International Journal of Earth, Energy and Environmental Sciences
ISSN: 2517-942X
Vol:12, No:11, 2018

Investigation of Some Flotation Parameters and the Role of Dispersants in the Flotation of Chalcopyrite

H. A. Taner, V. Önen

***Abstract*—**A suitable choice of flotation parameters and reagents have a strong effect on the effectiveness of flotation process. The objective of this paper is to give an overview of the flotation of chalcopyrite with the different conditions and dispersants. Flotation parameters such as grinding time, pH, type, and dosage of dispersant were investigated. In order to understand the interaction of some dispersants, sodium silicate, sodium hexametaphosphate and sodium polyphosphate were used. The optimum results were obtained at a pH of 11.5 and a grinding time of 10 minutes. A copper concentrate was produced assaying 29.85% $CuFeS_2$ and 65.97% flotation recovery under optimum rougher flotation conditions with sodium silicate.

***Keywords*—** Chalcopyrite, dispersant, flotation, copper.

I. Introduction

FLOTATION is one of the most important mineral processing techniques commonly used to separate valuable minerals from gangue minerals utilizing the surface/interface properties of minerals [1]. In the world, among the total amount of produced copper, about 90% is recovered from the ore containing sulphide minerals [2]. Flotation is also used for the enrichment of chalcopyrite, which is a copper mineral. Flotation of chalcopyrite from the pyrite and gangue minerals is difficult because pyrite, and chalcopyrite could have the same flotation performance and gangue minerals could cause problems in flotation. So, a proper dispersion between fine mineral particles by dispersants is an essential prerequisite for their successful separation.

The effects of some dispersants such as sodium silicate, sodium hexametaphosphate and sodium polyphosphate have been investigated in order to decrease the effect of a large number of slimes and fines in chalcopyrite, iron and zinc flotation [3]-[5]. In flotation, sodium silicate (Na_2SiO_3), called water glass, has fairly common use to depress silicate and carbonate minerals present as gangue minerals and it is also an effective dispersant. Sodium silicate, in which chemical composition could vary, acts as either a dispersant or a depressant depending on the SiO_2/Na_2O ratio, also known as a module number [6], [7]. Sodium hexametaphosphate is a widely used dispersant in the flotation process and in clay industries. Sodium hexametaphosphate is also called Graham's salts, and commercial sodium hexametaphosphate is typically a mixture of polymeric metaphosphates [8]. Polyphosphate reagents are widely used in mineral processing industries as dispersants and rheological modifiers [9]. Polyphosphates have the ability to adsorb onto metal oxides and clay particle surfaces via electrostatic and/or chemisorption mechanisms. Chemisorption dominates polyphosphate adsorption at alkaline conditions such as pH 9 whilst at acidic condition, such as pH 4, a combination of chemisorption and electrostatic interaction occurs [10], [11].

The purpose of the present study is to investigate the flotation of chalcopyrite with different conditions and dispersants. Flotation parameters such as grinding time, pH, type of dispersant and dosage of dispersant were studied. In order to understand the interaction of dispersants, three types of dispersants, sodium silicate, sodium hexametaphosphate and sodium polyphosphate were used.

H. A. Taner is with Mining Engineering Department, University of Selcuk, Konya, 42130 Turkey (phone: +90 543 533 2181; fax: +90 332 241 0635; e-mail: hasanalitaner@selcuk.edu.tr).

V. Önen is with Mining Engineering Department, University of Selcuk, Konya, 42130 Turkey (phone: +90 332 223 2107; fax: +90 332 241 0635; e-mail: vonen@selcuk.edu.tr).

II. Experimental

A. Material

Samples used in this study were taken from chalcopyrite mine which is located in the southeastern Anatolia region Siirt Province (Fig. 1). The size distribution of the representative sample was carried out by Malvern Mastersizer 2000 laser diffraction analyzer and given in Fig. 2. It is observed that the percent passing 80 µm is 80%, and 44% of particles are smaller than 20 µm (slime particles).

