THE EFFECT OF VARIOUS COLLECTOR TYPES ONTO THE COPPER ORE OF ÇAYELİ THAT MILLED TO DIFFERENT PARTICLE SIZE

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ABSTRACT

One of the biggest problems encountered in flotation of sulfite minerals is the usage of improper collector type and dosage, without taking particle size distribution into account. Flotation studies of a certain mineral group are carried out with a single particle size and the possibility of achieving a more efficient flotation with other collector types and dosages once the process is applied on plant-scale grinding is largely overlooked. However, a mineral's surface area changes with its particle size distribution. Using the same dosage and type of collectors on different particle sizes can acquire to different recovery of mineral and concentrate grade. In this study, effects of different collector types (A-3418A, A-3477) and dosages (50-100-150 g/t) according to particle size variations is researched on Cayeli copper ore with 4.8% Cu, ground to different sizes (-0.075 mm and -0.038 mm). In the experiments; frother amount and pH is applied as variables together with particle size, collector type and collector dosages. As a result, it is observed that a certain collector type and dosage suitable for a particle size provides lower recovery of mineral and concentrate grade when used on smaller particle sizes. It can be necessary to investigate variations on particle size distribution arising from changes in grinding conditions on plant-size grinding, and to change the type or dosage of collector used accordingly.

Keyword: Flotation, Particle Size, Collector Type, Collector Dosage, Complex Sulphur Ore.

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INTRODUCTION

First studies regarding effects of particle size on mineral flotation are done by Gaudin, Groh and Henderson (1931). After these works, effects of particle size on flotation performance has been researched thoroughly (Gaudin et al., 1931; Anthony et al., 1975; Trahar, 1976; Trahar, 1981) and it has been determined that physico-chemical factors are closely related with particle size of a mineral. However, the effects of these factors are very difficult to predict. For instance, it is known that particle size plays a vital role for a pulp-phase particle to collide with and to stick to bubble (Spedden and Hannan, 1984; Whelan and Brown, 1956). Consequently, recovery of mineral can decrease for reduction at probability of collision with bubble of fine particles and for increase at probability of detaching from bubble of large particles. However, numerical value of this reduction can not be calculated precisely.

It has been learned with experience that collector type and dosage have a bigger effect on flotation system than particle size has. Even though small amounts of increases on collector dosages were prove to be useful in flotation, excess amounts are mostly detrimental. Schuhmann (1942), stated with his works that an increase on xanthate dosage causes a reduction on galena grade, and Taggart (1951) used angle of contact, which is a measure of floatibility and hydrophoby, and stated that hydrophobic behaviour decreases with high collector concentrations. Klimpel (1984), showed that increasing collector concentration increased flotation performance but reduced concentrate grade.

Finer particles, compared to larger ones, have higher specific surface areas (cm^2/g). For this reason, the amount of collectors required to achieve a certain degree of hydrophoby is higher compared to that of large particles. In flotation systems that include both large and fine particles together, most of the collector used will be consumed by fine particles, and the desired level of hydrophoby will not be attained. In industrial applications, reagent type and concentration, pH regulators and particle size are the main elements of achieving selectivity. Because of this, appropriate reagent type and dosage for a certain particle size should be used in ore dressing with flotation. If, in a flotation plant, particle size distribution is changed by modifying grinding parameters, reagent types and dosages should also be reconsidered. Otherwise, both the flotation recovery and grade, and reagent types and dosages would alter. Maybe, another type and dosage of collector can be more economical. Non-conventional collectors (i.e., collectors different to xanthate) are more frequently used in the sulphide flotation practice (Gorken et al., 1992; Uribe-Salas et al., 2000), due to the complex association of most exploitable minerals. One example of non-conventional collectors is sodium-di-isobutyl dithiophosphinate (DTPINa), known under the trademark of Aerophine 3418A (Fig. 1). DTPINa is mainly recommended for floating lead, copper and precious metals from minerals containing high levels of pyrite, as is the case of complex minerals (Avotins et al., 1991). In this regard, an example of its successful application is that of a Mexican operation where the grades of silver of a lead-silver concentrate was increased from 10 to 30 kg/ton by simply substitution of xanthate with DTPINa (Confidential communication, 1999). This was due to the increased selectivity against pyrite, which constitutes the matrix of the mineral (Pecina et al., 2003).

In this study, the effect of different collector types and dosages on a complex sulphur mineral sample ground to two separate particle sizes is researched. In order to do this, flotation of a copper sulphur ore ground to two different particle sizes (-75 μm; -38 μm) is carried out with three types of collectors (A-3418; A-3477), each used in three different concentrations (50-75-100-125-150 g/t). This way, it is shown how the required types and amounts of collectors vary with different surface areas related to certain particle sizes.

