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IMPROVEMENT OF FLOTATION TECHNOLOGY FOR RE-TREATMENT OF MAGNETITE CONCENTRATES



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At the present time when high-grade iron ore reserves are depleted and the world markets of iron ore materials face high competition, the quality standards for iron concentrates continuously grow. Iron ore producers have to modernize flow charts they use.

This is conditioned by advisable use of rich concentrates both in blast-furnace practices and in steelmaking, and by strict requirements imposed on the contents of iron, silica, toxic admixtures and moisture of the concentrates employed in direct reduction processes. The optimal content of iron and admixtures of concentrate is determined based on the comprehensive economic analysis of smelting and dressing performance indicators in the aggregate.

Currently, the routine method of increasing iron content of magnetite concentrates is their re-grinding and wet-type weak magnetic separation. Though readily available, this method yields minimum increment in iron content, consumes much energy and results in enlarged specific areas of concentrates, which has an adverse effect on moisture content of cake in filtration and pelletizing.

Currently, the most popular way of increasing iron content of magnetite concentrates is re-grinding and wet weak-magnetic field separation. Though readily available, this technology yields minimum increment in iron content, features high energy input and results in enlarged specific surface of concentrates, which has an adverse influence on moisture content of cake in filtration and subsequent pelletizing.

Flotation re-treatment of iron concentrates is technologically the most selective method of mineral processing, since it allows reduction of content of silica, phosphorus and other admixtures, and cardinally solves the problem on production of super concentrates.

At the present time when rich iron ore reserves have been depleted and the world market of iron ore material faces high competition, quality standards for iron concentrates increasingly grow. Iron ore producers have to modernize process flow charts they use.

Within the past ten years, RIVS Science and Production Association has accomplished a wide range of works toward improvement of iron ore processing technology and equipment (Russia, Ukraine, Philippines). The ample research has resulted in development of the technology for re-treatment of iron concentrates.

The paper describes the results obtained in re-treatment of magnetite concentrates by the method of reverse cationic flotation using collecting agents based on amines. High selectivity of the agents eliminates the use of depressors. Flotation uses hard water with partial water rotation. The re-treatment enables production of iron concentrates with the iron content of 69.5% (at the recovery of 94.62%) and silica content of 1.75%.

Key words: magnetite concentrates, aluminum silicate flotation, amines.

Perfection of iron concentrates in flotation is technologically the best selective method, since it allows reduction in content of silica, phosphorus, ash and other admixtures, and in a big way solves the problem of super concentrate production.

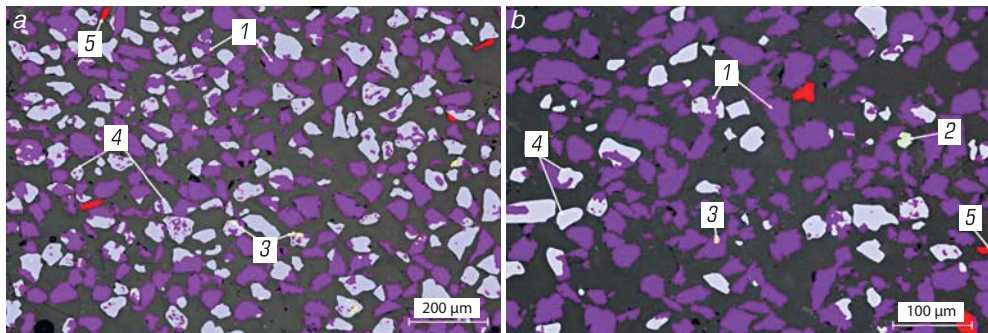


Fig. 1. Magnetite concentrate size -71+45 μm (a) and -45+20 μm (b) obtained from the mixture of ore Lauricocha and Yeristovskoe field. Reflected light, parallel nicols:
1 — magnetite; 2 — hematite; 3 — pyrite; 4 — quartz; 5 — amphiboles