For improving the enrichment process, the identification minerals are important. According to the mineralogical analyses determined by XRD analysis (Fig. 3), it was found that the sample contained chalcopyrite, pyrite, magnetite, kaolinite, illite and chlorite as the main minerals. The chemical composition of the sample is given in Table I. The dominant elements are iron, sulphur, copper, aluminum and zinc.

TABLE I
CHEMICAL COMPOSITION OF THE SAMPLE

Element	Content (%)
Cu	2.577
Fe	38.380
S	>30
Zn	0.651
Pb	0.209
Al	1.210
Mg	0.790
Ca	0.520

Fig. 1 Location map of the mine

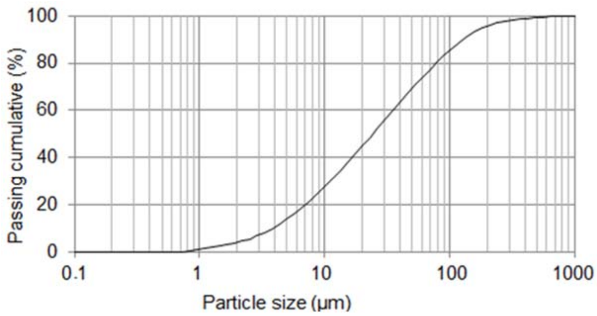

Fig. 2 Particle size distribution of the sample

Aerophine 3418A used in this study as collector was obtained from Cytec Solvay Group. Dispersants used as sodium silicate (NaS), sodium hexametaphosphate (NaHMP) and sodium polyphosphate (NaPP) were obtained from different companies. Methyl isobutyl carbinol (MIBC) was used as frother obtained from Arkema Innovative Chemistry. Lime and sulphuric acid were used as pH regulators.

B. Flotation Experiments

Flotation experiments were carried out in a 1 L conventional laboratory cell (Denver model), at 10% solid ratio, 10 L/min air flow rate, 2 cm froth depth and agitation rate was 1350 rpm. MIBC was used as frother (80 g/ton) and 3418A was used as collector (50 g/t). The mineral suspension was prepared by adding solids and tap water. Firstly, pH of the mineral suspension was adjusted to 11.5 by adding lime stock solutions and conditioned for 5 minutes. Then, prepared dispersant solution was added at a desired concentration and conditioned for 3 minutes. With the addition of collector and conditioning 3 minutes, lastly frother added to solution and conditioned for 1 minute. The froth was handpicked for 3 minutes to collect the concentrate.

For individual mineral flotation, the floated and unfloated particles were collected, filtered, and dried. The flotation recovery was calculated based on solid weight distributions between the two products. For mixed minerals flotation, the $CuFeS_2$ contents of the concentrates and tailings were analyzed, and the recovery of chalcopyrite was calculated. The experiments were conducted in three parts. In each part, the effect of only one parameter was examined, while the other parameters were kept constant.

III. Results

A. Effect of Grinding Time on Chalcopyrite Flotation

The effect of grinding time on the flotation of chalcopyrite was studied and the results are shown in Fig. 4. It is evident from the figure that the flotation recovery of chalcopyrite was increased as the grinding time was increased. The grade of chalcopyrite increased until grinding time of 10 minutes, but then fell off. As the grinding time increased, the grain size decreased. So, the gangue minerals which are in slime size could be mixed with the concentrate. A more efficient enrichment was obtained in the experiments made with the samples obtained at the grinding time of 10 minutes.