EXPERIMENTAL

Samples of copper sulphur are obtained from “Çayeli Bakır İşletmeleri” situated in Rize. Chemical composition of sample used is shown on Tab. 1. The chemical and microscopic analysis, coupled with XRD determination, indicated that the sample contains chalcopyrite and sphalerite with minor amounts of galena, gold and silver minerals.

For flotation concentration of minerals, anionic collectors Aero 3418 and Aero 3477 were used, promoters were supplied by Cytec Industries B.V., Holland. In addition to the above mentioned chemicals, DF-250 was used as frother, and NaOH was used for pH regulation.

The sample was crushed to -2 mm in the jaw crusher and dry classified. Later, the sample are dry ground in ball mill and wet classified to achieve two distinct groups, 80 – 85 % of one of the groups being finer than 0.075 mm, and 80 – 85 % of the other being finer than 0.038 mm (Fig. 2). Flotation experiments were performed in a laboratory Denver, model D12, machine, using a 2L cell. In the experiments, collector type, collector dose, pH, frother dosage are taken as variable parameters, whereas 3.0 cm froth height, 6 L/min air speed, 30% solid rate and 1350 rev/min mixing speed were accepted for constant parameters. Conditioning durations applied for flotation reagents are 5.0 minutes for pH regulator and collector, and 1 minute for frother. The tests were performed at three pH levels: 10.0, 10.5, 11.0, at three collector dosages: 50-75-100-125-150 g/t, at three frother dosages : 25-50-75 g/t and at three collector types: A3418 and A3477. Froth is taken for 2.0 minutes and overflown froth is subjected to chemical analysis, and results are evaluated considering copper grade and yield.

RESULTS AND DISCUSSION

The effect of frother dosage and pH are determined before experimenting with particle sizes. –0.075 mm samples are used to determine this effect. Optimal pH and frother concentration values are derived from the results obtained, and those values were used in the subsequent experiments. Finally, experiments are run using samples of particle sizes –0.075 mm and –0.038 mm to determine the effect of particle size on collector type and dosage.

Effect of pH

pH of the pulp plays an important role on particle hydrophoby. For this reason, flotation tests are carried out with two collectors on pH 10.0-10.5-11.0, and results are given on Fig. 3 and 4. It can be seen that recovery of copper increases with pH, and reaches its highest value on pH 11.0. This increase in recovery is caused by increased hydrophoby of copper mineral. Flotations with two collectors show similar results. Highest copper yield is achieved on pH 11.0 using collector A-3477, and is found to be 80.92%.

Generally, copper grade increases with increasing pH. While the increase is continue at A-3418, content of copper is decrease after pH 10.5 at A-3477. Hence, it is considered to start being hydrolysis of A-3477. The reason copper grade increases is that collector selectivity increases with pH and amount of pyrite carried along with concentrate decreases. In addition to this, as pH increases, sulphur anion on pyrite surface displaces with OH^- anion, keeping the surface of pyrite negative charged. For this reason, pyrite minerals are suppressed on high pH values. The main reason for this difference between collectors is pyrite selectivity. Best results are obtained using the collector with highest pyrite selectivity. Highest copper grade is achieved in pH 10.5 using collector A-3477, and contains 9.36% copper.

Effect of frother concentration

Results of flotation tests carried out with the three collectors in pH 11.0 using 25-50-75 g/t frother concentrations are given on Fig. 5 and 6. Frother concentration is very important for copper recovery, and has a considerable part on the success of the flotation. Introduction of high amounts of frother causes excess froth formation, which results in higher flotation recovery. Furthermore, high frother concentrations can combine similar particles, causing them to float. Alternatively, bigger bubbled froths with loose configurations are obtained with low frother concentrations. This case reduces mechanical transportation, and also decreases recovery. Copper recovery increases with frother concentration, and reaches its peak value at 75 g/t. Similar results were obtained on flotations with all two collectors. Highest recovery of copper is acquired at 75 g/t frother concentration using collector A-3477, and is found to be 91.92%.

Generally, copper grade falls as frother concentration rises. This is because of excess froth formation, and excessive mechanical transportation of fine gangue (pyrite) particles in such froth. As low frother concentrations cause irregular and large bubble formations, which gives way to a minimum amount of mechanical transportation, concentrate quality increases.

The differences in results obtained using different collector types is caused by variations in selectivity of collectors. Highest copper grade is achieved using collector A-3477 with 25 g/t frother concentration, and contains 10.5% copper. Therefore, a frother concentration of 50 g/t is suitable for all collectors considering mineral recovery and grade.

