Implementation of Magnetic Conditioning Technology, ProFlote®, to CBI Cu/Zn Concentrator

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ABSTRACT: A full-scale statistically-based on/off plant trial of ProFlote® conditioning technology in CBI copper flotation circuit was started on September 2008 by installing two units of ProFlote® in copper rougher conditioners. Based on the promising results after 4 months of operation, another unit was installed in copper cleaner conditioner on May, 2009 and data collection continued till the end of August, 2009. Plant trail of ProFlote® in the copper rougher and cleaner circuit has confirmed the preliminary test results and the installation of a ProFlote® in the cleaner has sustained the increased copper recovery in the rougher through to the final concentrate. The beneficial effect of ProFlote® was more pronounced while processing non-spec ores. It was seen that copper recovery is increased by 2,5% while zinc in final copper concentrate is decreased 8%. Also, zinc in final tail is decreased by 7% during the test period. Consequently, it was decided to continue the operation of ProFlote® both in copper rougher and cleaner circuits. Metallurgical results after continuous operation also confirmed the beneficial effect of magnetic conditioning on copper metallurgy.

INTRODUCTION

The relationship between particle size and flotation recovery was first recognised and reported by Gaudin, et al. (1931); from data collected at operating concentrators. While the particle size, where optimum flotation efficiency occurs, may vary between sites and between different sulphide minerals, Trahar and Warren (1976) showed that as particle size decreases below 20µm, and certainly below 10µm, flotation efficiency declines markedly. However, particularly in some sulphide-sulphide separations mineral liberation may not occur until particles are reduced to this very fine particle size range, and so flotation separation of these fine particles is a necessity.

One method that has been investigated is selective aggregation of the sulphide ultrafines. Different aggregation methods have been tested to improve <20µm mineral recovery. These include shear flocculation Holder (1994) and floc-flotation (Song et al. 2000, 2001; Peng et al, 2005). These aggregation methods are not utilised widely, most probably due to their high operating cost.

Magnetic Aggregation of Fine Sulphide Minerals

A selective aggregation method that has been evaluated recently is magnetic aggregation of paramagnetic sulphides (Engelhardt et al., 2005; Rivett et al., 2007; Holloway et al., 2008; Bott and

Lumsden, 2009). The demonstrated advantages of this method is its; selectivity, effectiveness on very fine particles, simplicity and low operating cost.

The magnetic aggregation is dependent on the magnetic induction, the particle size and the magnetic susceptibility of the mineral. Svoboda (1987) has shown that <20 µm paramagnetic minerals with a magnetic susceptibility similar to chalcopyrite, bornite and sphalerite will aggregate at magnetic inductions available with high strength permanent rare earth magnets. For example Svoboda showed that at magnetic inductions of 10^{-2}T, 5µm paramagnetic particles will readily aggregate. High strength permanent rare earth magnets will easily achieve magnetic inductions of $>10^{-1}$T.

The magnetic susceptibility of sulphides commonly recovered by flotation are given by Svoboda (1987);

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Chalcopyrite............................1.6-5x10^{-6} m^3kg^{-1}
Sphalerite ....3.8x10^{-8} to 5.9 x 10^{-6} m^3kg^{-1}
Pyrite.......................................1-5x10^{-9} m^3kg^{-1}
Bornite....................................8.8x10^{-9} to 1.6 x10^{-7} m^3kg^{-1}.

The range in magnetic susceptibilities of these sulphides has generally been attributed to the varying iron content in the minerals. This is most clearly shown for sphalerite where relatively small changes in iron content can change the magnetic susceptibility by an order of magnitude.

