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Abstract: A flotation column could be considered as one of the major breakthroughs in the field of mineral processing in the last decades. Due to an increase in the trend of the use of these type of cells in the mineral processing plants, an investigation regarding the performance of these cells was initiated. The flotation column at the Sarcheshmeh pilot plant with some modifications was restarted. When all necessary measures were taken, the possibility of using the flotation cell in the cleaner and recleaner stages was investigated. Replacing the cleaner cells by the column flotation increased the separation efficiency by 7%. When the column cell was used as recleaner and both cleaner and recleaner, an improvement of 10% was observed. It was found that using a column cell instead of mechanical cells in addition to a decrease in repair and maintenance costs could result in 76% and 83% reduction in energy cost of cleaner and cleaner-recleaner stages, respectively, at the pilot plant.

Keywords: Flotation, flotation column, mechanical cells

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INTRODUCTION

Flotation column appears to be one of the major breakthroughs in the mineral processing field in the last two decades (1–5). At the present time, flotation columns are successfully used in processing of fine porphyry copper ores along with other metallic and non-metallic ores. In the past few years, at the Sarcheshmeh copper complex, a laboratory and a pilot column were designed and tested (6). In the expansion project of the concentration plant, flotation columns have also replaced conventional mechanical flotation cells. This research was initiated with the objective of obtaining some experiences with the installation and operation of flotation columns and determining the best location for the column in the plant flow sheet. The results indicated that installing flotation columns at the cleaners and recleaner sections could lead to improvements in the performance of the circuit.

The Pilot Plant Flow Sheet

The pilot plant, with the capacity of 50 t/d, with a similar flowsheet to the plant, consists of two major sections. The first section includes 14 mechanical flotation cells as roughers which is fed by the primary grinding circuit. Rougher tailing constitutes the bulk of the final tailings. Rougher concentrate is fed to the cleaning section. This section includes cleaner, recleaner, and scavenger cells each consisting of six mechanical cells. Figure 1 shows the overall view of the pilot plant flow sheet.

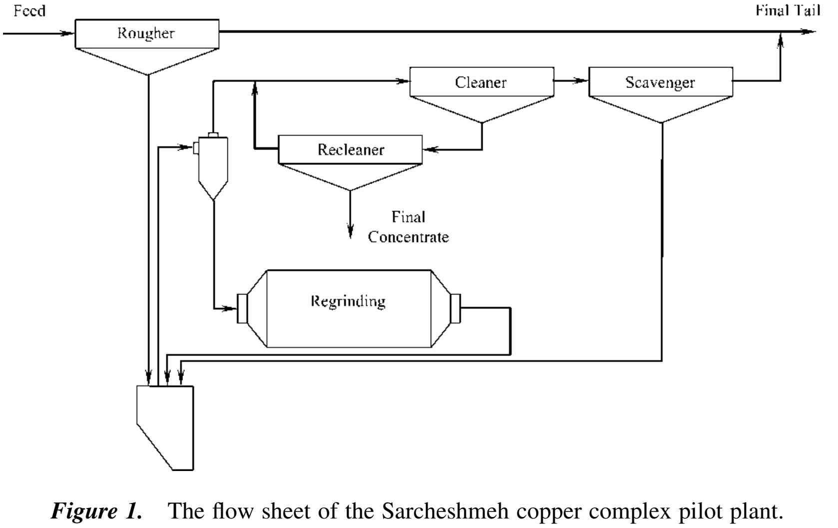

Figure 1. The flow sheet of the Sarcheshmeh copper complex pilot plant.

The Flotation Column

The pilot column (26 cm diameter and 478 cm height) with the objective of using in a cleaner section was designed, constructed, and installed. To detect the interface level (froth depth) a conductivity probe was constructed and the level was controlled by varying the speed of the tailing pump. Provisions to use pressure sensors to determine the interface level have also been considered. The bubble generator system includes two filter cloth spargers and a perforated copper pipe network was used as froth washing system. The type of sparger used was mainly due to availability and the ease of operation. The performance of spargers was kept constant through the visual inspection of the system after each test. At the pilot plant, where usually single tests in a rather short period of time are performed, this approach was found to be practical and reliable.

EXPERIMENTAL

Since traditionally columns have primarily been used to increase the concentrate grade, in this research project the application of the column was considered only for the cleaner and recleaning stages.

In order to determine the best location for the column in the flotation circuit, the column was installed as cleaner and recleaner in separate steps and various tests were performed. For comparison, with each column test a respective test with mechanical cells was also carried out. After performing the preliminary tests, based on the results obtained, the possibility of using the column in place of both the cleaning and the recleaning stages was investigated.