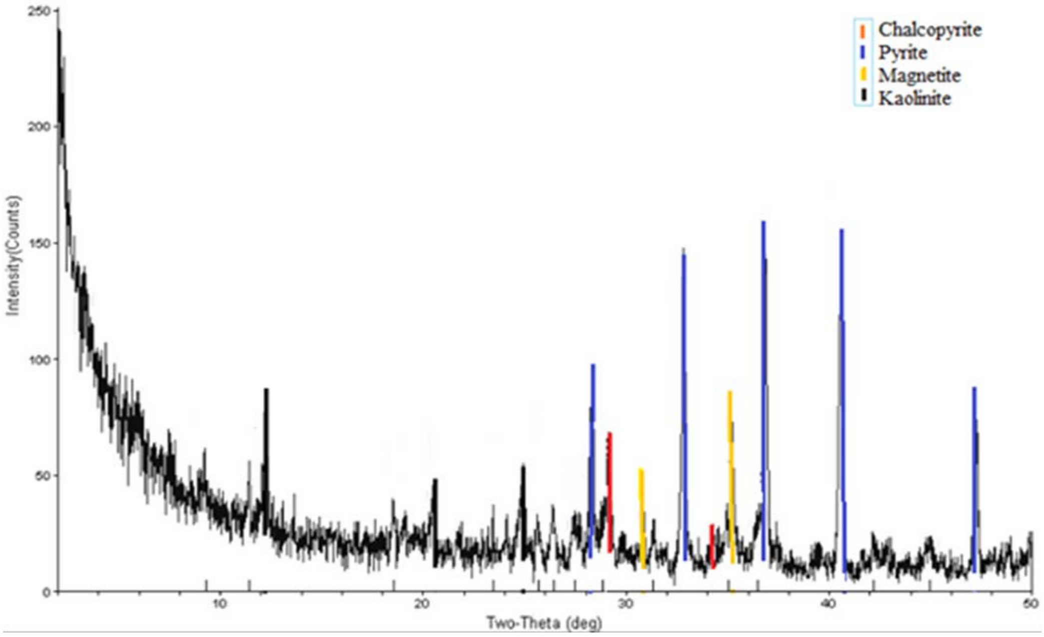

Fig. 3 XRD result of the sample

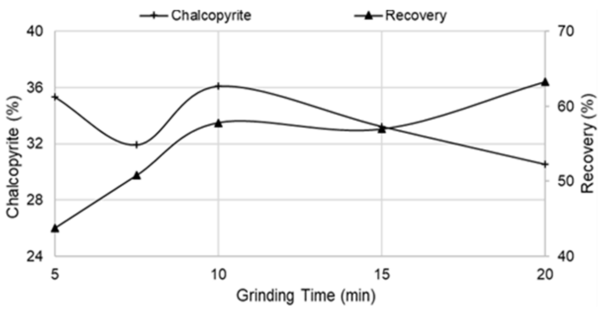

Fig. 4 Effect of grinding time on the flotation of chalcopyrite

B. Effect of pH on Chalcopyrite Flotation

The pH of the pulp must be optimized so that the chemicals used in the flotation can react with the mineral surfaces in the pulp. The effect of pH was investigated at 8, 9, 10, 11, 11.5, 12 and 12.70 and the results obtained are given in Fig. 5. Chalcopyrite recoveries increased dramatically as the pH increased. After pH 11.5, recovery of the chalcopyrite was observed to be decreased sharply. On the contrary, the grade of chalcopyrite continued to rise. This result confirms that high pH of the pulp caused to depress pyrite. The surface of chalcopyrite also gains more hydrophobicity, and the amount of chalcopyrite coming to the concentrate is higher. In later experiments, flotation was continued at pH of 11.5.

C. Effect of Dispersants on Chalcopyrite Flotation

An appropriate choice of dispersant quality and quantity has an important effect on the flotation recovery. The dispersant dosage is also an important factor in the flotation process, which affects the recovery seriously. Fig. 6 shows the effect of sodium silicate (NaS) dosages on the recovery and grade of chalcopyrite. Recovery of chalcopyrite increased substantially until the use of 100 g/t dosage of NaS but then slightly decreased. NaS can effectively disperse the chalcopyrite, pyrite and gangue minerals reducing the coverage of pyrite and gangue minerals on chalcopyrite surfaces and improving the flotation recovery of the chalcopyrite.

