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The use of gravity and magnetic separation to recover copper and lead from Tsumeb flotation tailings

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SYNOPSIS

The use of gravity or magnetic separation followed by upgrading on a shaking table recovered about 25 per cent of the copper and lead minerals, at a combined metal grade of 20 per cent, from the final flotation tailing at the Tsumeb Mine.

Magnetic separation recovered the copper minerals more efficiently than the lead minerals; it also recovered finer particles more efficiently than standard gravity separators. However, the grade of the concentrate produced by magnetic separation was not of sufficiently high grade, and further upgrading by gravity separation was necessary.

It was decided to install an 'all-gravity' plant, which would have the added advantage of acting as a monitor or 'policeman' on a plant that receives a fairly variable feed.

SAMEVATTING

Die gebruik van gravitasie- of magnetiese skeiding gevolg deur opgradering op 'n skudtafel het ongeveer 25 persent van die koper- en loodminerale, met 'n gekombineerde metaalgraad van 20 persent, uit die finale flottasie-uitskot by die Tsumeb-myn herwin.

Magnetiese skeiding het die koperminerale meer doeltreffend as die loodminerale herwin; dit het ook die fyner partikels meer doeltreffend as standaardgravitasieskeiers herwin. Die graad van die konsentraat wat deur magnetiese skeiding verkry is, was egter nie hoog genoeg nie, en verdere opgradering deur gravitasieskeiding was nodig.

Daar is besluit om 'n hele gravitasieaanleg te installeer wat die bykomende voordeel sou hê dat dit as 'n monitor of waarskutoestel kan dien by 'n aanleg met 'n redelik veranderlike toevoer.

Introduction

The difficulties encountered by the Tsumeb Corporation Limited in recovering various complex copper and lead vanadate and arsenate minerals by flotation have been described elsewhere[1]. The Council for Mineral Technology (Mintek) undertook to investigate the possibility that additional copper and lead minerals could be recovered from the flotation tailings by gravity and magnetic separation.

That paper[1] discusses the results obtained by magnetic separation, and describes batch and continuous tests in which the effects of flowrate, different matrices, magnetic susceptibility, desliming, pulp density, wash water, and dispersant were investigated. The magnetic fractions from those tests generally had a lower combined copper and lead grade than the 20 per cent specified by the smelter at Tsumeb. A second stage of magnetic separation was unable to produce material of the required purity, and it was necessary to clean the concentrates by gravity separation.

This paper describes the work done in which gravity separation was employed as a primary concentration step in parallel with wet high-intensity magnetic separation (WHIMS), and for further upgrading of primary concentrates. Batch tests were conducted at Mintek, followed by pilot-plant tests at the Tsumeb concentrator.

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Batch Spiral Tests

In the first phase of the investigation into gravity separation described here, samples of the feed to the flotation of oxides, the oxide-flotation tailings, and the oxide-flotation tailings that had been deslimed by a cyclone at Tsumeb were upgraded on a Mineral Deposits LG7 spiral concentrator. This spiral, which was designed to treat material containing less than 5 per cent heavy minerals and does not require the addition of wash water, is equipped with one set of product cutters at the discharge end of the trough.

Three runs were generally carried out with the product splitters set to cut high-, intermediate-, and low-grade fractions, as shown in Fig. 1. The grades and recoveries of the concentrates and middlings from the tests were cumulated and plotted as grade–recovery curves (Figs. 2 to 4). The recovery of lead was better than that of copper, and the zinc recovery was very low. The recoveries of copper and lead at a grade of 5 per cent each are compared in Table I. Fig. 3 shows the improved performance obtained with a feed that had been deslimed.

The concentrates contained major amounts of cerussite, minor amounts of malachite, conichalcite, and duftite, and trace amounts of azurite, bornite, and mottramite.

Duplex Concentrator

At the start of the project, a large proportion of the losses from the flotation circuit had been in the finer sizes.