In these tests, samples were taken from a bulk sample of 200 tonnes which was specifically prepared for this research. The reagents used were a combination of collectors Z11 (sodium isopropyl xanthate) and R407 (Mercaptobenzothiazole) and frothers pine oil ($C_{10}H_{17}OH$) and Dowfroth (CH_3-$C(O$-$C_3H_6)_4$-OH). In all the tests the pH and the percent solids of feed to rougher cells were 11.8 and 28%, respectively.

To perform the tests, at first the flotation circuit was started, conditioned, and stabilized under the normal operating conditions, then for a period of 30 minutes using the mechanical cells samples were taken from various points of the circuit. Subsequently, after replacing the desired mechanical cells by the column, without changing the operating conditions, the test was repeated with the new circuit layout. With this arrangement the column was tested against mechanical cells in various points in the flotation circuit. The assays using an in-house mass balance software were balanced which in turn was used for calculation of the performance of various stages of the circuit. All data were analyzed with the t (student) test at the 80% confidence level to compare the mechanical cells performance with the column cell. Due to the nature of the pilot plant work, which is usually associated with moderate fluctuations, the designated confidence level was deemed appropriate. In order to obtain size-by-size recovery with the column and mechanical cells samples of feed, tailings, and concentrate were screened and analyzed. The flotation kinetics study in the column cell was also carried out using the methodology proposed by Finch and Dobby (1).

RESULTS

Using the Column as Cleaner

Using the column cell with in place of six 35-liter mechanical cells various tests were performed. At this stage, 13 tests with the column were carried out. The range of froth depth, air superficial velocity, and wash water superficial velocity used at this stage were 50–80 cm, 1.2–2.5 cm/s, and 0.02–0.2 cm/s, respectively. The operating conditions were then varied with the objective of studying the effect of various factors on the column performance.

The performance of the cleaner section of the flotation circuit with mechanical and column cells for seven tests was compared. The results showed that when the column was used in the cleaner section the separation efficiency (i.e., the difference between recovery of values and gangue to concentrate) increased by 7.3% while the change in recovery and concentration ratio was marginal (0.5%). Hence, it was concluded that the use of the column at the cleaning stage could increase the performance of the flotation circuit.

Figure 2 shows the relationship between concentration ratio and recovery for the cleaning section for mechanical and column cells. The inspection of Fig. 4 indicates that at the constant recovery the use of column instead of mechanical cells could increase the concentration ratio of the cleaning section.

The Use of Column as Recleaner

Various tests, were carried out where a column replaced six 35-liter mechanical cells in the recleaning section. These tests were the first experience of using the column in the recleaning stage at the pilot plant. Since the feed flow rate of the recleaning section was much less than the feed flow rate of the cleaning section, the recycling of tailings in order to control the interface level of the column was necessary. At this stage, 18 tests with the column were performed in which the froth depth was varied between 40 and 120 cm and the superficial air velocity was in the range of 0.94–1.9 cm/s. The superficial wash water velocity for all tests was kept constant at 0.2 cm/s.

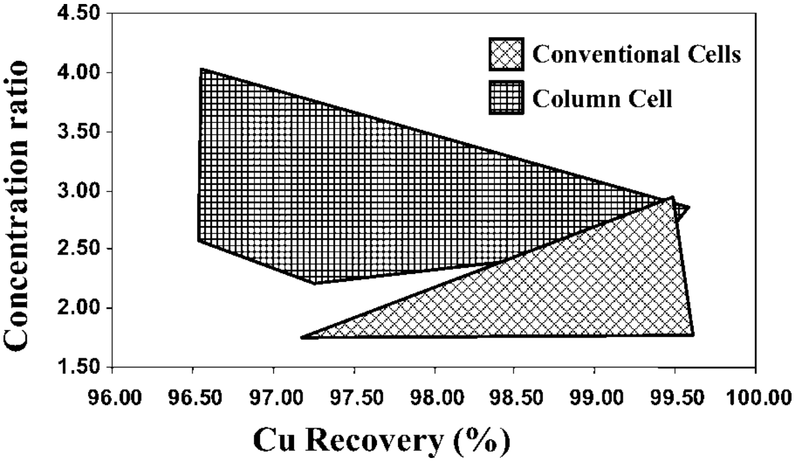

Figure 2. The relationship between concentration ratio and recovery of the cleaning section for mechanical and column cells.

It was found that using the column in the recleaning section compared with the current practice of the pilot plant, decreased the recovery by 0.6% and increased the concentration ratio and separation efficiency 1% and 10.3%, respectively.

The relationship between the concentration ratio and recovery for mechanical and column cells for this stage is shown in Fig. 3. Observation of Fig. 3 indicates that using column instead of mechanical cells at the recleaning stage increased the concentration ratio and decreased the recovery.

