J. S. Afr. Inst. Min. Metall., vol. 88, no. 10.
Oct. 1988. pp. 345-347.

On-line analysis at Rooiberg Tin Limited*

by T.V. OWEN†

SYNOPSIS

This paper describes the flotation of cassiterite from fine slimes at Rooiberg Tin Limited, and gives an account of the Amdel on-line analysis system that was installed in 1984 to aid in the control of the concentrate grades.

The system, which is easy to install and maintain, and which uses X-ray-fluorescence analysis, has resulted in improved control, and therefore a better recovery of tin.

SAMEVATTING

Hierdie referaat beskryf die flottasie van kassiteriet uit fynslik by Rooiberg Tin Limited en doen verslag oor die Amdel gekoppelde ontledingstelsel wat in 1984 geïnstalleer is om te help met die beheer oor die konsentraatgrade.

Die stelsel, wat maklik geïnstalleer en onderhou kan word, en wat van X-straalfluoressensieontleding gebruik maak, het gelei tot beter beheer en gevolglik beter herwinning van die tin.

Introduction

In April 1984, an Amdel on-line analysis system was installed on the tin-flotation plant at Rooiberg A Mine. The system was required because of large variations in the grade of the feed to the plant and the resultant need for rapid operational adjustments to control the concentrate grades and so maximize the financial returns. Before the installation, a study was made of the experience of other tin-mining operations in Tasmania and the United Kingdom where similar systems were in use.

The installation and initial calibration at Rooiberg took a month, and the final installed capital cost was R328 500.

Flotation of Cassiterite from Fine Slimes

In the process at A Mine (Fig. 1), fine slimes generated within the gravity-concentrator plant at Rooiberg are thickened in two 15 m thickeners to a relative density of 1,4. Traditionally at Rooiberg, the size distribution of slime has been expressed in terms of the percentage minus 6 μm (cassiterite-containing) material present. The slime currently produced contains 30 to 40 per cent minus 6 μm material. Prior to flotation, this is deslimed to below 15 per cent minus 6 μm material in a series of cyclones of 100 mm and 50 mm diameter. The fine discard slime that is produced contains approximately 90 per cent minus 6 μm material, and totals 20 per cent by mass of the original slime.

The deslimed pulp is fed via a drum magnetic separator (for the removal of magnetite) and a tonnage box to a small conditioner tank ahead of the sulphide-flotation plant. The sulphides are floated using a mixture of xanthates as collectors and TEB frother, and the sulphide concentrate is pumped to a sulphide-cleaning circuit prior to its disposal on a sulphide-slimes dam.

The cassiterite-bearing slime is treated with depressants in two conditioners in series: initially with sodium silico-fluoride (for the adjustment of pH and the depression of tourmaline and silicates), and then, in the second conditioner, with a sodium silicate solution. The pH value of the pulp is controlled in each conditioner to 4,6 by

