6 PILOT COLUMN FLOTATION TESTS TO INVESTIGATE THE EFFECT OF AN OSCILLATING MAGNETIC FIELD ON THE BASE METAL FLOTATION PERFORMANCE

6.1 Introduction

The pilot flotation column was erected at Nkomati Mine, a nickel mine in Mpumalanga, South Africa. A massive sulphide ore body is currently being mined at a rate of 16 000 tons per month with an average head grade of 2.5% nickel, 0.8% copper and 0.3% cobalt. The Nkomati flotation concentrator produces a nickel sulphide concentrate for toll treatment at various refineries in Southern Africa. Nickel is recovered as the primary metal with copper, cobalt platinum, palladium, rhodium and gold as by-products.

Flotation is used to separate pentlandite, chalcopyrite and the cobalt sulphides from pyrrhotite and waste minerals. Two concentrates, a high grade and a bulk concentrate, are produced by the concentrator. The high-grade concentrate is floated from the first cell and a high percentage of platinum group metals is floated into this concentrate. The bulk concentrate is produced by bulk flotation with cleaning and scavenging steps.

In the cleaner application, pentlandite and chalcopyrite are floated away from pyrrhotite. This is an ideal application to apply an oscillating magnetic field to a flotation column. The magnetic fraction of pyrrhotite reporting to the concentrate can be depressed in the flotation column using the oscillating magnetic field. It should thus be possible to increase the grade of the concentrate without sacrificing the recovery of nickel and copper.

A pilot column from Baker Hughes Process was tested in a cleaner application. A magnetic coil was installed around the column and testwork was done to establish the effect of an oscillating magnetic field on the performance of the column in this application.

6.2 Experimental procedure

The 75mm internal diameter column consisted of three 1.5m perspex sections to give a total height of 4.5m. The feed port was situated 2m from the top of the column and the air sparger was located 1m from the bottom. PID controllers controlled the feed and airflow rates. The feed rate into the column was kept constant during the experiment. A variable speed discharge pump, at the bottom of the column, controlled the discharge rate and the pulp level. A pressure sensor, situated at the bottom of the column, was used as input for a PID controller that controlled the variable speed discharge pump. When the pressure was high in the column, i.e. the pulp level in the column was too high, the PID controller increased the pump speed until the set point pressure was reached. Similarly, the pump slowed down when the pressure was too low. Wash water was added at a constant rate of 0.5l/min from the top of the column.

A magnetic field in the column was generated by using a similar set-up as described in figure 3-3. A 200mm long copper coil with 2000 turns was placed 1.2m from the top of the column in the froth zone. A Hall probe was used to measure the magnetic field strength in the middle of the magnetic coil before the experiment was started. The magnetic field strength was set at 1000 Gauss with a frequency of 15Hz. With this flux and frequency the pyrrhotite particles should be rotated but not levitated.

A cleaner feed stream, with a feed analysis of 7.3% nickel and 1.8% copper with pyrrhotite as the main gangue mineral, was used as feed to the flotation column. An agitated tank was filled with the slurry from the main cleaner feed circuit. This tank ensured a constant composition and a stable feed to the flotation column. No extra reagents were added into the feed tank. The feed rate into the column was kept constant at 2l/min with a density of 1.2kg/l. A stabilisation time of at least 3 times the average residence time was allowed before any samples were taken. Six samples were taken at 5 minute intervals and composited into a single sample for analysis.

Samples of the concentrate and tails were taken for each test and were analysed for nickel, copper and cobalt by the Nkomati laboratory. Recoveries and grades were smoothed using a mass balance package from Kenwalt Systems called Massbal (v1.02). The assay results and the smoothed results are shown in appendix 6.

6.3 Results and discussion

6.3.1 Effect of a magnetic field on mass recovery

The mass recovery into the concentrate was a function of the airflow rate into the column as shown in figure 6-1. It can be seen that the mass recovery was lower when the magnetic field was applied to the column.