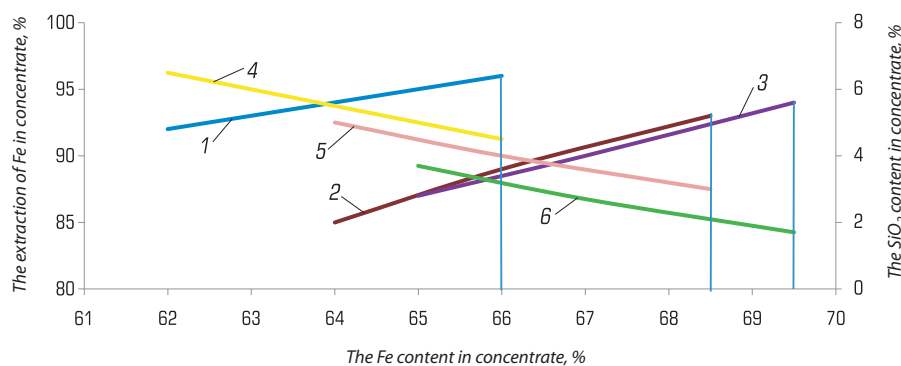


Fig. 2. Technological characteristics the reverse cationic flotation with the perfection of magnetite concentrate:
1, 2, 3 — the extraction of Fe in concentrate when using the collectors A, B, C respectively; 4, 5, 6 — the SiO₂ content in the concentrate when using the collectors A, B, C respectively

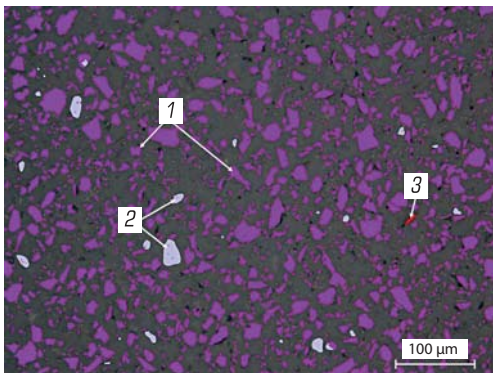


Fig. 3. Magnetite concentrate after finishing. Reflected light, parallel nicols
1 — magnetite; 2 — quartz; 3 — amphiboles

In the past 10 years, RIVS has accomplished a wide range of works toward improvement of iron ore dressing technology and equipment (Russia, Ukraine, Philippines). The effort has resulted in development of the flotation technology for re-beneficiation of iron concentrates.

An important factor of selecting a reagent regime is material constitution of the concentrate. Nonidentity of minerals

composing deposits allows no universal reagent regime for reverse cationic flotation of magnetite concentrates produced from all types of ferruginous quartzites. Especial complexity is caused by amphiboles and pyroxenes that are weakly floatable with the existing reagent regimes.

The analysis of magnetite concentrates produced by Poltava Mining-and-Processing Integrated Works, Ukraine, and sent for flotation re-treatment shows, aside from quartz (present in aggregates mainly), essential amount of aluminum silicates (mica and amphiboles) and carbonates, therefore, production of high quality magnetite concentrates (iron content of 69–70%) at the maximum iron recovery (over 92% after re-treatment) is only possible with new efficient reagent regimes unavailable in the industry.

Base metallic minerals and admixtures were determined from the mineralogical analysis of magnetite concentrate produced by Poltava MPIW (Fig. 1). The base metallic mineral of the technological sample was magnetite in amount of 82.53% actual, pyrite and hematite are less spread and make 0.28% actual Nonmetallics are 17.19% actual in total. Prevailing rock-forming minerals are quartz (10.74% actual), amphibole group minerals (cummingtonite, riebeckite) making 3.10% actual, phyllosilicate minerals (biotite and cololeles mica) in amount of 1.70% actual, and carbonate minerals (siderite, dolomite and, less, calcite) making 1.65% actual; accessory minerals are from group of feldspars.

In development of the high quality magnetite concentrate technology, an emphasis was made on selection of a collecting agent for difficult-to-float amphiboles. Aluminum silicates cannot be floated with primary monoamines, therefore, after research, the collector (a) based on combination of esters of quaternary amines and diamines was used (Fig. 2). This combination of the collectors reduces foam formation.