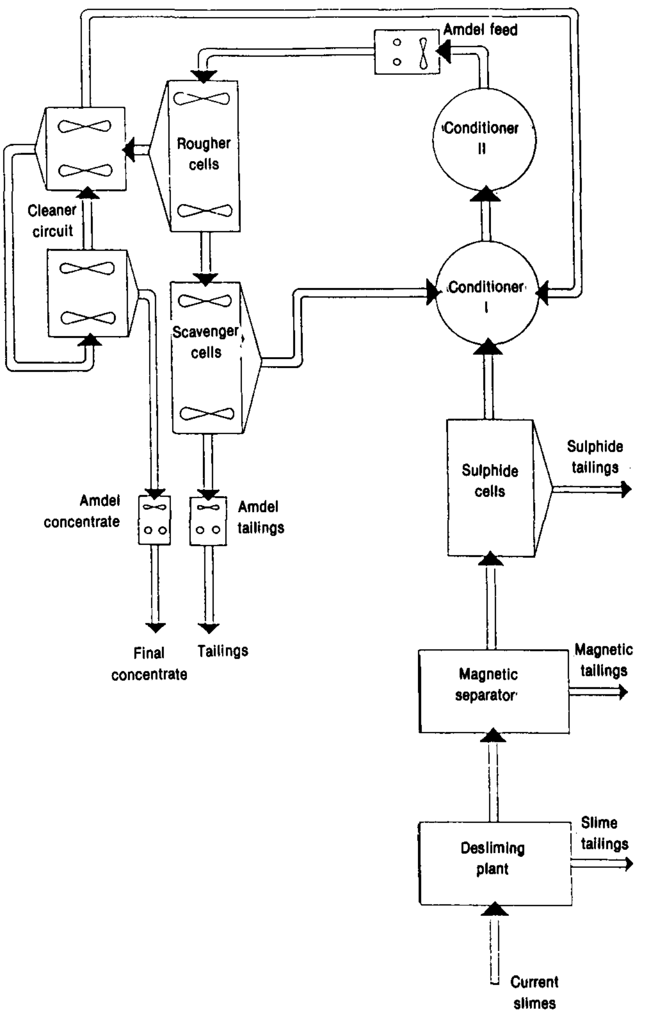

Fig. 1—The slime-treatment plant at Rooiberg Tin Limited

* Paper presented at the Colloquium on On-stream Analysis, which was held by The South African Institute of Mining and Metallurgy at Randburg on 10th November, 1987.

† Assistant Consulting Metallurgist, Gold Fields of South Africa Limited, P.O. Box 1167, Johannesburg 2000.

the addition of a 5 per cent solution of sulphuric acid. The collector, a solution of styrene phosphonic acid in caustic soda, is introduced at four positions in the circuit: two on the rougher banks and two on the scavenger banks of the flotation cells.

The flotation plant consists of 8 No. 18 Denver cells on the rougher bank, 8 No. 18 Denver cells on the scavenger bank, and two banks of No. 15 Denver cells for the cleaner–recleaner circuit. The scavenger concentrate and cleaner tailings are recycled to the first conditioner.

Control of Concentrate Grade

Whether the concentrate is to be sold for toll smelting or is to be smelted at the Rooiberg Smelter, its eventual grade has a very significant effect on the final financial return. Several studies have shown a rapid rise in financial gain as the grade of the concentrate is increased to a peak, followed by a sharp decline after that, the position of the peak being affected by several factors.

Control of the circuit has always presented the operator with the problem of balancing the recovery against the concentrate grade and against the circulating loads within the circuit, for low circulating loads result in low concentrate grades but high recoveries. Fluctuations in the grade of new feed to the plant have to be countered by alteration of the circulating loads to control the grade of the final concentrate.

It has been proved that to control the grade of the concentrate, the grade of the in-circuit 'feed' to the rougher banks must be controlled. A small flotation plant and a concentrate that has proved very sensitive to variations in pH or reagent addition require rapid assay results for the 'feed', concentrate, and tailings if the financial return is to be optimized. For many years, this control was exercised at Rooiberg by the use of small laboratory X-ray-fluorescence analysers. Although analyses with these instruments are rapid, the sample preparation is time-consuming, the normal reporting time for the analysis of routine plant samples being 1 to 2 hours.

An on-line analyser system presented itself as a suitable alternative to the existing control method. The Amdel analyser was chosen mainly because of cost considerations and the ease with which it could be fitted into the circuit.

Description of the Amdel System

Each stream of slurry to be monitored has its own dedicated detection probes, and these are located in an analysis zone situated in each slurry stream. The analysis zones are each tailored to the particular characteristics of the material and stream to be monitored.

A typical analysis zone has several sections. The pulp enters below the surface of the slurry in the first section in order to minimize the entrainment of air, and this is followed by a short section that allows for de-aeration of the pulp stream. Next are the immersion probes and a small agitator that prevents any settling of solids within the zone. The overflow from the analysis zone is large enough to permit clear access for the sampling of slurry for normal calibration purposes.