All of the published testing of magnetic conditioning of flotation feed has been undertaken where the paramagnetic mineral recovered by flotation was separated from a primarily diamagnetic matrix. As would be expected only the paramagnetic mineral was affected, so that an improved grade recovery curve resulted. In some testing the effect of magnetic conditioning was so significant that both the mineral recovery and the concentrate grade increased (Holloway et al., 2008). However, at Cayeli the mineral recovered by flotation, chalcopyrite, was being separated from a diamagnetic matrix that contained another paramagnetic sulphide mineral, sphalerite. The aim was to increase the fine chalcopyrite recovery by aggregation, but not impact the sphalerite and increase its recovery into the copper concentrate. The best outcome would be to increase the recovery of the desired paramagnetic mineral (chalcopyrite) by selective aggregation and reduce, or leave unchanged the recovery of the other paramagnetic mineral (sphalerite).

It is possible that some of the sphalerite in the chalcopyrite concentrate was composited with chalcopyrite that some was activated and so floated but it is also possible that some of the sphalerite in the chalcopyrite concentrate was entrained, and aggregating this sphalerite may actually reduce its entrainment in the chalcopyrite concentrate. The effect of magnetic conditioning on this separation was very important.

Plant Description

Cayeli Bakir Isletmeleri A.S. ("CBI") is a Turkish company owned by INMET Mining of Toronto, Canada. The Company was formed in 1983. The Cayeli mine is located in north eastern Turkey in the Rize province, approximately eight kilometers from the coast of the Black Sea. The operation has access to well developed infrastructure, including a port facility at the nearby city of Rize. CBI's mining operations produce copper and zinc concentrates. Construction of the facility began in 1992 and the first concentrate shipment was made in December of 1994. Since the start of production, the facility has constantly been expanding from the initial capacity of 600,000 tonnes per year throughput to its current throughput of 1.2 million tonnes annually. Average feed rates are 3.5% copper and 6% zinc with major gangue of pyrite. CBİ produces approximately 250,000 tonnes of copper and zinc concentrates per year which is sold mainly to international smelters.

Briefly, after three stages of crushing down to 15mm, ore is ground to a grinding size of 75% -36μm in a grinding circuit consisting of two ball mills in operation with hydrocyclone unit. Material was subjected to copper flotation after grinding. Copper circuit tail was pumped to zinc circuit for producing zinc concentrate. More detailed information about the CBI concentrator can be found at various papers presented before (Aslan, A and Boz, H, 2010; Aslan, A. and Mian, M.N., 2008; Aksani, B. and Mian, M.N., 2003)

EXPERIMENTAL

A full-scale statistically-based on/off plant trial of ProFlote® conditioning technology in CBI copper flotation circuit was started on September 2008. Two units of ProFlote® were installed in copper rougher conditioners (Figure 1). After four months of data collection, it was seen that the preliminary results are promising in terms of both copper recovery and copper/zinc selectivity.

Based on these results, it was planned to extent the plant trial and to install another unit to copper cleaner conditioner in order to increase the significance level of statistical results. Third unit was installed on May, 2009 and data collection continued till the end of August, 2009.

It was started to run all the units continuously after the mid of September, 2009.

Figure 1 – ProFlote® installation at copper rougher conditioners

RESULTS AND DISCUSSION

The CBI plant treats two distinct ore types, designated non-spec and spec. These two ore types give different metallurgical results, and are stockpiled separately and treated by campaign in the plant.

The testwork was undertaken on both ore types and the data allocated between non-spec and spec ores and analysed separately. The results for both ores were similar but because the non-spec ore predominates, and gives the most statistically meaningful results its analysis is contained in this publication.

Non-Spec Ore

The results for the copper metallurgy are summarised in Table 1.