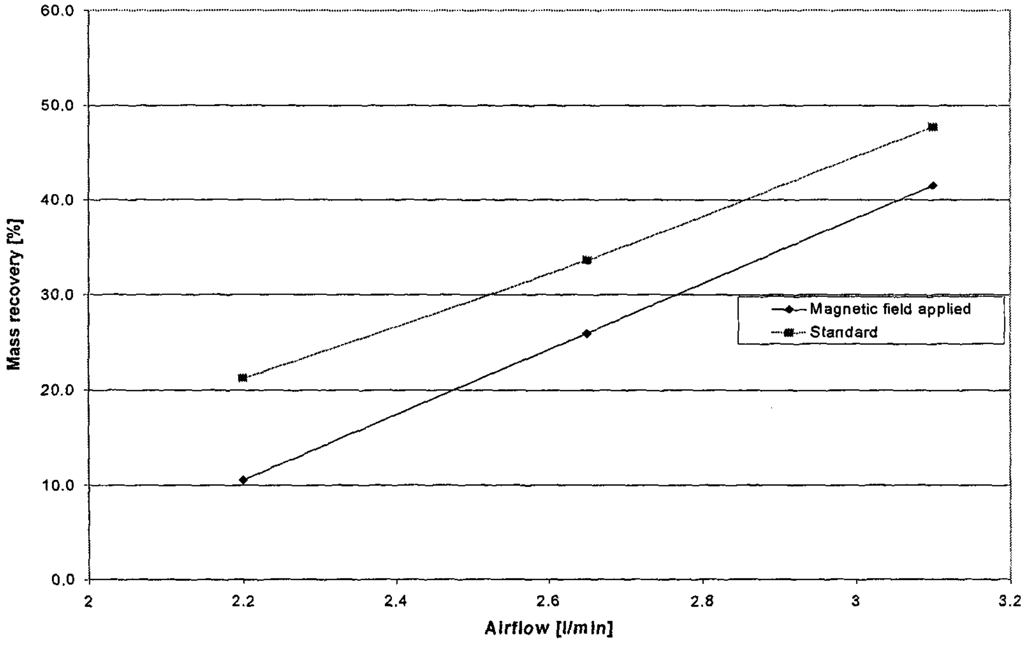

Figure 6-1: Mass recovery of a base metal sulphide feed at various airflow rates for standard column flotation tests and column flotation tests with an externally applied oscillating magnetic field.

At lower airflow rates, the froth flow up the column was slower than at higher flow rates. The retention time of the minerals attached to the air bubbles in the froth zone was higher at lower airflow rates. The magnetic field was applied to the froth zone of the column. Therefore, the time that a pyrrhotite particle, attached to the air bubble, was exposed to the magnetic field increased by decreasing the air flow rate. The probability that the pyrrhotite particle will lose contact with the air bubble is greater at lower airflow rates because of the longer residence time within the magnetic field. It can be seen from figure 6-1 that at low airflow rates there was a greater difference between the mass recoveries for the standard and magnetic tests than for higher airflow rates.

6.3.2 Effect of a magnetic field on copper recoveries and grades

The copper grade and recovery are shown as a function of the airflow rate in figure 6-2.

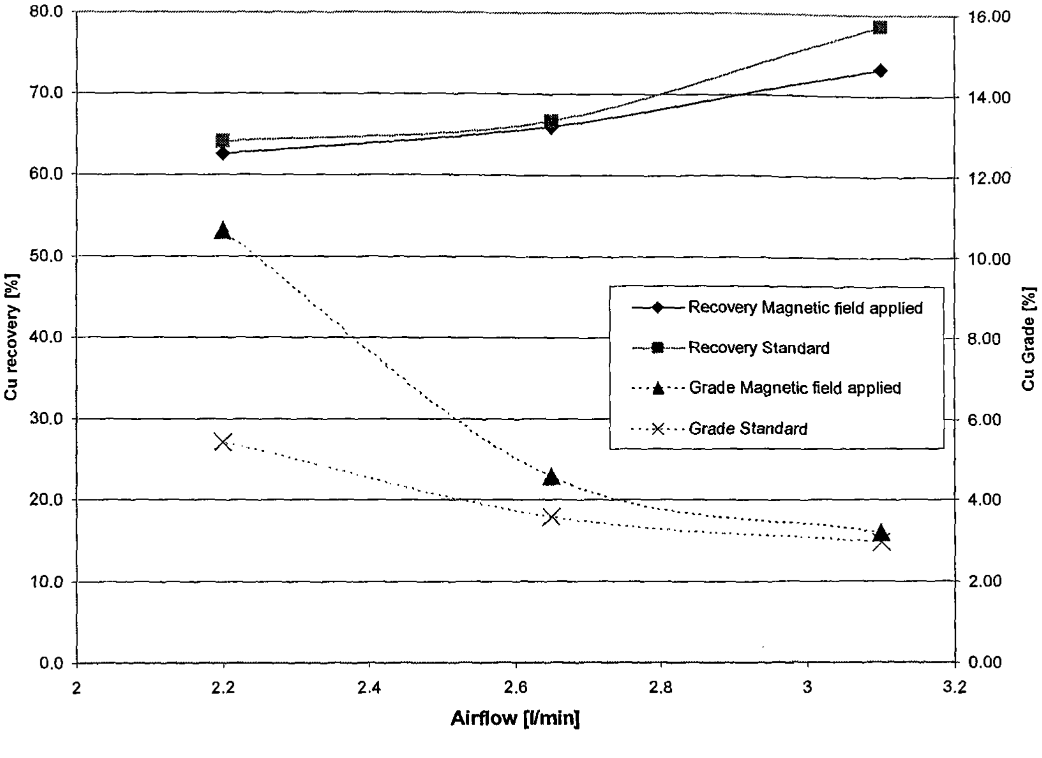

Figure 6-2: Copper recovery and grade at various airflow rates for flotation and for flotation with and without the application of a magnetic field.

