

1 INTRODUCTION

Nickel is produced from either lateritic or sulphide ore bodies. Generally sulphide nickel deposits are mined and upgraded to produce a nickel sulphide concentrate, which is either hydrometallurgically or pyrometallurgically treated to recover the nickel. With sulphide orebodies the nickel occurs predominantly in pentlandite, a nickel-iron-sulphide mineral. Pyrrhotite, an iron-sulphide, is almost always associated with the nickel bearing pentlandite. These sulphide minerals are hosted in minerals like gabbros, micas, dolomites and serpentine minerals.

Flotation is used to separate the sulphide minerals from the host (gangue) minerals. The surfaces of the sulphide minerals are typically rendered hydrophobic by the addition of flotation collectors such as xanthates. In a flotation cell, the hydrophobic sulphides are floated while the gangue minerals remain in the pulp. Serpentinized minerals like chrysotile, lizardite and talc inhibits the flotation of the sulphide minerals by also collecting at the air bubbles and preventing adherence at the sulphides. Various reagents like carboxymethylcellulose, starches and guar gums can be added to depress the flotation of these gangue minerals and to increase the flotation recovery of the sulphide minerals and the grade of the concentrate. The use of magnetic fields may possibly be used to oscillate magnetically susceptible sulphides to remove these gangue materials from the surfaces of sulphide minerals.

Although pyrrhotite is a sulphide mineral which contains small amounts of nickel as either finely intergrown pentlandite or as nickel in solid solution in the crystal matrix, it is seen as a mineral that dilutes the nickel grade of the flotation concentrate. Pyrrhotite can be depressed by manipulating the chemistry during flotation. However, pyrrhotite occurs in two crystal forms, monoclinic and hexagonal pyrrhotite. Monoclinic pyrrhotite is magnetically susceptible and offers

the possibility to separate the monoclinic pyrrhotite magnetically from the other sulphide minerals but this usually results in unacceptable nickel losses.

Combining flotation and magnetic separation techniques in a single device may offer some beneficial effect; for example applying a magnetic field to a flotation column might enhance the recovery and concentration of the flotation concentrate.

1.1 Testwork

Various experimental set-ups, including micro flotation (Hallimond tube), mini column flotation, pilot scale column flotation, visual observation and chemical analysing techniques were used to determine the effect of an oscillating magnetic field on the chemistry, movement and flotation response of magnetic and non-magnetic minerals.

The first aim of this work was to establish the behaviour of the magnetic minerals in the presence of an oscillating magnetic field. A visual (observation by microscope) laboratory experimental set-up was used to observe the effect of an oscillating magnetic field on magnetically susceptible particles attached to the air bubbles.

The second aim was to determine the effect of the oscillating magnetic field on the flotation performance of the minerals and this was established using various flotation techniques. Laboratory flotation testwork was done in a Hallimond flotation tube and in a 300mm long and 25mm diameter column. Various parameters like magnetic field properties, chemical reagents and the addition of gangue minerals, were also investigated in the laboratory.

The possibility that the oscillating magnetic field will influence the chemical reactions between sulphide minerals and potassium amyl xanthate (flotation collector) was also investigated. UV spectrophotometry was used to measure the concentration of various aqueous xanthate species formed during the conditioning of pyrite in a xanthate solution with and without the application of a magnetic field.

Finally, to prove this technique, an oscillating magnetic field was applied to a pilot flotation column at an operating nickel mine to determine the effect of the magnetic field on the flotation process. The pilot testwork was done at Nkomati Mine in the Mpumalanga province of South Africa. A pilot flotation column from Baker Hughes was used and material from the cleaner flotation circuit was used as feed for the pilot column.