Effect of Particle Size on Collector Type and Collector Dosage

Five collector dosages, two collector types and two different particle sizes are used in these experiments devised to put forward the effect of particle size on collector type and dosage. Results of experiments done in pH 11.0 with 50 g/t frother concentration can bee seen on Fig. 7 and 8. In general, copper recovery increases with collector dosage. This is resulted by the increase in hydrophoby of precious minerals and the increase in recovery of mineral, with increased collector concentration. However, higher collector concentrations can cause micelle formation, and reduce recovery of copper. And the main reason for obtaining a lower recovery on finer particles compared to that of larger ones, is that fine particles provide a larger specific surface area (cm^2/g). Because of this, collector dose required to achieve the same level of hydrophoby is higher than that needed for larger particles. For example, while recovery of copper is acquired 68.12% with 50 g/t A-3418 type collector at -0.075mm particle size, for same recovery is need too collector at -0.038mm particle size. Highest copper yield is achieved on -0.075mm particle size, using 125 g/t of collector A-3477, and is found out to have a copper yield of 84.71%.

In large particle sizes (-0.075mm), copper recovery generally increases with collector concentration and declines after 100 g/t of collector concentration. The principle reason behind this decrease is the reduction of selectivity because of excess collector amounts. As selectivity decreases, gangue minerals are also carried to the concentrate. On smaller particle sizes however, more precious minerals are turned hydrophobic and carried to concentrate, with increasing collector concentrations. As a result, recovery of copper increases continuously. Highest copper grade achieved contains 9.28% copper, and is obtained using 100 g/t of collector A-3418.

CONCLUSIONS

Comparing the results of laboratory research on the application of particle sizes -0.075mm and -0.038mm, collectors A-3418/A-3477 and collector’s dosages 50-75-100-125-150 g/t with results obtained in the floatation concentration of copper ores from Çayeli Province, Rize-Turkey, it can be concluded:

- Considering recovery of mineral and grade, optimal results are achieved in pH 11.0 for all collectors, because of suppression of pyrite mineral on high pH values. Best recovery of copper and grade is obtained in pH 11.0 using collector A-3477.

- Acceptable grade and recovery achieved with suitable froth formation is obtained with 50 g/t of frother concentration for all collector types. Best recovery of copper and grade is achieved on pH 11.0 using collector A-3477 and 50 g/t of frother concentration.

- It is determined that collector type and dosage should be changed to achieve the same level of mineral recovery and grade once the particle size distribution is changed. When applied to finer particles, same collector type and dosage gave lower recovery of copper and grade.

As a conclusion, even small changes in particle size can alter recovery and grade of mineral in ore dressing with flotation. This condition can act both as an advantage and a disadvantage, depending on the situation. For this reason, collector type and dose should be chosen specifically for a certain particle size at “Çayeli Bakır İşletmeleri”.

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Figure 4. Effect of pH on recovery of copper.

Figure 5. Effect of frother concentration on grade of copper.

Figure 6. Effect of frother concentration on recovery of copper.

Figure 7. Importance of particle size on selection of collector dosage and type: Grade of copper.

Figure 8. Importance of particle size on selection of collector dosage and type: Recovery of copper.

TABLE 1

Chemical composition of sample.

Element	Component
Cu	4,8%
Zn	1,7%
Pb	0,08%
Au	1 ppm
Ag	0,2 ppm

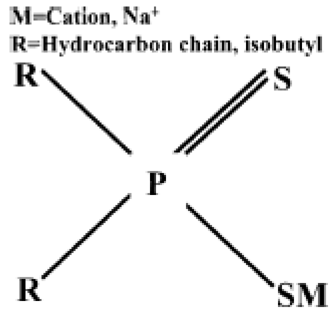

FIG 1 – Chemical structure of sodium-di-isobutyl dithiophosphinate (DTPINa).