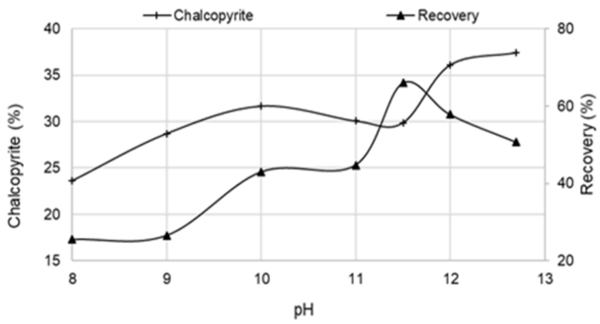

Fig. 5 Effect of pulp pH on the flotation of chalcopyrite

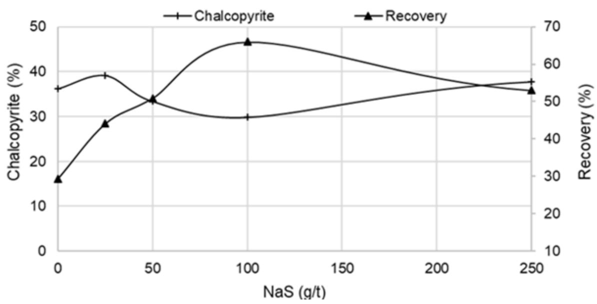

Fig. 6 Effect of NaS on the flotation of chalcopyrite

Fig. 7 shows the effect of sodium polyphosphate (NaPP) dosages on the recovery and grade of chalcopyrite. The use of NaPP resulted in poor separation with the lowest recovery than NaS.

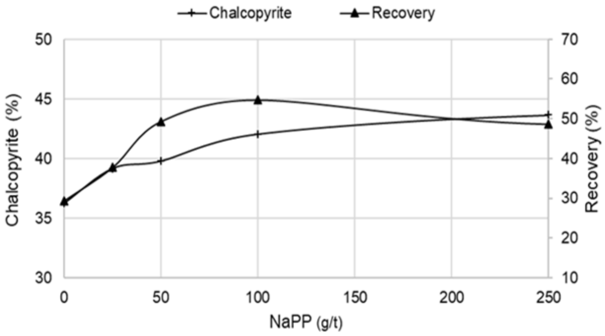

Fig. 7 Effect of NaPP on the flotation of chalcopyrite

Fig. 8 shows the effect of sodium hexametaphosphate (NaHMP) dosages on the recovery and grade of chalcopyrite. A maximum increase in chalcopyrite recovery was obtained with 100 g/t NaHMP, while higher NaHMP concentrations produced little gain in recovery. Pyrite flotation is depressed when pH is higher than 10.5 and the floatability of pyrite over this pH range is not restored by NaHMP [12]. This result is also matched up with this study.

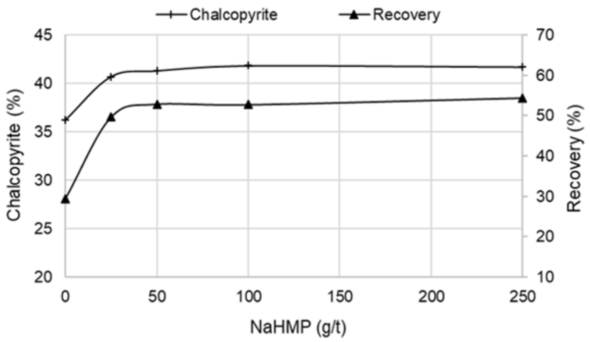

Fig. 8 Effect of NaHMP on the flotation of chalcopyrite

Optimum dispersant dosages results are given in Fig. 9. According to these findings, it can be concluded that the appropriate dispersant for the flotation of chalcopyrite should be sodium silicate. Sodium polyphosphate and sodium hexametaphosphate gave similar optimum results on grade and recovery of chalcopyrite. Among the dispersants tested, sodium silicate gave a higher chalcopyrite recovery.