Table 1 – Statistical evaluation of on/off plant trial in copper circuit

	Cu % in Feed	Cu % in Cu Conc	Cu % in Cu Tail	Cu Rec % in Cu Conc	Cu % in Final Tail
ProFlote® ON	3.07	19.80	0.92	73.36	0.63
ProFlote® OFF	3.03	19.13	1.00	70.67	0.70
Difference	0.04	0.67	0.08	2.69	0.07
t value	low	2.05	2.35	2.11	2.44
Level of Confidence		97.5	98.7	97.8	99.0

The copper circuit flotation results show that magnetic conditioning substantially improves the copper metallurgy. There is an increase in copper recovery of 2.69% to a very high level of confidence and a higher copper in copper concentrate of 0.67% also at a very high level of confidence. This is a substantial increase in the copper grade recovery response and similar to the results reported elsewhere on ore of similar grind size (Holloway et al., 2008; Bott and Lumsden, 2009). Concurrently, as expected there is a reduction in copper to both copper tail and final tail also to a very high level of confidence.

The results for the zinc metallurgy are given in Table 2.

Table 2 - Statistical evaluation of plant trial in zinc circuit

	Zn % in Feed	Zn % in Cu Conc	Zn % in Cu Tail	Zn Rec % in Cu Conc	Zn % in Final Tail	Zn Rec % in Zn Conc
ProFlote® ON	7.31	9.15	7.06	15.06	1.01	74.04
ProFlote® OFF	7.83	9.90	7.53	15.38	1.08	73.76
Difference	0.52	0.75	0.47	0.32	0.07	0.28
t value	low	2.48	low	low	1.3	low
Level of Confidence		99.0			90%	

The only statistically meaningful result is lower zinc to copper concentrate of 0.75%, at a very high level of confidence. The difference in zinc in feed while not statistically meaningful does show that there is high variability in the zinc in feed for this ore. This data would suggest that there is an improvement in copper/zinc selectivity. There is certainly no evidence to suggest that there is deterioration in zinc metallurgy through higher zinc recovery to the copper concentrate with magnetic conditioning.

The important parameter of copper-zinc selectivity can best be seen by comparing copper/zinc recovery in the copper circuit (Figure 2).

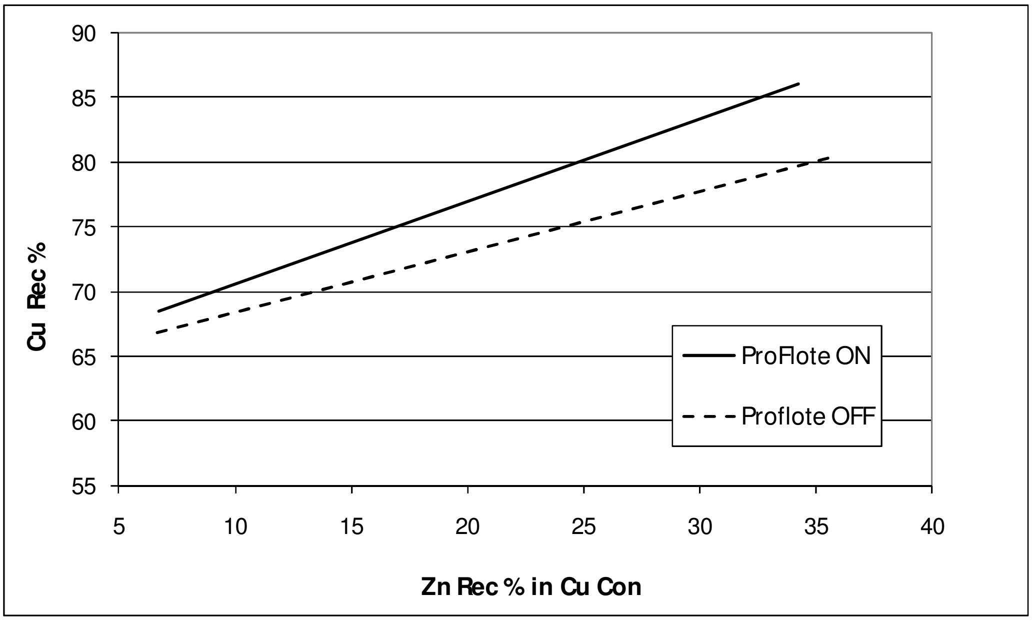

Figure 2 – Cu/Zn selectivity in the copper circuit

It can be seen that there is a substantial increase in chalcopyrite/sphalerite selectivity in the copper circuit. The trend lines for selectivity are similar but separated by about 5% zinc recovery at the same copper recovery. This graph is showing that at the same copper recovery to copper concentrate there is about 5% less zinc recovered.