As expected, the recovery with and without the application of a magnetic field increased with an increase in airflow rate. Applying an oscillating magnetic field did not significantly affect the recovery of copper. However, the grade at an airflow rate of 2.2l/min in the presence of a magnetic field, was significantly higher than the grade when it was not applied. The higher copper grades can possibly be attributed to depression of pyrrhotite and pentlandite. At higher airflow rates, the difference between copper grades obtained with and without the application of a magnetic field decreased. Using this technique, a copper rich concentrate can be produced albeit at a reduced copper recovery.

6.3.3 Effect of a magnetic field on nickel recoveries and grades

Nickel recoveries and grades for different airflow rates are shown in figure 6-4. Nickel recovery was depressed when a magnetic field was applied to the flotation column. At higher airflow rates, the effect of the magnetic field on nickel recovery diminished. With lower airflow rates, the residence time of a loaded bubble in the magnetic field increased and the possibility of pyrrhotite depression was enhanced. Pentlandite, the nickel bearing sulphide, is closely associated with pyrrhotite. In the cleaner feed stream, used as feed to the pilot column, fine-grained pentlandite is present in pyrrhotite. Therefore, the depression of pyrrhotite will lead to the depression of some of the nickel.

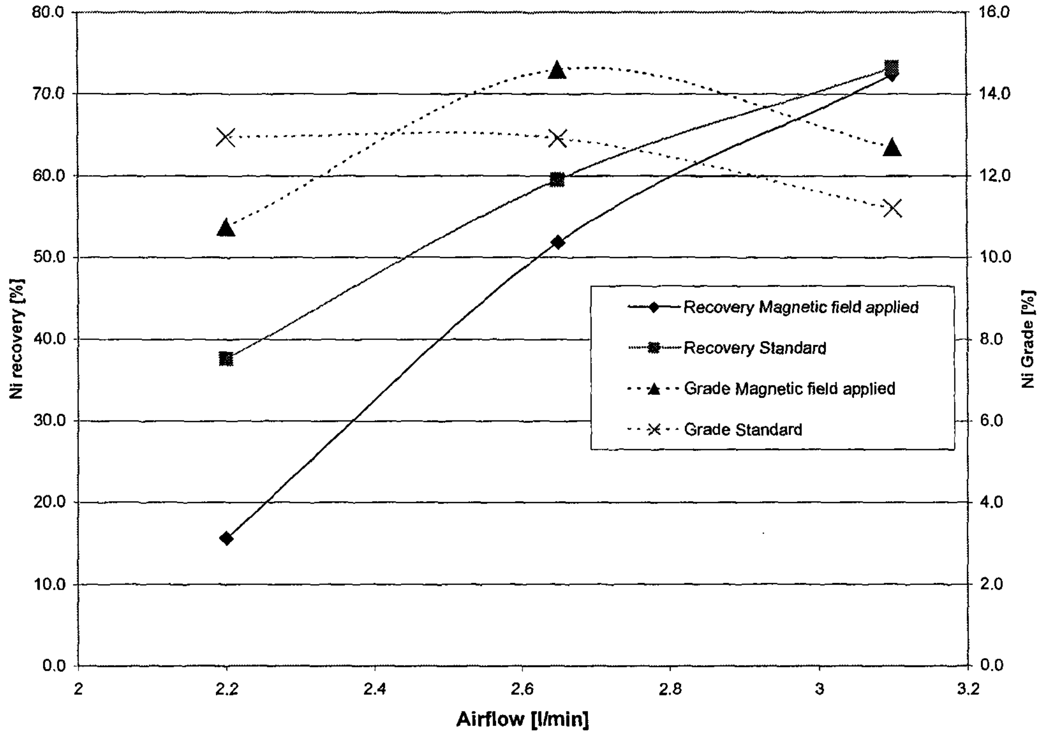

Figure 6-4: Nickel recovery and grade at various airflow rates for standard flotation and for flotation in an oscillating magnetic field.