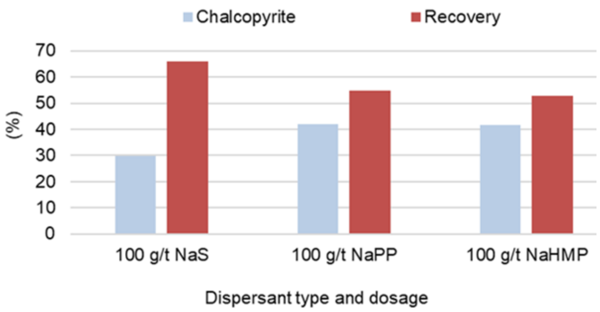

Fig. 9 Optimum dispersant dosages

IV. Conclusion

In this study, recovery of chalcopyrite was investigated by different conditions and dispersants. The effect of some dispersants, sodium silicate, sodium hexametaphosphate and sodium polyphosphate were evaluated. Optimum flotation conditions are obtained as a result of rough flotation experiments; 10 minutes of grinding time, 11.5 of pH and 100 g/t of Na_2SiO_3 dosage. Flotation experiments showed that flotation of chalcopyrite was much better with sodium silicate and a concentrate of 29.85% $CuFeS_2$ content was obtained with 65.97% flotation recovery. As a result of this study, using sodium polyphosphate and sodium hexametaphosphate as dispersant was not suitable in chalcopyrite flotation.

Acknowledgment

The authors gratefully acknowledge the financial support of the Scientific Research Projects Coordination Unit of the Selcuk University and Academic Staff Training Program (OYP) Coordination Unit of the Selcuk University which made this work possible.

References

[1] S. Atak, *Flotasyon İlkeleri ve Uygulaması*, I.T.U. Vakfı, 34, Istanbul 1990.

[2] A. Wieniewski, B. Skorupska. "Technology of Polish copper ore beneficiation-perspectives from the past experience," in Mineral Engineering Conference MEC2016, Poland, 2016.

[3] A. E. C. Peres, A. M. Borges, R. Galery, "The effect of dispersion degree on the floatability of an oxidized zinc ore," *Minerals Engineering,* vol.7 (11), pp. 1435–1439, 1994.

[4] A. H. Navidi Kashani, F. Rashchi, "Separation of oxidized zinc minerals from tailings: Influence of flotation reagents," *Minerals Engineering,* vol. (21), pp. 967–972, 2008.

[5] A. Ramirez, A. Rojas, L. Gutierrez, J. S. Laskowski, "Sodium hexametaphosphate and sodium silicate as dispersants to reduce the negative effect of kaolinite on the flotation of chalcopyrite in seawater," Minerals Engineering, vol. (125), pp. 10–14, 2018.

[6] E. C. Cilek, *Mineral flotasyonu*, Yayın No:59, Isparta: Suleyman Demirel Universitesi Mühendislik-Mimarlık Fakültesi. Isparta, 2006.

[7] H. A. Taner, V. Onen, "Control of clay minerals effect in flotation. A review," in Mineral Engineering Conference MEC2016, Poland, 2016.

[8] Y. Han, W. Liu, J. Zhou, J. Chen, "Interactions between kaolinite AlOH surface and sodium hexametaphosphate," *Applied Surface Science,* vol. (387), pp. 759–765, 2016.

[9] M. O. Silvestre, C. A. Pereira, R. Galery, A. E.C. Peres, "Dispersion effect on a lead–zinc sulphide ore flotation," *Minerals Engineering,* vol. 22(9-10), pp. 752–758, 2009.

[10] M. L. Taylor, G. E. Morris, R. S. C. Smart, "Polyphosphate interaction with aluminum-doped titania pigment," *Colloids Surf. A,* vol. (190), pp. 285–294, 2001.

[11] S. Farrokhpay, G. E. Morris, G. L. Britcher, "Stability of sodium polyphosphate dispersants in mineral processing applications," *Minerals Engineering,* vol. (39), pp. 39–44, 2012.

[12] E. Rebolledo, J. S. Laskowski, L. Gutierrez, S. Castro, "Use of dispersants in flotation of molybdenite in seawater," *Minerals Engineering,* vol. (100), pp. 71–74, 2017.

Hasan Ali Taner was born in Antalya, Turkey on 12th of March in 1986. He graduated from University of Zonguldak Karaelmas, Department of Mining Engineering in 2008. He has a master degree of science in mining engineering from Bulent Ecevit University. He is PhD student at Selcuk University since 2013. His major field is mineral processing. He was published eleven articles in his research field. His current and previous research interests are to flotation of sulphide minerals, leaching, grinding and mineral preparation.

MSc. Taner is a member of Turkish Mining Engineering Chamber Society.