ISBN : 81-87053-53-4
Processing of Fines (2)
Eds. : P. Bhattacharyya, R. Singh and N. G. Goswami

Use of organic depressors for selective flotation of copper-nickel and polymetallic ores

M. I. MANTSEVICH and I. I. KHERSONSKAYA
State Research Institute for Non-ferrous Metals "Gintsvetmet" Moscow, Russia

ABSTRACT

An analysis of experimental data and research in the field of non-ferrous ore beneficiation indicates that the conventional processing technologies currently in use have been developed for readily upgradable ores and do not ensure high performance values when treating refractory complex ores. Treatment of such ores results in production of low-grade selective concentrates and creates serious problems relating to their further metallurgical processing, resulting in high losses and additional expenses for detoxification of waste materials generated. One of the most promising approaches for solution of the problems relating to treatment of such types of ores is development of innovative reagents.

A series of processing technologies have been developed in the Gintsvetmet Institute for selective flotation of copper-nickel, polymetallic and copper-zinc ores. They are based on the use of low-molecular weight organic depressors ensuring efficient adjustment of selective separation of non-ferrous minerals and iron sulfides. In the process of copper-nickel ore flotation, efficient depression of pyrrhotite is ensured resulting in better nickel and precious metals recoveries into nickel concentrate with simultaneous improvement of concentrate grades.

In the process of polymetallic ore flotation (including oxide ores) the use of organic depressors results in an improvement of silver recovery into lead concentrate by about 5-8%. The use of organic depressor for selective flotation of copper-zinc ores reduces the loss of zinc with copper concentrate. The results of the research conducted have been extensively used at a number of mines in Russia.

Key words : *Polymetallic ore, Flotation, Reagents, Concentrate, Recovery.*

INTRODUCTION

A flow-sheet for processing copper-nickel ores normally includes upgrading operations to produce copper, nickel and pyrrhotite concentrates and discard tailings. Copper and nickel concentrates are further subjected to pyrometallurgical processing, while pyrrhotite concentrate undergoes additional treatment and is stockpiled[1].

The main mineral contaminating both copper and nickel concentrates is pyrrhotite. Copper concentrate containing about 24-26% copper contains about 18 to 26% pyrrhotite, while nickel concentrate with about 7-8% Ni contains as much as 60-65% pyrrhotite; the nickel content of pyrrhotite is only 0.6-0.8%. When most of pyrrhotite in ore is non-magnetic, its removal into a separate intermediate product is possible only by means of flotation and is dependent on the efficiency of selected flotation conditions and first of all on the reagent addition conditions. Unfortunately, all traditional methods used for separation of nickel minerals and pyrrhotite involving depression of the latter by aeration conditioning and use of lime result in lower pentlandite recoveries into nickel concentrate.

The use of additional technological operations involving combined processes complicates the overall processing technology and increases the costs incurred. For this reason, it is desirable to subject only a minimum amount of valuable constituents to an additional combined treatment, while separating the bulk of valuable metals into respective selective concentrates. In this connection, the flotation conditions must ensure maximum recovery of main minerals into selective concentrates and leave in an intermediate product only refractory minerals which adversely affect the grades of concentrates produced.

Polymetallic ores containing both sulfide and oxide minerals of copper, lead, zinc and iron belong to so called refractory ores. Selective flotation of such ores is in general carried out using selective reagents adjusting the flotation conditions, including reagents such as sodium sulfide aimed at sulfidizing oxide minerals and reagents, such as cyanides of alkali metals to ensure depression of flotation of copper, zinc and iron flotation. The use of such reagents, especially cyanides, has a negative effect on the recovery of precious metals as by-product of flotation, and precious metals play a significant role in the economics of ore beneficiation processes. Furthermore, cyanides used worldwide as an effective regulator of selective flotation of sulfide minerals pose a threat for the ambient environment. Cyanide is a highly toxic substance requiring extraordinary safety measures.

The difficulty relating to the search for efficient substitutes for cyanide is attributed to the multifunctional character of its action. In addition, cyanide is a depressor for iron sulfides and inhibits flotation of sphalerite; at higher addition rates it is used for separation of copper-lead concentrate.

Another example of ores with a complex composition is refractory copper-zinc ores. Currently, their processing has low performance values and the use of new efficient reagents could substantially improve the situation. The degree of integrated utilization of such ores remains low[2].

