2011 2nd International Conference on Chemistry and Chemical Engineering
IPCBEE vol.14 (2011) © (2011) IACSIT Press, Singapore

Examination of Flotation Reagents Suitable for Nickel Concentrator Plant

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Abstract. Examination of flotation reagents suitable for a nickel concentrator plant was investigated using nickel sulphide ore. A number of different new reagents were examined for the best suit for the nickel concentrator plant. It was found that more nickel was found on the magnetic particles, which were assumed to be mostly pyrrhotite. A dosage of 50 g/t was found to be a suitable dose for the collector Betacol 380 AC and gave the best results, however, it was found to be expensive. Betacol 380 AB was found to be suitable at a dose of 75% g/t. There was no flotation improvement when depressants were used in conjunction with Betacol 380 AC. An activator (copper sulphate) was found to improve the grade of copper, nickel and iron meaning it activated pentlandite. The ions improved the flotability of sulfides at the normal process pH after grinding in steel mill.

Keywords: collector, flotation, magnetic separation, depressants, dosing optimization, frother.

1. Introduction

Froth flotation is widely used for separating sulphide minerals in complex ores. Reagents represent the strongest and most flexible variable of interactions in flotation processes. In fact, they determine the necessary flotability and productivity in the flotation process. The theory of action of flotation reagents is therefore of great practical significance. However, despite many years of investigations, the theory is still not sufficiently developed to deal with all problems arising in flotation practice [1, 2, 3]. The flotation target was a higher nickel recovery from a concentration grade of 4% nickel and 35% iron. Sulphide ore is mainly associated with the following minerals pyrrhotite, pentlandite, chalcopyrite and pyrite. Pentlandite is the most abundant sulphide mineral and is the main nickel mineral in almost all nickel sulphide deposits [4, 5, 6]. The problem associated with floatability of individuals nickel minerals is that these minerals contain mineral impurities and therefore the surface properties of the individual minerals vary from one deposit to another and consequently the flotation properties also vary. The type of gangue minerals plays an important role in the floatability of nickel and copper-nickel minerals [7, 8, 9]. The aim of this work was to find the most suitable flotation reagents for the nickel concentrator plant. A number of reagents tests were conducted including magnetic separation, collector dosing optimization, collectors (xanthate and xanthate combination), depressants dosing optimization, depressants, co-collectors, an activator, selection of frother

2. Experimental Procedure

Laboratory scale flotation experiments for collector dosing optimization were conducted. Pans, reagents, 1 ml of frother into 25 L of water and 1% solution of Betafroth 206 and SIBX were prepared. The milling process was then conducted using 1 kg ore sample in the wet mill with 12 laboratory scale stainless steel rods of different sizes. 400 ml of water was added and then milling was performed for 10 min. Flotation was carried out in the alkaline region at pH 9 using copper sulphate as a collector. Laboratory water was then added to up to the mark C (80% of cell volume); the air was open for aeration to take place with a constant air flow of 4 l/min as measured by the rotameter. The froth was allowed to overflow and the float was kept at the level mark C using water from the wash bottle. Samples of the froth were collected for the concentration test after every 5 min. The samples were then dried and all assays were conducted using the sodium peroxide digestion method and atomic absorption spectroscopy.

3. Results and Discussion

3.1. Magnetic Separation

The aim was to find the amount of magnetic material in the ore. It was found that ± 96.09% by mass was non-magnetic. It was then concluded that 3.91% fraction of the magnetic particles was pyrrhotite and 96.09% fraction represented the non magnetic namely, other minerals and gangue. Assay results (Fig 2 and 3) showed that the ore has a high concentration of iron on magnetic particles (pyrrhotite), which could lead to improved collector adsorption on the mineral surface and consequently an improvement in floatability.

