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QUALITY IMPROVEMENT OF IRON ORE CONCENTRATES VIA THE METHOD OF BACK CATIONIC FLOTATION



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Technology of treatment of the fine-ingrained magnetite quartzite has been currently formed in CIS. The technology and proper apparatus base permit to obtain magnetite concentrates containing 64–68% of Fe and 5–10% of SiO₂. Magnetic concentration is the basis of the new technology. Studied earlier methods of improvement of quality of the concentrates (fine screening, involving of the elements of the gravitation treatment in the schemes) do not ensure significant increase of content of Fe in the final concentrates. It is stipulated first of all by decrease of quality of initial ore. Content of Fe in processed ores for last 50 years has decreased more than by 30% alongside with increase of volume of mining more than triple [1].

Already for many years iron-ores processing plants in the USA, Canada and European countries use flotation concentration for obtain of the low-siliceous concentrates with high content of Fe.

Improvement of quality of the iron concentrate is necessary first of all for decrease of spending of the metallurgical facility. Today Russian metallurgical combines feel the need in initial raw minerals containing not less than 70% of Fe and not more than 3% of silica. Together with that improvement of quality of the iron-content concentrates does not accompanied by significant economic return for producing enterprises. Quite the contrary, it is connected with increase of the operating and capital costs. At the same time significant economic effect is reached at the metallurgical and others facilities. Surplus of silica in the iron concentrates is especially harmful. It needs addition of great volume of the lime-

stone for slagging of silica. Cost of the coke occupies the special place in the cost of the cast iron. Share of the cost for coke reaches 50%. So, criterion of improvement of quality of the iron-content raw material is the cost of the products in consuming brunches of industry rather than in fabricating ones.

High requirements of the metallurgists to quality are feasible by means of development and introducing into existing technological schemes of processing of the new technical-technological solutions with provision for characteristic of initial raw materials. Coming from chemical composition of the iron-containing minerals, the high-grade concentrate may be obtained only from the magnetite ores.

Magnetite quartzite, processed now at the Russian and Ukraine combines, are characterized by the fine mutual inter-germination of the minerals [1, 2]. That is why the concentrates, obtained by magnetic method and contenting up to 68% of Fe and 5–10% of silica, are characterized by coarseness at the level 80–85% of the class –0.044 mm. The dry magnetic separation of the big pieces of material, fine screening and sedimentation are used in some schemes apart from the wet magnetic separation (WMS).

The researches of finishing of the concentrates of WMS by means of back cationic flotation have been carried out within last five years by the different organizations. The study has been carried out with small difference in time by the engineering center of Inguletsky GOK, Poltavsky GOK, department of processing of Mykhailovsky GOK jointly with the company SRT,

Table 1. Chemical composition of the iron concentrates of WMS

Component	Content, %	
	"Centralny GOK" JSC	"Karelsky okatysh" JSC
Fe _{total}	67.6±0.4	68.2±0.4
Fe _{magn}	61.8	68.0
SiO ₂	5.12±0.14	4.44±0.14
Al ₂ O ₃	0.20±0.02	0.18±0.02
MgO	0.18±0.04	0.12±0.04
CaO	0.32	0.12
TiO ₂	<0.1	<0.1
MnO	0.030±0.003	0.030±0.003
P ₂ O ₅	0.016	<0.05
K ₂ O + Na ₂ O	–	0.21±0.09
S _{total}	0.093	0.43±0.07
Losses under tempering	1.2	0.80±0.04

research center of NPO "RIVS" [3]. In 2004–2008 NPO "RIVS" has worked up technological regulations for construction of the nodes for finishing of the concentrates of WMS at the "Centralny GOK" JSC (Ukraine) and "Karelsky okatysh" JSC (Russia). Productivity of every node is 4 million tons of flotation concentrate per year.

Chemical compositions of the concentrates (table 1) are analogous in many cases. Content of the class –44 μm in the concentrate of the "Centralny GOK" JSC is 86%, in the concentrate of "Karelsky okatysh" JSC — up to 96%. Share of the free magnetite in the class –44 μm exceeds 90% in both concentrates.

More than half of magnetite in the class +44 μm is in the accretions with the minerals of barren rock (fig. 1), mainly with the quartz. It arouses the necessity to use additional comminuting of above mentioned class.

Separating by the grains of 44 μm in the modern classifying devices (hydrocyclones, screens) may be carried out with efficiency 40–60%. So, separation of the accretions from the opened particles by means of

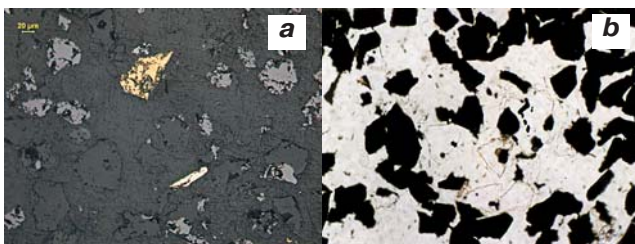


Fig. 1. Concentrate of the wet magnetic separation (class +44 μm):
a — "Karelsky okaysh" JSC; b — "Centralny GOK" JSC

mechanical methods, subsequent comminuting and additional treatment in magnetic separators permit to increase significantly mass share of Fe in the concentrate of WMS without reduction of Fe extraction into the final product.