EXPERIMENTAL PROCEDURE

A flow-sheet for processing high-grade copper-nickel ores is shown in Fig.1. The tests of reagents on copper-nickel ores were performed based on the flow-sheet and reagent conditions used for these ores on commercial scale, and namely: grinding to 85-87% -0.044 μm fraction; aeration time prior to copper flotation 20 min; copper flotation retention time 15 min; re-cleaner flotation of copper concentrate 8 min; pH 7.5-8. Nickel and pyrrhotite flotation was conducted during 12 and 20 minutes, respectively. The following reagents were used: for copper flotation butyl Aeroflot reagent was added (15 g/t); for nickel flotation, lime was added to nickel flotation to adjust the pH value of 10.5, as well as butyl xanthate as depressor (50 g/t) and frother (20 g/t); and for pyrrhotite flotation butyl xanthate (180 g/t) and frother (40 g/t) were added, and the pH was adjusted at a level of pH = 9. The performance values of the process during the tests of various depressors in nickel and pyrrhotite flotation circuits are presented in Table 1.

The use of D-1 reagent in the nickel-pyrrhotite flotation circuit sharply im-

Table 1: Results of nickel-pyrrhotite separation

Depressor		Product	Yield, (%)	Content, %			Recovery, %		
Ni flotation	Pyrrhotite flotaion			Ni	Cu	S	Ni	Cu	S
Without depressor		Ni concentrate	35.1	6.8	1.93	33.2	70.3	68.7	48.8
		Pyrrhotite conc.	39.5	2.3	0.98	27.7	26.9	26.1	45.8
		Tailings	25.4	0.38	0.3	5.1	2.8	5.2	5.4
		Feed	100	3.39	1.48	23.9	100	100	100
K-1	K-1	Ni concentrate	16.4	13.4	2.6	32.4	66.4	46.2	26.5
		Pyrrhotite conc.	19.7	3.8	1.5	30.4	22.6	32.2	27.5
		Tailings	63.9	0.57	0.31	15.7	11.0	21.6	46.0
		Feed	100	3.31	0.92	21.8	100	100	100
D-1	D-1	Ni concentrate	16.4	14.8	2.6	32.0	73.0	51.6	24.9
		Pyrrhotite conc.	10.1	5.35	1.7	30.4	16.4	20.6	14.7
		Tailings	73.5	0.48	0.3	17.3	10.6	27.8	60.4
		Feed	100	3.32	0.8	21.3	100	100	100