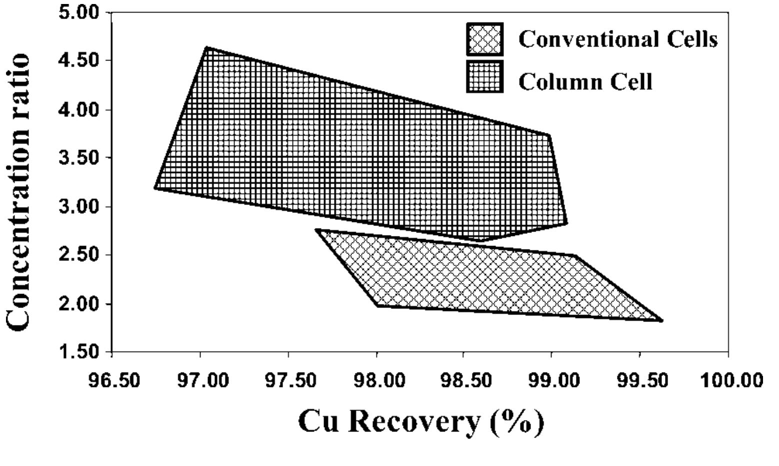

Figure 3. Relationship between concentration ratio and recovery for mechanical and column cells for recleaning stage.

The Use of Column as Both Cleaner and Recleaner

During the tests with the column it was observed that the concentrate grade of the column in some cases was higher than the final concentrate grade where the mechanical cells were used. Given this fact and the published results of studies where the column successfully replaced several stages of mechanical cells led to the idea of using a single stage column to combine the cleaning and the recleaning stages (7–9). For this purpose 12 tests were performed. The first six tests carried out with the column as both the cleaning and the recleaning stages and the rest were parallel tests of column and mechanical cleaning and recleaning cells. In these tests, the column replaced 12 mechanical cells each with the volume of 35 liters. The range of froth depth, air superficial velocity, and wash water superficial velocity used at this stage were 60–100 cm, 1.2–1.9 cm/s, and 0.17–0.2 cm/s, respectively.

The results showed that using the column for both cleaning and recleaning stages at constant recovery could increase the concentration ratio and separation efficiency by 1% and 9.6%, respectively.

The concentration ratio and the recovery relationship for three cases of using mechanical and column cells in both the cleaning and the recleaning and parallel tests of mechanical and column cells in two stages are shown in Fig. 4. In parallel tests the residence time for both cases increased due to an increase in the cleaning section.

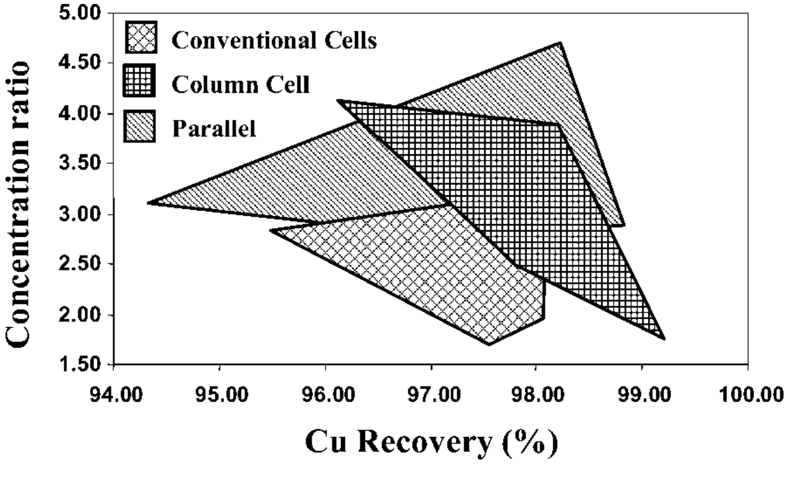

Figure 4. Concentration ratio and recovery relationship for three cases of using mechanical and column cells in both cleaning and recleaning and parallel tests of mechanical and column cells in two stages.

DISCUSSION

The overall results obtained from tests revealed that using a column cell in the cleaning and recleaning stages could lead to improvement in the second part of the flotation circuit of the pilot plant. The comparisons of the column and mechanical cells in the cleaning and the recleaning stages showed that the column had better performance in the cleaning section but in recleaning the mechanical cells performed better. This was attributed to recycling of the major part of the column cell tailings to its feed which in turn increased the recovery significantly at the expense of the concentrate grade.

In order to determine the causes of higher performance of the column against mechanical cells, samples of feed, tailings, and concentrate of both units from various tests were selected, screened, and assayed. The results of a size-by-size analysis indicated that the performance improvement at various stages when using the column was not due to an increase in the recovery of a specific size class. Then it was postulated that the difference stems from the inherent difference between mechanical and column cells in aspects such as mixing pattern, mechanism of bubble-particle collision, froth depth and in particular the use of the froth washing system.