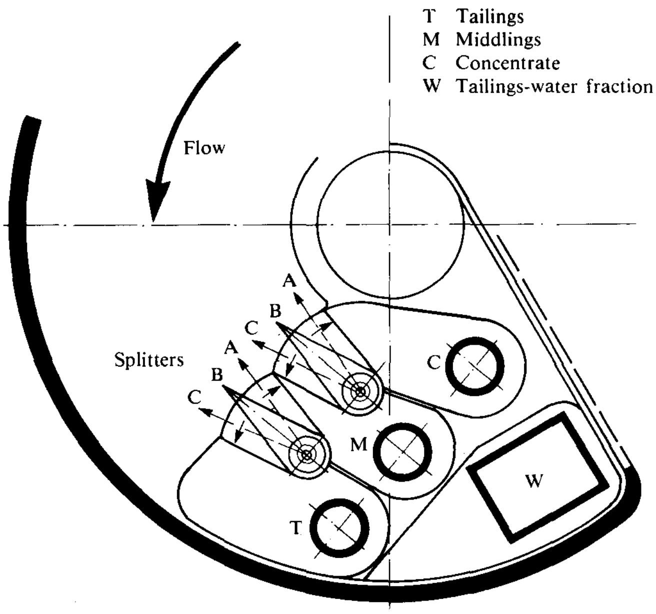

Fig. 1—Position of spiral splitters

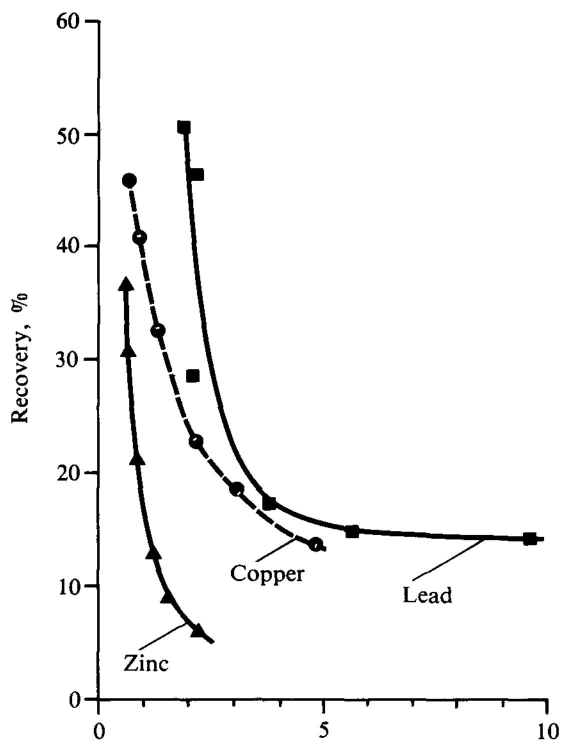

Fig. 2—Spiral tests on oxide tailings

For this reason, it was decided to use a gravity separator specifically designed to treat finer-size particles, such as the GEC Duplex concentrator (Fig. 5), which uses the principle of thin-film separation and has two smooth decks. The concentrate is washed alternately off one deck while material is fed to and concentrated on the other deck.

A portion of the tailing from the oxide flotation was screened at 75 μm, and the fines were upgraded on the GEC Duplex. The results are shown in Fig. 6. The grade

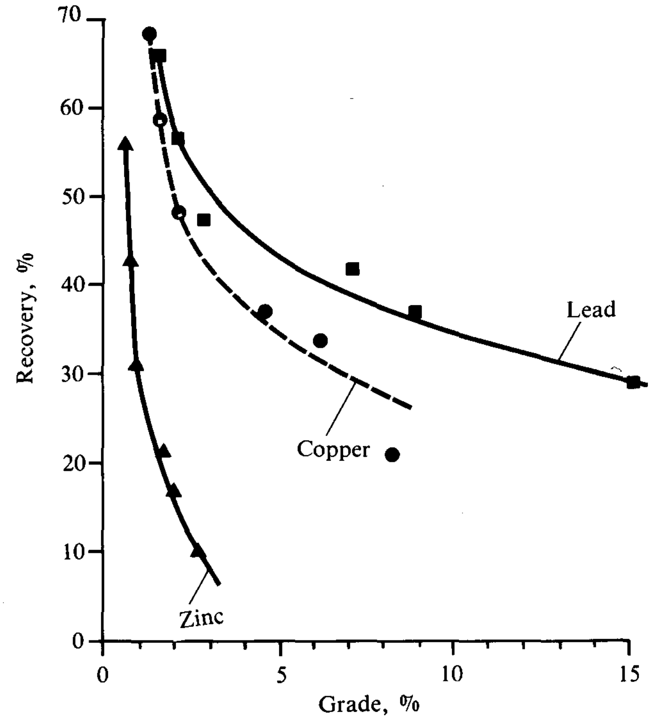

Fig. 3—Spiral tests on deslimed oxide tailings

and recovery of the lead minerals, which have a higher relative density, again surpassed those for copper or zinc, the recovery of copper and lead being 25 and 28 per cent respectively at a grade of 5 per cent each. The recovery of copper dropped off rapidly as the grade of the concentrate improved, whereas the drop in the recovery of lead with improved grade was low.

The concentrates contained major amounts of duftite, minor amounts of cerussite and malachite, and traces of mottramite, mimetite, and conichalcite.

Secondary Upgrading by Gravity

In the second phase of the investigation, additional samples of tailings were received for primary gravity separation on a spiral, and for cleaning of the primary concentrates from the spiral and of those from batch and continuous magnetic separators by tabling.

A minimum combined copper and lead grade of 20 per cent is specified by the smelter. Curves of grade versus recovery and grade versus mass were plotted to show the mass of concentrate and the recoveries of copper and lead at a combined grade of 20 per cent. Fig. 7 shows such a curve for the secondary upgrading by tabling of the magnetic fraction obtained in the continuous test on the cyclone underflow from Tsumeb.

The results, calculated at a combined copper and lead grade of 20 per cent, of tests in which secondary upgrading of gravity and magnetic concentrates was done are shown in Table II.