"Centralny GOK" JSC and "Karelsky okatysh" JSC have set the task NPO "RIVS" to increase Fe content in the concentrate up to 70.5% with extraction not less than 95%. Besides, silica content in the concentrate has to be less than 2%.

Method of the back cationic flotation has been chosen as the principal technology. It is the cost-effective method. It is used successfully abroad and is tested at the Russian and Ukrainian combines. Back cationic flotation ensures the highest removing of the minerals of the barren rocks out from initial product with minimum consumption of cationic collector and with small flotation period amongst the all known methods. Modified amines, presented by primary amines, diamines and their compounds, are used widely now as collectors of the barren rocks.

The schemes of finishing of the WMS concentrates by the back cationic flotation are very simple. They consist as a rule the principal and finishing operations (fig. 2). The foamy product is sent to the finishing cycle. The last one foresees the operations of re-cleaning and control flotation in some cases. WMS is used at the some factories as additional finishing operation.

The cationic collectors foreign production have been tested in the laboratory by technological group of NPO "RIVS" on the samples of the concentrates of "Centralny GOK" JSC and "Karelsky okatysh" JSC.

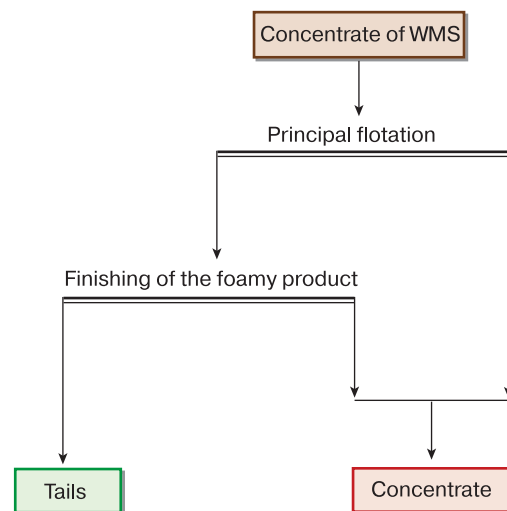


Fig. 2. Principal technological scheme of flotation finishing of the concentrate of WMS

Table 2. Results of the laboratory tests for finishing of the Fe concentrates

Products	Output, %	Content, %		Extraction, %	
		Fe	SiO ₂	Fe	SiO ₂
<i>Concentrate of "Centralny GOK" JSC</i>					
Chamber 1 (concentrate 1)	82.9	70.2	1.29	85.8	15.7
Chamber 2 (concentrate 2)	9.2	69.3	6.94	9.4	9.4
Total chamber	92.1	70.19	1.85	95.3	25.1
Foamy (tails)	7.9	39.9	64.5	4.7	74.9
Concentrate of WMS	100	67.8	6.8	100	100
<i>Concentrate of "Karelsky okatysh" JSC</i>					
Chamber 1 (concentrate 1)	80.82	71.23	1.09	84.52	19.1
Chamber 2 (concentrate 2)	12.7	66.24	2.71	12.35	7.48
Total chamber	93.52	70.56	1.31	96.87	26.58
Foamy (tails)	6.48	32.9	52.24	3.13	73.42
Concentrate of WMS	100	68.12	4.61	100	100

The collectors of the firm Clariant have demonstrated the best results both by content of Fe and silica in the concentrate and by extraction of Fe into concentrate. It has been recommended to use the foam generator and modifiers for improvement of parameters of flotation. The results of the laboratory study, carried out by the scheme, shown at the fig. 2, are given at the table 2.

Parameters, obtained in the laboratory conditions, were the basis for fulfillment of the semi-industrial tests. In the course of the last ones it has been obtained the concentrate containing 70.5% of Fe and 1.8% of SiO₂ with Fe extraction — 95.8%. The above mentioned concentrate has been obtained from the sample of the concentrate of "Centralny GOK" JSC containing 67.6% of Fe and 6.78% of SiO₂.

Besides, it has been obtained the high-grade concentrate from the sample of the concentrate of WMS of "Karelsky okatysh" JSC, containing 68% of Fe and 5.12% of SiO₂. The final high-grade concentrate contents 70.88% of Fe and 1.17% of SiO₂, Fe extraction — 97.06%. Chemical composition of flotation concentrate is given in the table 3. The results achieved in the course of testing completely correspond to the technical requirements of the customer.

Semi-industrial tests have been carried out in conditions of total water circulation. It has permitted to decrease 2–4 times consumption of the reactants in comparison with the laboratory tests owing to presence of the reactants in the circulating water (table 4).