The low grade of nickel at low airflow rates may be attributed to dilution from copper. Chalcopyrite recoveries were higher than the nickel recoveries, as can be seen by comparing the copper and nickel recoveries from figure 6-3 and figure 6-4. When the magnetic field was applied to the column, the high copper recoveries and the depressed nickel recoveries may be responsible for the low nickel grade at the low airflow rates.

6.3.4 Effect of a magnetic field on the base metal grade recovery curve.

A base metal grade recovery curve, which combines the nickel and copper, is shown in figure 6-5. The base metal grade recovery curve showed the combined nickel and copper recovered at a combined grade. From this curve it is clear that the magnetic field applied to a flotation column produced higher grades for the same recovery. This implies that the flotation recovery and grades can be improved by applying an oscillating magnetic field to the froth zone of a flotation column.

This base metal grade recovery indicates the pure metallurgical performance and does not take the economic metal values of nickel and copper into account. The economic evaluation of applying a magnetic field to a flotation column must be evaluated for each individual application.

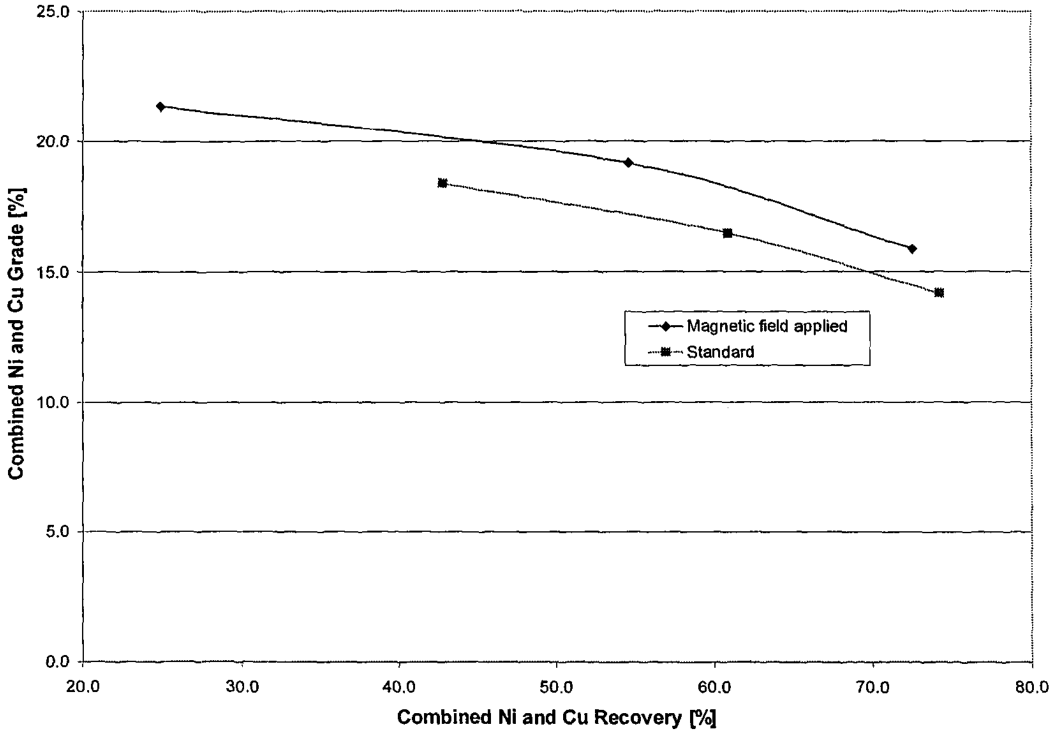

Figure 6-5: Total base metal recovery curves with and without the application of an oscillating magnetic field.

6.4 Conclusions

Copper recoveries were not significantly affected by the presence of an oscillating magnetic field in the froth zone of the flotation column. However, the copper grade obtained in the presence of an oscillating magnetic field and at low airflow rates was higher; possibly due to the depression of pyrrhotite.

The nickel in the cleaner feed stream is closely associated with pyrrhotite and the depression of pyrrhotite will cause some loss in nickel recovery. The combined base metal grade recovery curve with a magnetic field applied to the flotation column was higher than the standard test grade recovery curve. This implies that the metallurgical separation efficiency with a magnetic field applied to a flotation column is better than for standard flotation conditions, albeit at lower nickel recoveries.

This technique is for applications where magnetic minerals need to be depressed from a flotation concentrate. Due to practical constraints, it would not be possible to apply a uniform magnetizing field of up to 1000 Gauss to a large diameter mechanical flotation cell. Column flotation cells are more suited for this application. Even with column flotation cells, the diameter of the column is limited by magnetic gradient in the column. This technique is best suited for specialized applications with small diameter columns.