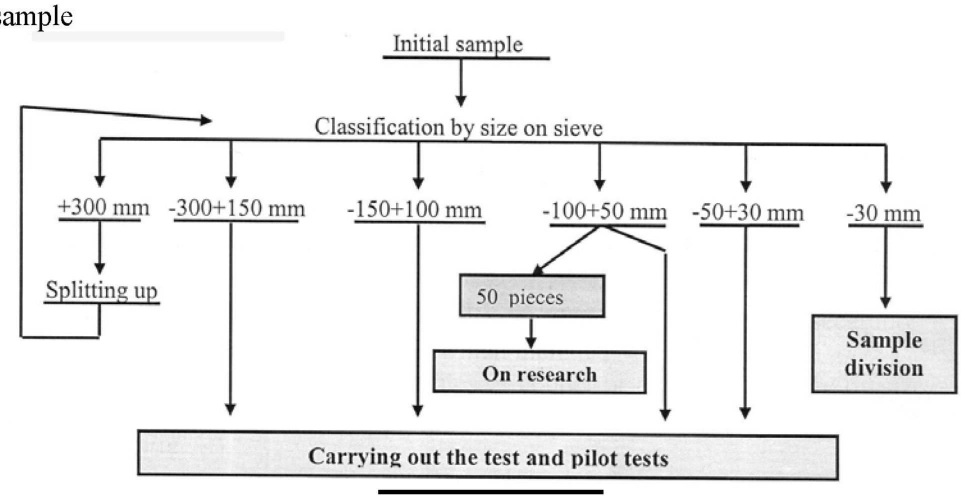

Figure 1 - Scheme of sample ore preparation of the copper or copper-zinc ores

- selection of the most representative samples of up to 50 pieces from engine class of each copper or copper-zinc ore with particle size of -100+50 mm to conduct preliminary studies on the X-ray radiometric separator SRF1-100;

- preliminary studies, including selection of algorithm and analytical areas of registration of the characteristic X-ray of copper, zinc and iron, as well as the scattered X-ray radiation, the definition of the algorithm values for the selected ore samples, the removal of the secondary characteristic spectra from the ore pieces and the determination of other separation parameters in accordance with technique.

The software separator contains two main modes of operation [5]:

- "Analysis" - mode, in which you can make spectra "removal" from samples for a long time 0,1-30,0 sec. without issuing a signal for actuators (verification, research mode);

- «separation" - direct mode of sorting using all the settings of the separator, with issuance signal to the actuators.

In preliminary studies in accordance with the method, the following main parameters of the separator are fitted in the "Analysis" mode:

• set the optimum x-ray tube anode material. Due to the fact that the secondary characteristic X-ray spectra of copper and molybdenum are much closer to each other (in Table of X-ray characteristics of the elements of the Mendeleev Periodic they are numbered 29 and 42 respectively), than the spectra of copper