In accordance with recommended technological scheme the tails of flotation treatment have to be joined with the tails of WMS and send to the tail-depot. It will

permit to decrease significantly remaining concentration of collector in the liquid phase of the joined product incoming to the tail-depot, owing to sorption on the solid phase of the tails of WMS. Ratio of volumes of the tails pulp of magnetic and flotation treatment in this case will be: for "Centralny GOK" JSC — 25:1; for "Karelsky okatysh" JSC — 82:1. It will ensure reducing of collector concentration in the liquid phase of the tails to the level lower than LPC (Limit Permissible Concentration) (fig. 3).

Now NPO "RIVS" works up the project of the node of flotation finishing of the magnetite concentrate of "Karelsky okatysh" JSC. Productivity of the node will be 4 million tons per year, with possibility of increase of the last one up to 8 million tons. It is going to begin construction of the first turn of the object in 2009. Pneumatic flotation machines RIF with great volume have been chosen as the principal flotation equipment. The project

Table 3. Chemical composition of the concentrates after flotation finishing

Component	Content, %	
	"Centralny GOK" JSC	"Karelsky okatysh" JSC
Fe _{total}	70.5	70.88
Fe _{magn}	69.2	69.85
SiO ₂	1.8	1.17
Al ₂ O ₃	0.09	0.09
MgO	0.063	0.05
CaO	0.055	0.03
MnO	0.056	0.03
P ₂ O ₅	0.002	0.01
K ₂ O + Na ₂ O	0.017	0.05
S _{total}	0.027	0.2

Table 4. Reactants consumption at the different stages of study

Concentrate of WMS	Reactant	Consumption, g/t of the concentrate	
		Laboratory study	Semi-industrial tests
"Centralny GOK" JSC	Collector	120	35
	Foam generator	20	10
"Karelsky okatysh" JSC	Collector	100	25
	Foam generator	20	10

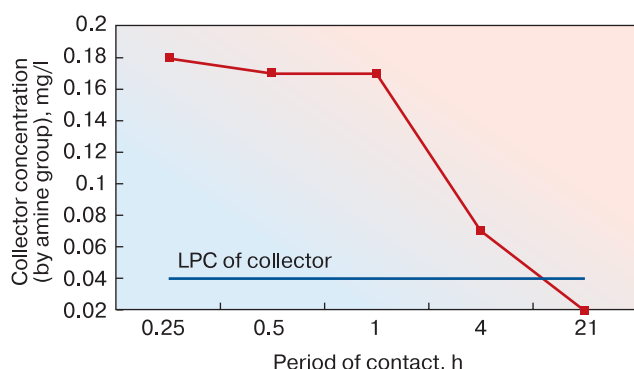


Fig. 3. Change of the collector concentration in the liquid phase after mixing of the tails of WMS and flotation in ratio 82:1

foresees the partial water circulation. It will permit to supply the section of flotation finishing with the own circulating water.

Flotation machines RIF have been put into practice for the first time in the iron-ore industry in industrial scale in 2003 at the ROF (Concentrating Factory) № 1 of Inguletsky GOK within the bounds of construction of flotation section for finishing of the magnetite concentrate (fig. 4). Productivity of the section is 4 million tons per year.

On the base of results of industrial development of the new technology and equipment at the Inguletsky GOK administration of the combine has decided to begin mounting of the second turn of the node of finishing with installation of the RIF equipment. Annual productivity of the node is 4 million tons of the concentrate.

Working up of the method of decrease of content of the harmful admixtures (S, K₂O, Na₂O and so on) is the perspective direction of improvement of quality of the



Fig. 4. Flotation machines RIF at the Inguletsky GOK

concentrates of magnetic separation. NPO "RIVS" has studied and worked up technology permitting to decrease of sulfur content in the concentrate of WMS more than four times.

Conclusion

Worked up technology of the back cationic flotation ensures obtain of the concentrate containing not less than 70.5% of Fe and not more than 1.2% of silica.

Operational extraction of Fe into the concentrate of flotation finishing is not less than 95.8–97%.

Organization of the partial water circulation permits to decrease four times consumption of the collector and to provide completely need for circulating water of the node of flotation finishing.

Aside from silica it is decreased content of sulfur and others harmful admixtures in the concentrate of flotation finishing.

Literature

1. Железорудная база России / Под ред. В. П. Орлова, М. И. Веригина, Н. И. Голивкина. — М. : ЗАО «Геоинформ-марк», 1998.
2. Чантурия В. А., Дмитриева Г. М., Трофимова Э. А. Интенсификация обогащения железных руд сложного вещественного состава. — М. : Наука, 1988.
3. Авдохин В. М., Губин С. Л. Современное состояние и основные направления развития процессов глубокого обогащения железных руд // Горный журнал. — 2007. — № 2.