The retention time in both the de-aeration and analysis sections is normally from 10 to 15 seconds. It is important that the retention time should be of this order, since short retention times induce excessive turbulence and entrainment of air, and long retention times tend to result in segregation of the slurry and a slow response to changes.

The concentrate-analysis zone installed at Rooiberg was initially the smallest size possible while still allowing room for the immersion probes. The zone was later increased in size to give retention times of about 5 minutes. Although this resulted in slower reaction times to variations in the tin content, the correlation between the sample analyses and the line readings improved considerably and the stirrer that was installed prevents segregation.

The most important requirement of the analysis zones is that they should present a perfectly mixed, de-aerated pulp to the immersion probes. In the system as installed at Rooiberg, two probes were fitted in each analysis zone: a density probe and a specific-element absorption probe.

The density probe uses high-energy gamma radiation from a 3 mCi caesium-137 source, this radiation having a reasonably constant absorption coefficient for all elements. The transmission of a collimated beam through matter follows a normal exponential law and, if the path length is constant, the transmission varies with the pulp density.

The specific-element absorption probe uses low-energy gamma radiation from a 1 mCi americium-241 source. The determination of elements by X-ray-fluorescence analysis depends on the measurement of characteristic X-rays, which are produced most efficiently by excitation with radiation just above the K or L shell-absorption edge.

The signals as received from the probes are fed via local signal analysers to a line receiver unit in the control room. A micro-computer accepts all the signals, calculates the various densities and concentrations, and prints out the information as required. At Rooiberg, the computer is programmed to print out analyses every 5 minutes, and average analyses every hour.

X-ray fluorescence or X-ray absorption is a comparative analytical technique, and reliable operation requires that the probes should be calibrated over the whole range of element concentrations and pulp densities normally encountered. Accurate analyses can be expected when interpolation is carried out within the range of conditions encountered during calibration, but not when extrapolation is done outside the range.

Pre-installation tests on samples of Rooiberg tin indicated that relative errors of approximately 5 per cent for the final tailings and 3 per cent for the flotation concentrates could be obtained on the plant.

The calibration procedure is somewhat lengthy and involves the recording of count rates (via a computer print-out) and the simultaneous collection of samples to be assayed for both percentage solids and percentage tin. So that the full range of slurry conditions is covered, the calibration is progressive and the factors used are updated as new samples are collected.

The system can be used for direct process control, but at Rooiberg it is used merely to monitor and record variations for operator information and action.

