Optimisation of Reagent Addition during Flotation of a Nickel Sulphide ore at the Nkomati Mine Concentrator

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Abstract

Batch scale laboratory testwork was conducted to evaluate collector and depressant addition on flotation performance of a nickel sulphide ore. The objectives of the study were to:

1. develop an understanding of the effects of collector and depressant dosage, and its interactive effects, on flotation performance and
2. determine the effect of stage dosing collector and depressant on flotation performance.

Testwork was conducted on the Nkomati Main Mineralized zone orebody, a nickel sulphide orebody in the Mpumulanga Province of South Africa consisting of pentlandite, chalcopyrite, pyrrhotite, pyrite and magnesium bearing silicates.

Characterisation testwork was conducted, including mineralogy on the major plant streams (by QEMSCAN) and a process survey. The results indicated that there was potential to increase the recovery of coarse pentlandite and that major nickel losses were observed in ultrafine pentlandite. Milling optimisation requires the minimisation of ultrafine generation while ensuring adequate liberation of the course nickel. Stage dosing of collector at nodal points (where more than one stream meets) is currently practiced on the plant, however, its effect had not yet been quantified on the plant or in the laboratory. Stage dosing of depressant is currently practiced on the cleaner flotation stage, however, this too has not been compared to upfront dosage on its own. Significant gangue depression was noted specifically for the cell at which stage dosing was done. The current study would provide an understanding of the current practices with the possibility of offering improvements.

The addition of collector progressively improved the hydrophobicity of the sulphide minerals and gangue (with particular emphasis on magnesium bearing gangue), improving recovery significantly. As a result of additional gangue recovery at the higher collector dosages, increased depressant dosages were required to maximise nickel recovery. The collector improved valuable mineral recovery, however, gangue recovery was increased simultaneously, albeit at a reduced rate or in reduced quantities. Furthermore, increased gangue entrainment was evident at higher collector dosages from the increase in water recovery. Excessive depressant addition destabilised the froth phase by the rejection of

froth stabilising gangue, which resulted in reduced recovery of the valuable minerals. Therefore, a careful balance must be maintained in order to maximise nickel recovery. Iron recovery was markedly increased at higher reagent dosages, indicative of increased pyrrhotite recovery. Pyrrhotite, although containing nickel, reduces the concentrate grade and may need to be depressed in the latter stages of flotation to ensure the final concentrate specification is achieved. This is an important observation as any improvement in nickel recovery in the roughing stages must be evaluated against the subsequent effect on the cleaning stages.

Stage dosing both collector and depressant, individually and collectively, proved to be beneficial by improving the nickel recovery. Stage dosing of both collector and depressant produced higher recoveries than stage dosing of the reagents individually. The time at which the reagent is dosed also proved to have an effect on the performance with an increased dosage in the latter stages providing the highest recovery. The typical recovery by size performance for flotation is characterised by low recovery of fines and coarse with an optimum recovery of an intermediate size fraction. Stage dosing ensures that fine particles are recovered with minimal reagent addition upfront, thereby, coarser particles can be effectively recovered once the high reagent consuming fines are removed. The results have indicated that stage dosing improved the recovery of both coarse and fine particles, whilst reducing the recovery of the intermediate size fraction.

Stage dosing can be implemented for two reasons:

1. maximising recovery
2. minimising reagent consumption to achieve the same recovery as upfront dosing

A financial evaluation should be conducted to quantify the optimum operating solution. Minimising reagent consumption could be beneficial under conditions of very low commodity prices and excessive reagent costs.