PRIMARY PROCESSING OF CHROMITE ORES AND ORE-PREPARATION OF WASTES FOR PRODUCTION OF REFRACTORY MATERIALS

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Chromite ore dressing technology is developed to take into account mineralogical, petrographic, and physicochemical features of raw material and its components. A possibility is shown for complex use of mineral resources of chromite deposits by improving the quality of ore-dressing wastes and intermediate products being a raw material for refractories, foundry sand, and antiburning-on paint.

Chromite ore, enclosing rocks, dressing, complex use of resources

At present prospecting and mining operations are carried out in the Sopccheozersk chromite ore deposit in the Murmansk Region. Development of new sources of chromite raw material is an urgent problem of national economy, as 80–90% of need for chromium concentrates and ferrochrome produced from them are satisfied by arrivals. The large-scale technological investigations began in the Mining Institute of the Kola Scientific Center of the Russian Academy of Sciences in 1995. In 2003 the investigations have been successfully completed and resulted in development of chromite ore dressing scheme that took into account the demands made by ferrochrome and refractory production with respect to particle-size distribution, and content of useful components and detrimental impurities in concentrates. Also, regulations should be adopted for designing of a concentrating mill.

Chromite ores of the deposit discussed are represented by chromite-magnesian-silicate ores. The basic minerals of the ore are chromospinelide (5–95%), olivine (5–90%), and rhombic pyroxene (0–15%). In lesser amount are plagioclase, monoclinic pyroxene, and secondary silicate minerals, such as serpentine, chlorite, talc, and amphiboles. Their content is usually no more than 5–10%. Based on the content of the main silicate component, chromite-forsterite and chromite-serpentinite mineral varieties of ore are distinguished. These varieties are present in all natural ore types and in different parts of the deposit under consideration. As a matter of fact, mineral varieties are unchanged or low serpentine-bearing (0–20% of serpentine) and changed (more than 20% of serpentine) kinds of ores. Among the latter ones are such varieties of chrome ores containing some amphiboles, talcs, and phlogopites. They occur mainly in the south-eastern part of the deposit.

Technological investigations into dressing were carried out on samples of mostly wide-spread forsterite-chromite ores from peridotite-plagiopyroxene zone of the north-western part of the deposit.

When selecting a dressing scheme, the most important factor is nonuniform mineralization of bowels. Together with morphology of orebodies, their thickness, character of contacts with enclosing rocks, texture, pre- and post-ore intrusions, etc., mineralization nonuniformity governs nonuniformity of chromospinelide distribution in orebodies, impoverishment, and, at last, degree of contrast of mined-

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out rock mass. Different methods were considered for the preliminary dressing, including heavy-medial separation and radiometric separation. When these methods are applied, physical properties of minerals and physico-technical factors determine correlation between the content of useful mineral component in separate ore lumps and the properties of these lumps (density, color, secondary radiation intensity, etc.). Due to the necessity of ore grading, need for large-lump marketable product, dependence of the efficiency of main processes on the amount and structure of feed, it has become expedient to use lump separation. Owing to the fact that all basic varieties of natural ores (from pure- to thick-impregnated and solid ores) are available in the Sopcheozersk deposit, gravitation methods of ore separation were applied.

The developed two-stage scheme of chromite ore dressing is based on the heavy-medial separation (HMS) and concentration in spiral sigers and on concentrating tables. The method of HMS is the most effective one for preconcentration of chromite ores. First of all, this is governed by the fact that the main minerals of the ores are olivine and chromite that considerably differ in density: $(3.1-3.3) \cdot 10^3$ and $(4.1-4.3) \cdot 10^3$ kg/m$^3$, respectively. Figure 1 presents the scheme that provides for ore crushing up to a size of 100 mm with further separation into three fractions of $+50$, $-50 + 5$, and $-5$ mm in size. The first fraction of $+50$ mm is dressed in drum heavy-medial separator at suspension density of $3.6 \cdot 10^3$ kg/m$^3$ with production of large-lump concentrate. The light fraction is crushed additionally up to $-50$ mm and then joins initial feed.

Fraction of $-50 + 5$ mm in size is dressed in conic heavy-medial separators in two stages. First, dump tailings are obtained at suspension density of $3.1 \cdot 10^3$ kg/m$^3$, and then concentrate and middlings are produced at separation density of $(3.55-3.60) \cdot 10^3$ kg/m$^3$. After the weighting compound washing off, the HMS middlings and size grade of $-5$ mm of initial ore are directed to crushing to $-10$ mm and then to grinding cycle. The close-cycle grinding is conducted in a ball mill with screen up to the size of $-0.3$ (0.2) mm. After dehydration, the product obtained is separated on concentrating tables with middlings repurified in the same devices. In addition to fine-grained concentrate, grainy tailings and slimes are obtained here. As a weighting compound, granular ferrosilicon with a density of $(6.6-7.2) \cdot 10^3$ kg/m$^3$ produced by the “Kuznetsk Ferroslavy” Joint-Stock Company was used.

Pilot testing of the technology developed was performed on a model heavy-medial installation in the Mining Institute, Kola Scientific Center, Russian Academy of Sciences. Volume of ore processed amounted to 4000 t. The chemical composition of the dressing products of commercial tests is presented in Table 1.

For complex development of the deposit, the Institute of Chemistry and Technology of Rare Elements and Mineral Raw Materials has studied preparation of dressing wastes and overburden rocks of the deposit discussed for production of refractories. It was taken into account that ferroalloy production would need a material with lump size of no less than 10 mm, refractory production would demand the lumps of $-3 + 0.5$ and $-3 + 0.0$ mm in size as well as a fine-ground component less than 0.06 mm in size.

The large-lump concentrate may be used to produce chromite, chromite-periclase, and periclase-chromite refractories. The data of the X-ray phase analysis indicate that the dominant mineral in the large-lump concentrate is chromdipicote with presence of serpentine-lisardite as an admixture. Therefore, in order to increase refractoriness of material produced from the concentrate in question, it is required to be added with MgO prior to calcination in the form of metallurgical magnesite or breakage of periclase products.