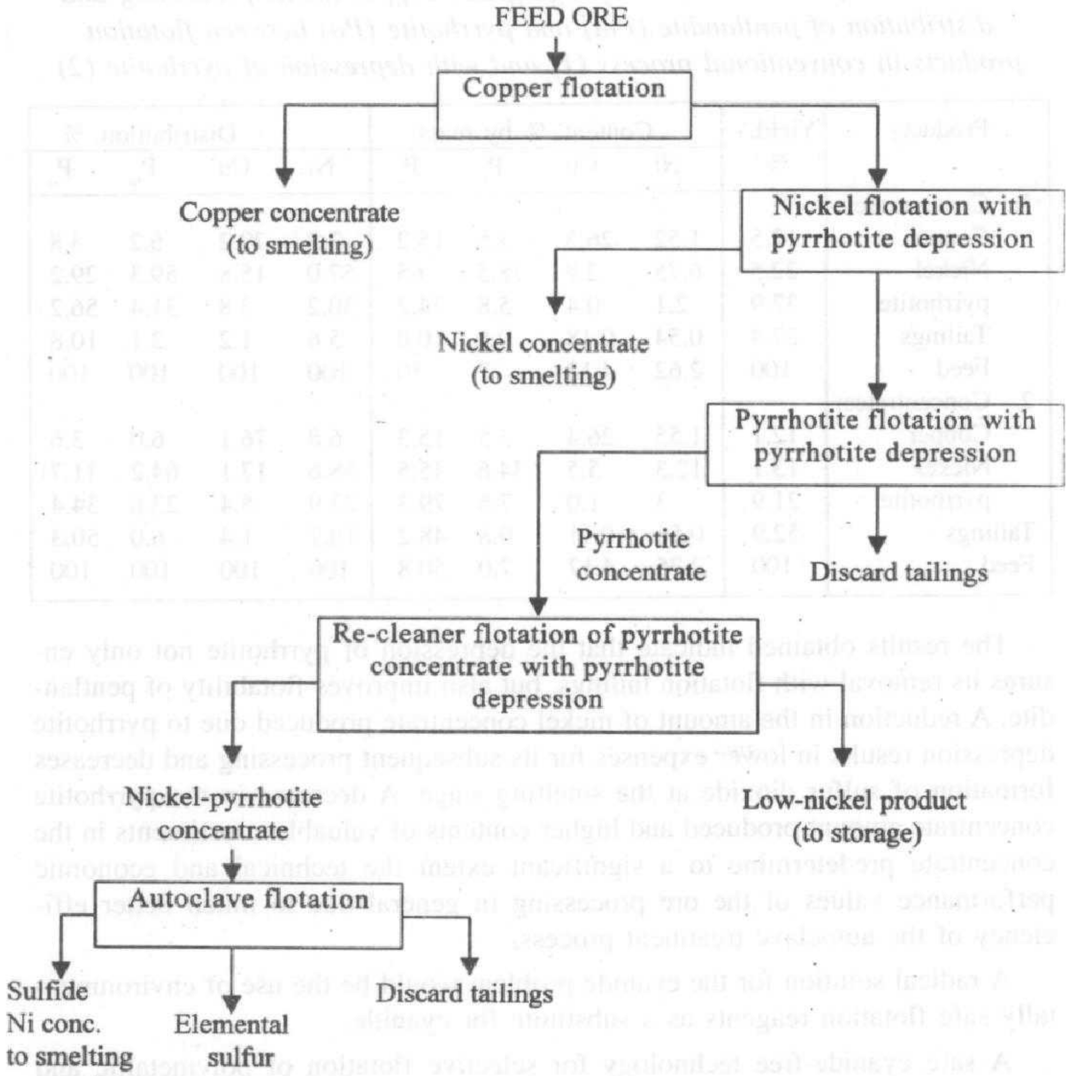

Fig. 1 : Basic flow-sheet for copper-nickel ore processing

proved the selectivity of the flotation process. The grade of nickel concentrate increased up to 14.8% as compared with 13.4% with K-1 without the use of these reagents with simultaneous improvement in the nickel recoveries by 6.6% and 2.7%, respectively. Sulfur recovery into tailings was as high as 60.4% which significantly improves the subsequent metallurgical processes and ensures a reduction in sulfur dioxide emissions into the ambient air. The flotation results using D-1 reagent attained in the process of full-scale operation are given in Table 2.

Table 2 : Performance values of high-grade copper-nickel processing and distribution of pentlandite (Pnt) and pyrrhotite (Po) between flotation products in conventional process (1) and with depression of pyrrhotite (2)

Products	Yield, %	Content, % by mass				Distribution, %			
		Ni	Cu	P_{nt}	P_o	Ni	Cu	P_{nt}	P_o
1. Concentrates:									
Copper	12.5	1.52	26.3	3.5	15.2	7.2	79.2	6.2	3.8
Nickel	22.5	6.75	2.9	18.5	65	57.0	15.8	59.3	29.2
pyrrhotite	37.9	2.1	0.4	5.8	74.2	30.2	3.8	31.4	56.2
Tailings	27.4	0.54	0.18	0.6	10.0	5.6	1.2	2.1	10.8
Feed	100	2.62	4.13	7	50	100	100	100	100
2. Concentrates:									
Copper	12.1	1.55	26.4	3.5	15.3	6.8	76.1	6.0	3.6
Nickel	13.1	12.3	5.5	34.6	45.5	58.6	17.1	64.2	11.7
pyrrhotite	21.9	3	1.0	7.6	79.3	23.9	5.4	23.8	34.4
Tailings	52.9	0.56	0.11	0.8	48.2	10.7	1.4	6.0	50.3
Feed	100	2.75	4.17	7.0	50.8	100	100	100	100

The results obtained indicate that the depression of pyrrhotite not only ensures its removal with flotation tailings, but also improves flotability of pentlandite. A reduction in the amount of nickel concentrate produced due to pyrrhotite depression results in lower expenses for its subsequent processing and decreases formation of sulfur dioxide at the smelting stage. A decrease in the pyrrhotite concentrate amount produced and higher contents of valuable constituents in the concentrate predetermine to a significant extent the technical and economic performance values of the ore processing in general due to much better efficiency of the autoclave treatment process.

A radical solution for the cyanide problem would be the use of environmentally safe flotation reagents as a substitute for cyanide.