Maintenance Requirements

Very little maintenance has been required on the system

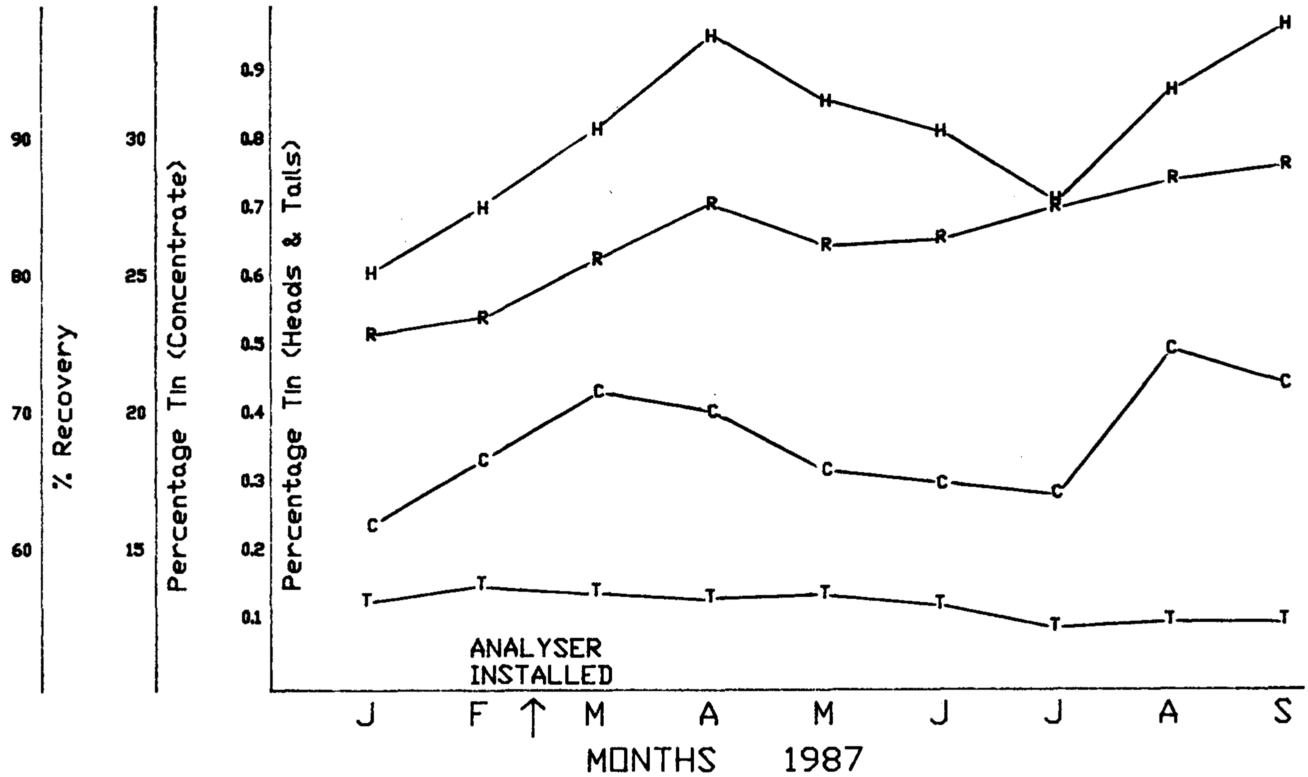

Fig. 2—The performance of a flotation plant at Rooiberg Tin Limited

at Rooiberg, other than the replacement of the stirrers used in the analysis zones. It was originally stated that the windows on the element probes would have to be replaced every month, but it has been found in practice that they need replacement only every 4 months.

On a regular basis during maintenance periods, the count rates measured on standards are recorded, and any variations encountered are corrected by the inclusion of these standard count rates in the correlation equations.

Several electronic problems were encountered initially at Rooiberg that proved difficult to trace, but these 'brown out' failures were eventually traced to a single faulty connection on a memory card.

Some indication of the ease of assembly and basic installation can be obtained from the fact that the equipment was originally installed at the concentrator on the A Mine but, after this plant was closed (during November 1986), the equipment was resited at the Leeuwpoort concentrator. This was carried out by the metallurgical and engineering supervisory staff at Rooiberg without any serious difficulty. The equipment is operating satisfactorily on three streams, but the process of recalibration is continuing.

Assessment of the Analyser

The metallurgical performance of the flotation plant at A Mine after the on-line analyser had been installed was compared with its performance during a 16-month period prior to the installation (Fig. 2). The relationship between the input of tin metal to the flotation plant, the grade of the flotation concentrate, and the recovery gave a reasonable correlation coefficient of 0,89. This relationship was used to predict the recovery of tin metal in the flotation concentrates for a similar period after the installation. Once the equipment had been calibrated and the full confidence of the operating staff had been gained, it was apparent that an average increase in recovery of approximately 2 per cent per month has been achieved, which is equivalent to a pay-back period of approximately 1 year (disregarding any interest payments).

Conclusion

In conclusion, the on-line installation at Rooiberg has several advantages.

(1) The equipment has proved to be reliable and sufficiently accurate for operator control of the plant.
(2) There is no need for mechanical sampling devices such as sample cutters, which have been proved to have biases particularly in the sampling of slurries that contain relatively heavy minerals.
(3) The ease of installation was a good feature.
(4) The equipment has low maintenance requirements.
(5) The system is flexible, and readily permits upgrading or modernization if the need arises.
(6) The recovery of tin by the concentrator has been improved.

Acknowledgements

The author thanks the Amdel agents for their assistance and material used in this paper, and the Management of Rooiberg Tin Limited for permission to present this paper.