The base metallic mineral of the concentrate after the flotation re-treatment (Fig. 3) is magnetite in amount of 97.88 actual percentage dissociated by 98.5% relative. It is worthy of noticing that 55.8% of free magnetite grains falls in the size grade smaller than 10 µm. Magnetite in aggregates with non-metals makes only 1.5% relative, and the size of the magnetite grains in the aggregates is not higher than 40 µm. Pyrite in amount of 0.09 actual percentage occurs as individual free grains up to 10 µm in size. Nonmetals making 2.04 actual percentage are present equally as aggregates and free grains. The size of rock-forming minerals is not higher than 40 µm.

After the mineralogical research and technological trials on perfection of magnetite concentrate of Poltava MPIW using the technology developed by IVS company, from the technological sample of difficult-to-process magnetite quartzites from Lavrikovsky and Eristovsky deposits, the concentrate with Fe content of 69.5% at Fe recovery of 94.62% was produced (Table 1). Such performance of the technology was reached due to high extraction of silica — 89.69%. The average silica extraction using other technologies varies from 75 to 80% depending on the complexity of material constitution.

Pulp preparation is never of less importance in iron ore flotation. For Inguletsky MPIW, Ukraine, the flotation re-treatment technology for magnetite concentrate has been developed. The final magnetic concentrate produced from rich difficult-to-process magnetite quartzites after 3 stages of autogenous milling and 3 stages of wet magnetic separation had 92% content of size grade of -44 µm. Stimulation of flotation activity of quartz used mechanical activation equipment manufactured by RIVS. With an attritioning machine employed, higher density adsorption layer was obtained owing to more uniform spread of collector over mineral surface.

The iron content was raised from 60.7% to 69.5%, the iron recovery after the re-treatment circuit was 94%. Silicon oxide content was decreased from 12.2% to 1.7% (Table 2) at its high recovery of 87.52%.

Due to worsened quality of ore and high ecological standards of production processes, requirements to reagent regimes are being strengthened. Aside from improved efficiency of mineral concentration, the requirements include maximized selectivity of mineral separation and minimized range and toxicity of reagents employed.

RIVS has accomplished a range of the related research. Industrial ecological monitoring procedures and environmental measures have been developed as a result.

The lab tests on water phase of tailing slime to determine concentration of flotation reagents used in the RIVS technologies were carried out with the help of various methods: spec-

Table 1. Production data of flotation re-treatment of Poltava MPIW magnetic dressing products using the IVS-developed technology based on laboratory test evidence

Product	Yield, %	Content, %		Recovery, %	
		Fe _{total}	SiO ₂	Fetotal	SiO ₂
Concentrate after re-treatment	82.5	69.5	1.75	94.62	10.31
Re-treatment tailings	17.5	18.64	71.75	5.38	89.69
Initial Fe ₃ O ₄ concentrate	100	60.6	14	100	100

Table 2. Production data of flotation re-treatment of Inguletsky MPIW magnetic dressing products using the IVS-developed technology based on laboratory test evidence

Product	Yield, %	Content, %		Recovery, %	
		Fe _{total}	SiO ₂	Fetotal	SiO ₂
Concentrate after re-treatment	83.41	69.29	1.78	94.75	12.48
Re-treatment tailings	16.59	13.80	74.85	5.25	87.52
Initial Fe ₃ O ₄ concentrate	100	60.75	12.22	100	100

trophotometry (a simple and inexpensive but less selective method) and gas-liquid partition chromatography. From the analysis data, the amount of toxic admixtures in water phase is under maximum allowable concentration, i.e., the used reagents possess high adsorption at solid phase (of the order of 90%).

Since the reagents do not almost adsorb at magnetite, the produced concentrate is well filtered, which has beneficial effect on subsequent balling and pelletizing.

The main factors to govern the preference of the developed technology for re-treatment of magnetite concentrates by the method of reverse cationic flotation are:

- flotation of silicates by a collector based on primary and quaternary monoamines;
- high selectivity and kinetics of flotation;
- no depressor required;
- applicability of hard water;
- ecological safety of the technology under conditions of partial water catch, due to high adsorption of cationic collectors at solid phase. EM

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