The increased chalcopyrite/sphalerite selectivity must be due to better rejection of sphalerite, or increased recovery of chalcopyrite. This result is not evidence that there is magnetic hetero-aggregation of chalcopyrite with sphalerite.

Better rejection of sphalerite may be due to magnetic aggregation of sphalerite fines reducing their entrainment in the copper concentrate.

The better chalcopyrite/sphalerite selectivity may be due to magnetic aggregation increasing the chalcopyrite recovery at the same sphalerite recovery.

Plant Results

The on/off plant trial confirmed the metallurgical improvement at the copper circuit and the ProFlote® units are in continuous operation since September, 2009. Monthly metallurgical results for non-spec ore with historical data are given at Figure 2.

It can be clearly seen that copper metallurgy was improved significantly after continuous operation. Copper grade-recovery curve is apparently above the historical data.

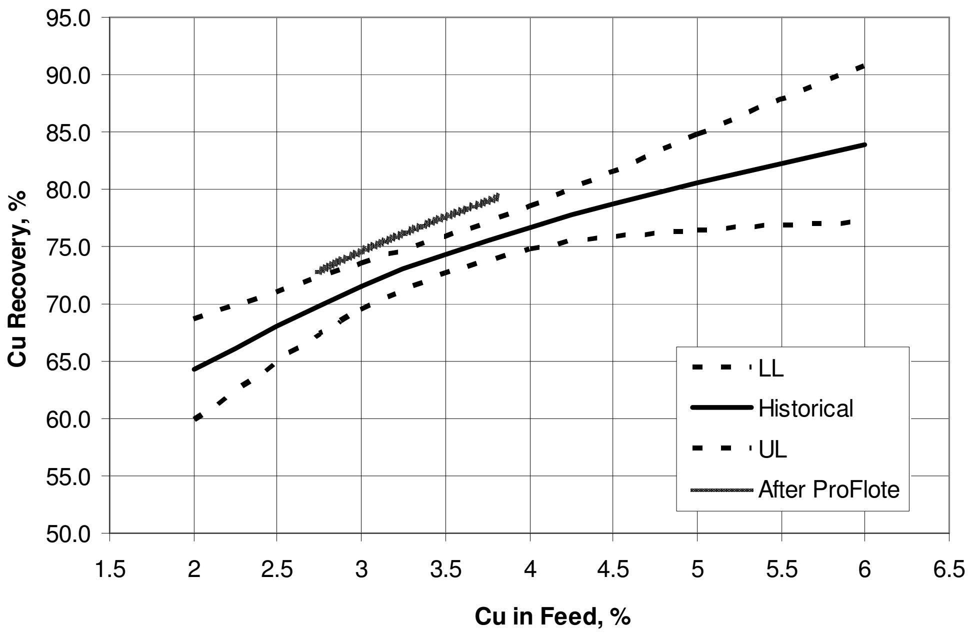

Figure 3 - Monthly metallurgical results for non-spec ore

CONCLUSION

On the predominant Cayeli ore, on/off trial of magnetic conditioning has been shown;

- increases copper recovery by 2,63% with a significance level of 98%
- increases copper/zinc selectivity by decresing zinc in copper concentate 8% with a significance level of 99%.
- Decreases zinc in final tail by 7% with a significance level of 90%

Continuous operation of ProFlote® system confirmed the on/off trial results. Improvement at copper grade-recovery curve compared to historical data is apparent. This improvement at the metallurgy contributes significantly to the net income of Cayeli Bakır Isletmeleri AS.

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