A safe cyanide-free technology for selective flotation of polymetallic and copper-zinc ores has been developed in the Gintsvetmet Institute. Along with replacement of cyanide with a low-molecular organic depressor, this technology ensures improved grades of selective concentrates and higher recoveries of non-ferrous and precious metals. The non-ferrous and precious metals recoveries into concentrates improve by 3-6% and 5-15%, respectively. The proposed technology does not require any additional capital investments and can be implemented using the existing equipment. The consumption of the proposed reagent is lower by about 50% than that of cyanide. Its cost is $2,000 per tonne.

The technology has been proven at a number of Russian concentrators and introduced on a full commercial scale at the Dalpolymetall Mine (Far East of Russia).

Table 3 provides comparative results of flotation of lead-zinc ores using cyanide and D-1 reagent, a selective depressor for sphalerite.

Table 3 : Results of flotation tests

Test conditions	Products	Yield, %	Contents, %, g/t			Recovery, %		
			Pb	Zn	Ag	Pb	Zn	Ag
Conventional conditions (using cyanide)	Pb conc.	1.08	46.2	8.0	1950	40.9	0.7	44.2
	Zn conc.	19.64	0.65	55.6	40.5	10.5	88.2	16.7
	Tailings	79.28	0.75	1.73	23.5	48.6	11.1	39.1
	Feed ore	100	1.22	12.38	47.7	100	100	100
Use of D-1 reagent	Pb conc.	1.40	44.8	4.4	1770	52.3	0.5	52.5
	Zn conc.	19.60	0.53	55.9	31.8	8.7	88.3	13.2
	Tailings	79.0	0.59	1.76	20.5	39.0	11.2	34.3
	Feed ore	100	1.20	12.41	47.2	100	100	100

Results of comparative flotation tests of the traditional flotation conditions commonly used at concentrators in Russia for flotation of copper-zinc ores using sodium sulfide and zinc sulfate and the new flotation conditions using the D-1 depressor are presented in Table 4.

Table 4 : Results of comparative tests of conventional and new (using D-1 reagent) flotation conditions for direct selective flotation of copper-zinc ores

Test conditions	Products	Yield, %	Content, %, g/t				Recovery, %			
			Cu	Zn	Au	Ag	Cu	Zn	Au	Ag
Na_2S+ $ZnSO_4$	Cu conc.	19.49	21.3	3.15	10.7	139	89.3	12.7	32.1	52.7
	Zn conc.	7.61	2.95	47.5	8.2	65.0	4.8	75.0	9.6	9.6
	Tailings	72.90	0.38	0.81	5.2	26.6	5.9	12.3	58.3	37.7
	Feed ore	100	4.65	4.82	6.5	51.4	100	100	100	100
DMDC	Cu conc.	19.19	22.0	2.84	14.8	167.0	91.6	11.2	43.7	63.1
	Zn conc.	7.90	2.79	47.9	5.3	44.0	4.8	78.0	6.4	6.8
	Tailings	72.91	0.23	0.72	4.4	21.0	3.6	10.8	49.9	30.1
	Feed ore	100	4.61	4.85	6.5	50.8	100	100	100	100

As can be seen from the above results, the use of D-1 reagent, as compared with he conventional technique, makes it possible not only to improve recoveries of copper and zinc into respective selective concentrates, but also substantially increases the recovery of precious metals into copper concentrate.

CONCLUSION

It can be concluded from the results of studies on the flotation properties of D-1 reagent with respect to sulfide minerals flotation, that co-adsorption of butyl xanthate and DMDC on galena and pentlandite is possible, whereas on sphalerite and pyrrhotite the D-1 reagent displaces butyl xanthate from the surface of minerals and forms water-repellent film. Thus, for lead sulfide and pentlandite, D-1 reagent is an additional collector, while for zinc sulfide and pyrrhotite it serves as depressor[3].

The use of D-1 reagent in nickel and pyrrhotite flotation circuits when treating copper-nickel ores not only results in an improvement of the flotation performance values (recoveries of non-ferrous and precious metals), but also prevents the need for the use of highly toxic cyanide for flotation.

The technology based on the use of D-1 reagent has good prospects for beneficiation of non-ferrous ores, especially at concentrators using currently cyanides. The cyanide-free flotation process has been proven for treatment of lead-zinc ores at the ore processing plant of the Hindustan Zinc Company (India).

REFERENCES

1. Mantsevich M.I. et. al., (1985), "Transactions of XV International Mineral Processing Congress", Cannes, Vol.3, p. 465.
2. Mitrofanov S.I., (1967), "Selective Flotation", Nedra, Moscow, p. 584.
3. Nedosekina T.V. et. al., T(1993), Svetnye Metally, No. 8, p. 13.