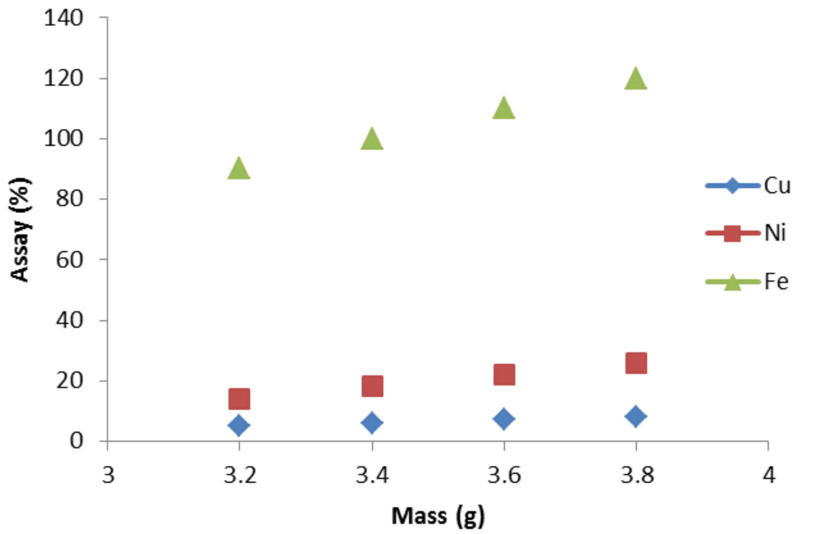

Fig. 2: Magnetic particle assays

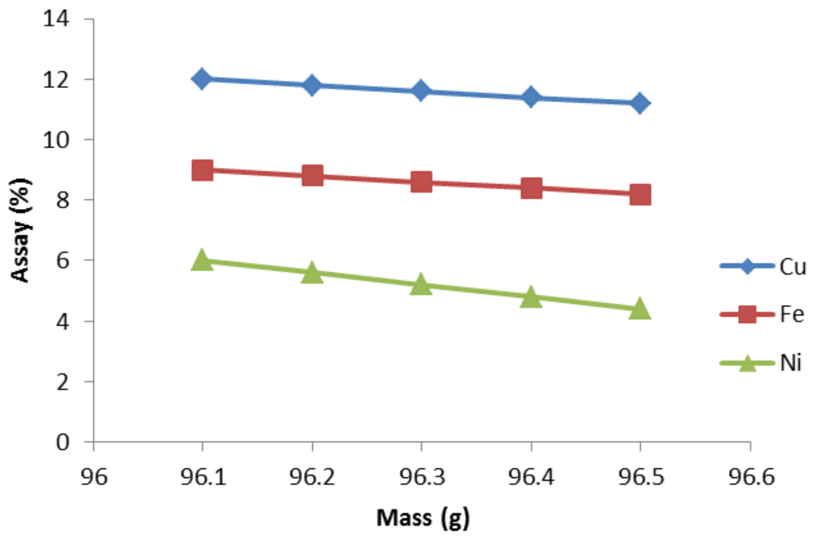

Fig. 3: Non magnetic particle assays

3.2. Laboratory scale floatation for collector dosing optimization

The aim was to find the most suitable dose of collector. SIBX (Sodium Isobutyl Xanthate) was used as a reagent for collector dosing optimization. Three dosing levels were selected namely; 30 g/t, 50 g/t and 100 g/t in order to determine which level had a good recovery and grade for all the metals. From the Table 1, it was found that the dosing level 30 g/t had low frother dosage with high cumulative mass compared to dosing level 50 g/t with high frother dosage but low cumulative mass.

Table 1: Collector dosing optimization

Xanthate Collector		Frother			Breakdown time	Cumulative Mass (C1)	Cumulative Mass (C1 +C2)
Brand	Dosage (g/t)	Brand	Dosage (g/t)	Height (mm)	Time (s)	Mass (%)	Mass (%)
SIBX	30	Betafroth 206	12	190	27	15.06	18.11
SIBX	50	Betafroth 206	20	190	28	10	11.4
SIBX	100	Betafroth 206	12	190	25	12.62	14.84