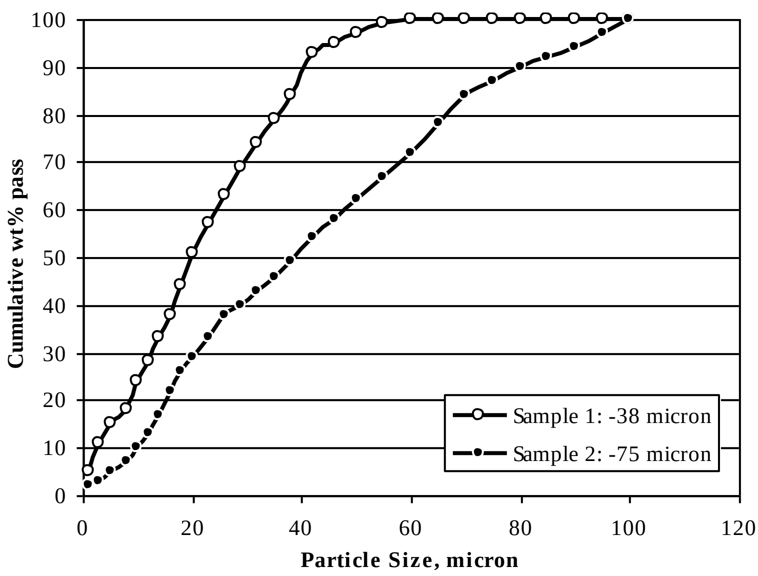

FIG 2 – Sample 1 and Sample 2's particle size distribution.

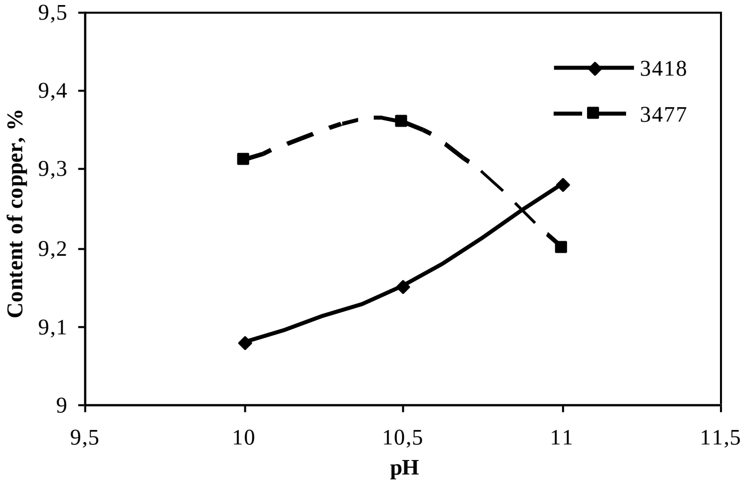

FIG 3 – Effect of pH on grade of copper.

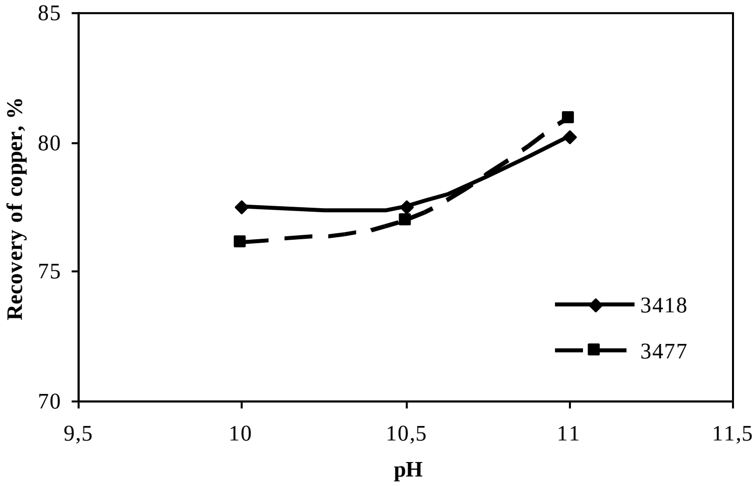

FIG 4 – Effect of pH on recovery of copper.

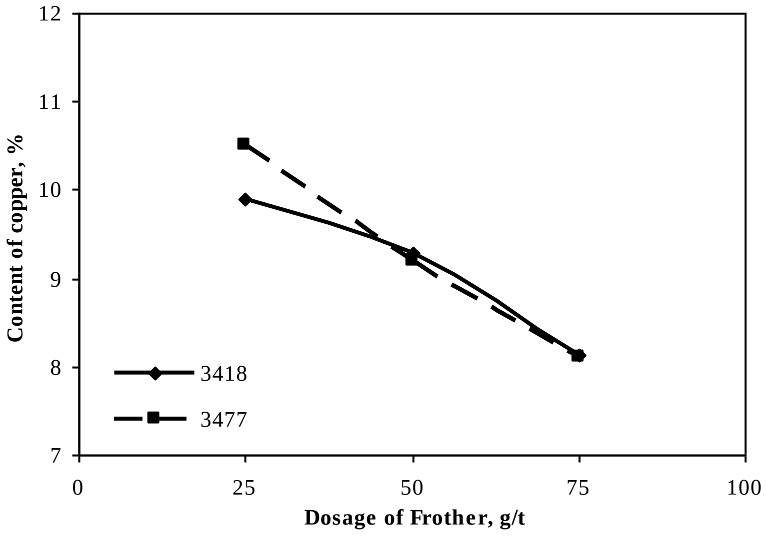

FIG 5 – Effect of frother concentration on grade of copper.