The results of kinetics study are shown in Fig. 5 as cumulative recovery (R) versus time (t) for a period of 20 minutes. The common two-parameter model ($R = R_{\infty}(1 - \exp(kt))$; where k is the rate constant and R_{∞} is ultimate recovery was used to fit to the data. The rate constant and ultimate recovery for copper were found to be 0.64 $\min^{-1}$ and 91.8%, respectively. It was concluded that a mean residence time of 10 minutes would be sufficient in the column because there is no significant increase in recovery after this time.

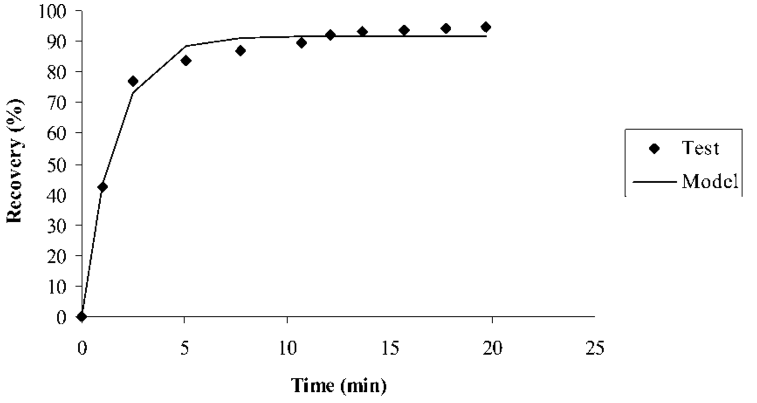

Figure 5. Recovery versus time for the column cell in cleaning section.

Based on the results, due to a higher recovery of mechanical cells and higher concentrate grade obtained from the column, the combined use of mechanical cells as scavenging unit along with the column cell could result in a higher overall circuit performance.

The replacement of the column cell in the pilot plant flotation circuit was carried out without any changes in operating conditions of the circuit. Thus, the application of the column cell in the circuit in addition to an increase in circuit performance, resulted in a significant saving in repair and maintenance costs due to the lower number of cells used. The amount of energy used was also decreased. The column cell uses a 1.1 kW/h pump while for mechanical cells in the cleaning section three 1.5 kW/h motors and in the recleaning section six 1.1 kW/h motors are used for impellers. This translates to a reduction of 24% and 17% in the cost of electricity at the cleaning and recleaning stages, respectively, when the column was used. If the column replaces both the cleaning and recleaning stages, the cost of electricity would only be 10% that of the mechanical cells.

Due to improvement occurring in the performance of the flotation circuit, the reduction of repair and maintenance and electricity costs, the use of the column cell in place of both the cleaning and the recleaning mechanical flotation cells seems to be the appropriate option.

CONCLUSIONS

1. A column flotation was installed and used instead of mechanical flotation cells at the Sarcheshmeh copper mine pilot plant.
2. Replacing the cleaner cells by the column flotation increased the separation efficiency by 7%.
3. When the column replaced two stages (i.e., cleaner and recleaner) in the circuit, an improvement of 10% in separation efficiency was observed.
4. It was found that using a column cell instead of mechanical cells in addition to a decrease in repair and maintenance costs could result in 76% and 83% reduction in energy cost of cleaner and cleaner-recleaner stages, respectively, at the pilot plant.

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REFERENCES

1. Finch, J.A. and Dobby, G.S. (1990) *Column Flotation*; Pergamon Press: New York.
2. Rubinstein, J.B. (1995) *Column Flotation-Processes, Designs and Practices*; Gordon and Breach Science Publishers: Switzerland.
3. Dobby, G. (2002) Column flotation. Mineral Processing Plant Design, Practice and Control Proceedings, 1, SME, 1239–1251.
4. Dobby, G. and Finch, J.A. (1985) Mixing characteristics of industrial flotation columns. *Chem. Eng. Sci.*, 40 (7): 1061–1068.
5. Finch, J.A. (1988) Fundamental fallout from column flotation. *Mining Engineering*, 50 (12): 49–56.
6. Banisi, S. and Finch, J.A. (2001) Testing a flotation column at the Sarcheshmeh copper mine. *Minerals Engineering*, 14 (7): 785–790.
7. Yinantos, J., Bergh, R., Lopez, R., Molinet, P., and Gimenez, P. (1999) Characterization of an industrial flotation column at division Andina, Codelco-Chile. *Minerals Engineering*, 12 (5): 565–575.
8. Del Villar, R. and Soto, H. (1993) Column flotation circuit design at Les Mines Selbaie. *CIM Bulletin.*, 86 (970): 35–45.
9. Finch, J.A. (1995) Column flotation: a selected review-Part IV: novel flotation devices. *Minerals Engineering*, 8 (6): 587–603.