3.3. Laboratory scale flotation work using a range of xanthate and xanthate combination

The aim of this test work was to find the most suitable collector that could improve the flotation performance. Dosages for all collectors were the same at 50 g/t. PAX (Potassium amyl xanthate) had a low recovery and high grade in all metals. Even though nickel had good recovery and grade, iron grade was too high exceeding the required one. SIPX (Sodium Isophosphate xanthate) had a good recovery but poor grade in all metals. SEX (Sodium Ethyl Xanthate) had a common pattern of increasing recovery and stable grade in all metals. Betacol 380 AC (SEX – PAX combination) had a low recovery when compared to SIPX, SIBX and SEX but good grade. Amount of frother used was low but the breakdown time was lower. Betacol 380 AB (SEX – SIPX) had a low recovery when compared to SIPX and SEX but good grade as indicated in Fig. 4. Nickel grade was low when compared with Betacol 380 AC but iron grade was acceptable and the amount of frother used was slightly high. Betacol 380 AD (SEX – SIBX combination) had the lowest recovery when compared to the rest of the collectors but a better grade.

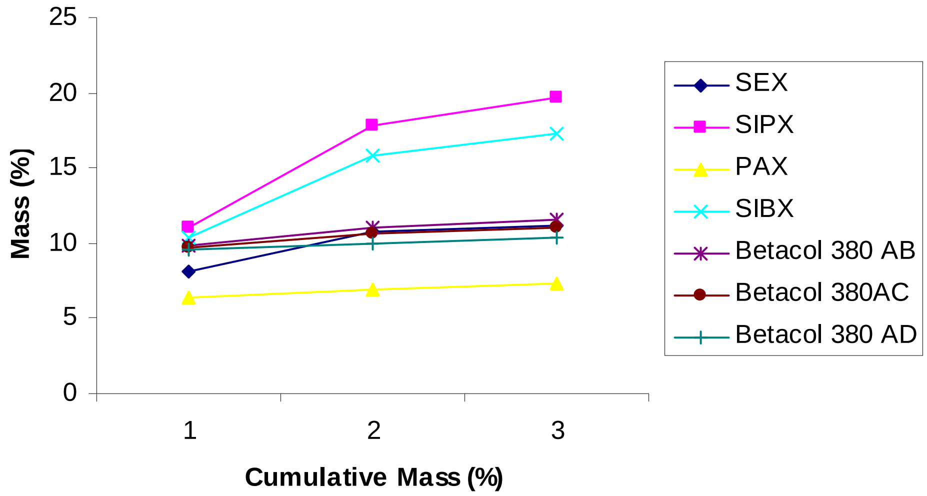

Fig. 4: Xanthate and Xanthate combination mass pull

3.4. Laboratory Scale Flotation Work on Depressants

The aim was to find a suitable depressant that will improve flotation performance in conjunction with Betacol 380 AC. Two reagents were formulated which were Betamin DTM1 and Betamin DTM2. The depressants were compared with Betacol 380 AB. Recovery for Betamin DTM1 was higher than Betamin DTM2 but a poor grade of nickel and iron was obtained. Even though Betamin DTM2 had good grade, the iron grade exceeded the required limit. When Betamin DTM2 was compared with Betacol 380 AB only, it was found that the collector alone was better than the depressants in terms of recovery and grade of iron and copper. Betamin DTM2 produced good grade but slightly low recovery when compared to Betacol 380 AB as shown in Table 3 and 4.

Table 3: Depressants test work

Depressants		Frother		Breakdown Times	
Brand	Dosage (g/t)	Brand	Dosage (g/t)	Height (mm)	Times (s)
Betamin DTM1	75	Betafroth 206	20	190	42
Betamin DTM2	75	Betafroth 206	20	190	30

Table 4: Depressants test work mass pull.

Depressants	**Cumulative Mass (C1)**	**Cumulative Mass (C1 + C2)**	**Cumulative Mass (C1+C2+C3)**
Brand	Mass (%)	Mass (%)	Mass (%)
Betamin DTM1	16.06	19.28	20.11
Betamin DTM2	7.97	8.57	9.31

3.5. Laboratory Scale Flotation Work Using a Range of Co-collectors

The purpose of this study was to find a suitable co-collector that will improve flotation performance in conjunction with Betacol 380 AB. Collectors were dosed at the same rate of 50 g/t similar to that of the co-collectors. Betacol 700 had a good recovery and a better grade for nickel. It used a low amount of water and had the highest mass pull. The highest amount of frother was also obtained when using Betacol 700. Betacol 201 had a poor recovery but a better grade of nickel and iron as compared to Betacol 316 and Betacol 380 AB. Betacol 316 had a poor grade but a good recovery in all metals as shown in Fig. 6. It also used more water but with good mass pull. Betacol 380 AB had a slightly high recovery and grade when compared with Betacol 316 but it had lower grade in all metals with a high recovery when compared with Betacol 700 and Betacol 201. Betacol 316 and Betacol 201 had a frothing characteristic because the amount of frother used was low.