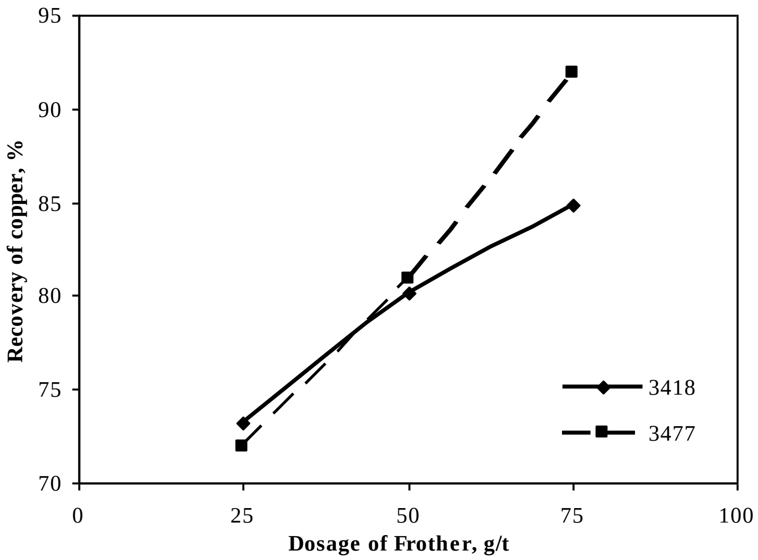

FIG 6 – Effect of frother concentration on recovery of copper.

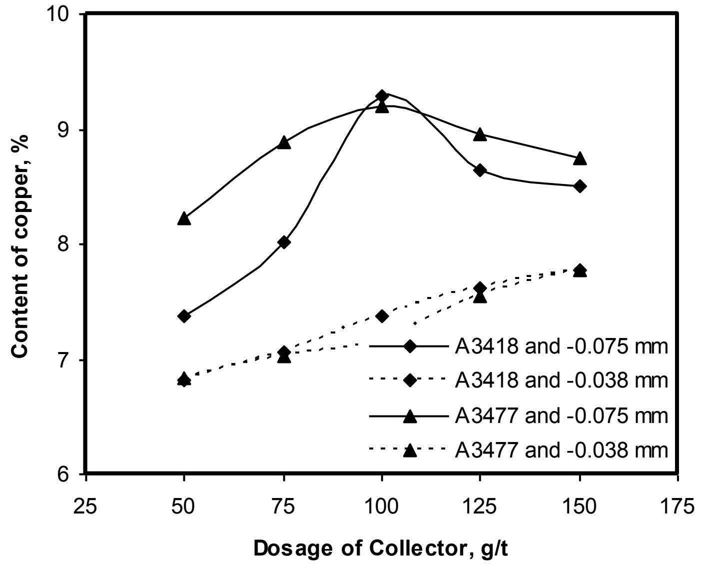

FIG 7 – Importance of particle size on selection of collector dosage and type: Grade of copper.

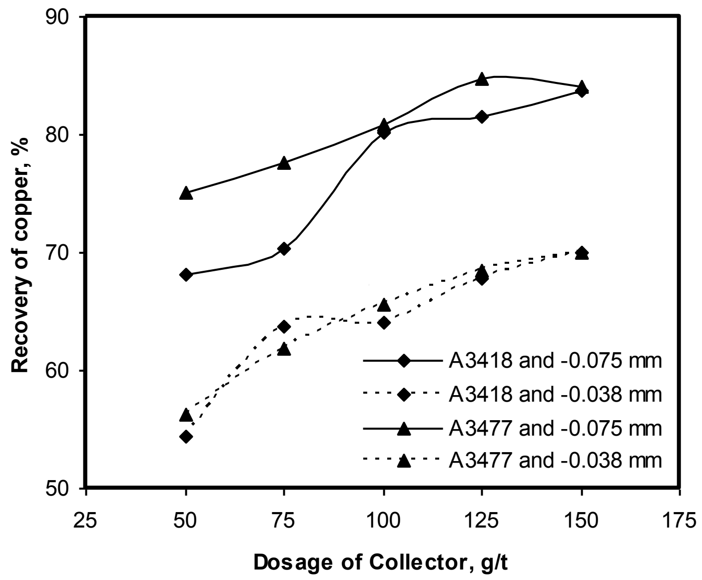

FIG 8 – Importance of particle size on selection of collector dosage and type: Recovery of copper.