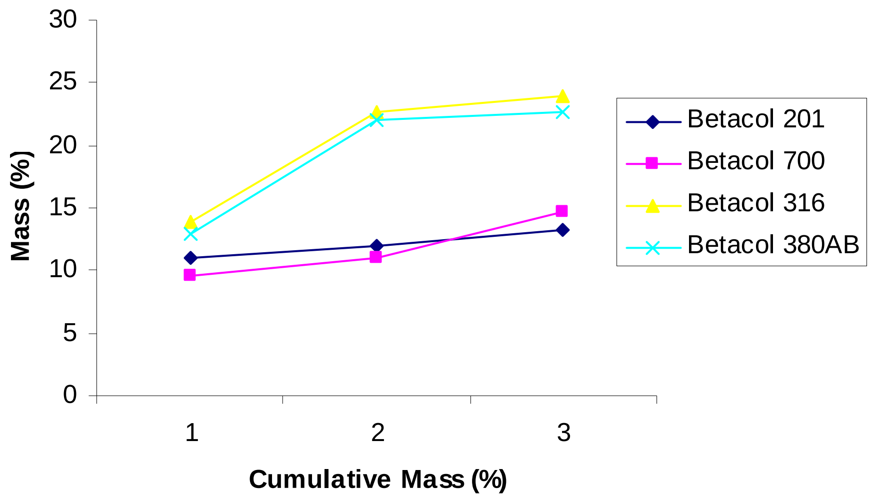

Fig. 6: Co-collectors test work pull

4. Conclusions

It was concluded that 50 g/t was a suitable dose for the collector. Betacol 380 AC was found to be the most suitable collector. A larger proportion of nickel was found on the magnetic particles, which meant that most of the nickel was on the pyrrhotite. 75g/t was found to be a suitable dose for the depressant. There was no flotation improvement when depressants where used in conjunction with Betacol 380 AC therefore no depressant should be used with it. Betacal 700 in conjunction with Betacol 380 AC had a better influence on flotation performance.

5. Acknowledgements

The authors would like to acknowledge financial support from the Department of Chemical Engineering, University of Johannesburg.

6. References

[1] V.I. Klassen and V.A. Mokrousov, An Introduction to the theory of flotation, London, Butterworths. 1963, pp. 151.

[2] S. M. Bulatovic and R Salter, Evaluation of alternative reagent schemes for the flotation of platinum group minerals from various ores. J. Miner.2003, 13: 123-133.

[3] R.D Crozier. Flotation Theory, Reagents and Ore Testing, New York: Pergamon Press, 1992

[4] V.A. Kavovskii and V.I Klassen, Theory of Flotation, 2nd edn, Nedra, Moscou, 1963

[5] DR Nagaraj, The chemistry and Structure Activity Relationships for New sulphide collectors, In (G.S. Dobby and S.R. Raolds) Processing of complex ores, Pergamon, pp 157-168, 1989

[6] V Kirjavainen, N Schreithofer, K Heiskanen. Effect of calcium and thiosulfate ions on flotation selectivity of nickel-copper ores, Mineral Engineering. 2001, 14: 435-345.

[7] NC Fuerstenau, Chemistry o collectors in solution, In (R.P King ed.) Principle of Flotation, South Africa, IMM, 1982

[8] D.W. Fuerstenau and C. Pradip, The Adsorption of Hydroxamate on semi-soluble Minerals, Part 2, Colloids and Surfaces, 1983, 8:143-148.

[9] H.S Fry, New Methods for Preparing Thiocarbanilides, Journal of the American Chemical Society, 1973,35: 1539-1546.