Desliming of the feed in the cyclone at Mintek had been more efficient than at Tsumeb[1]. In all cases, the results after secondary upgrading showed that higher recoveries were obtained when the feed had been deslimed efficiently. With the 'all-gravity' circuit, the combined recovery for the Tsumeb overflow and underflow, which were treated separately, was the same as that for the Mintek

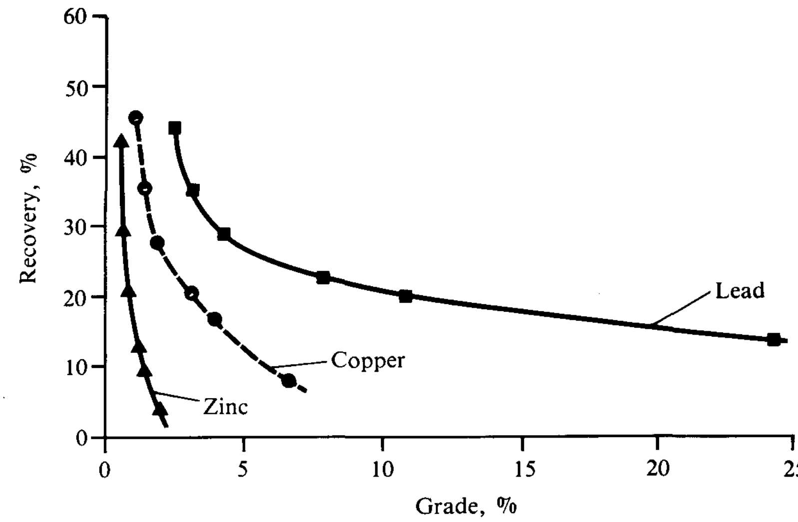

Fig. 4—Spiral tests on oxide feed

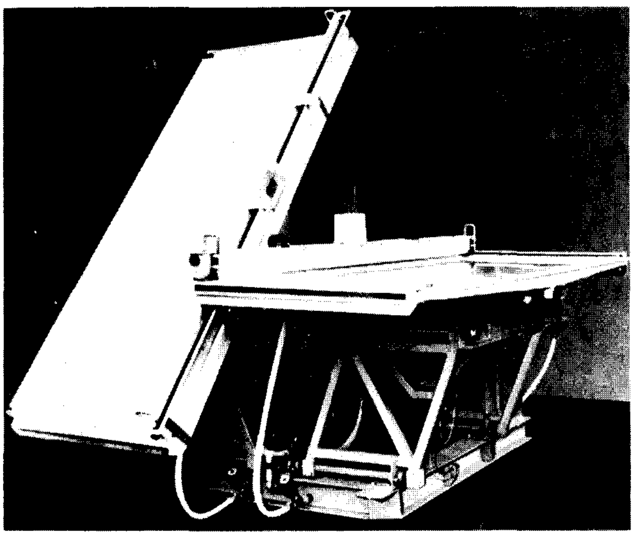

Fig. 5—The GEC Duplex concentrator

TABLE I
RECOVERIES OF COPPER AND LEAD AT A GRADE OF 5 PER CENT EACH

	Recovery, %	
Spiral feed	Copper	Lead
Oxide feed	12,9	27,0
Oxide tailing	12,8	15,5
Deslimed oxide tailing	34,6	43,0

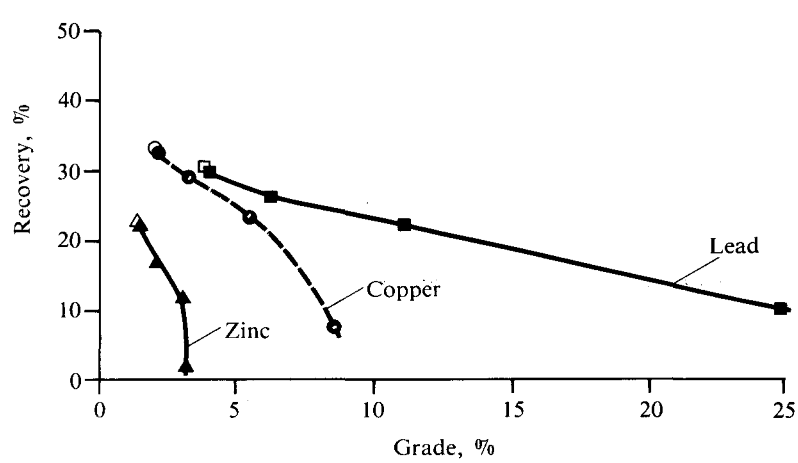

Fig. 6—Results of tests on the GEC Duplex concentrator

underflow. However, with the magnetic-gravity circuit, the Mintek underflow gave a better recovery than the Tsumeb underflow and overflow together. This highlights the importance of efficient desliming of the feed before separation.

The use of a spiral for cleaning yielded concentrates of acceptable grade, but the recoveries were lower than when the shaking table was used.

The treatment of the samples in the first phase showed that gravity separation recovered a larger amount of lead minerals but, for the new samples, the recoveries of copper and lead were fairly similar. This indicates to some

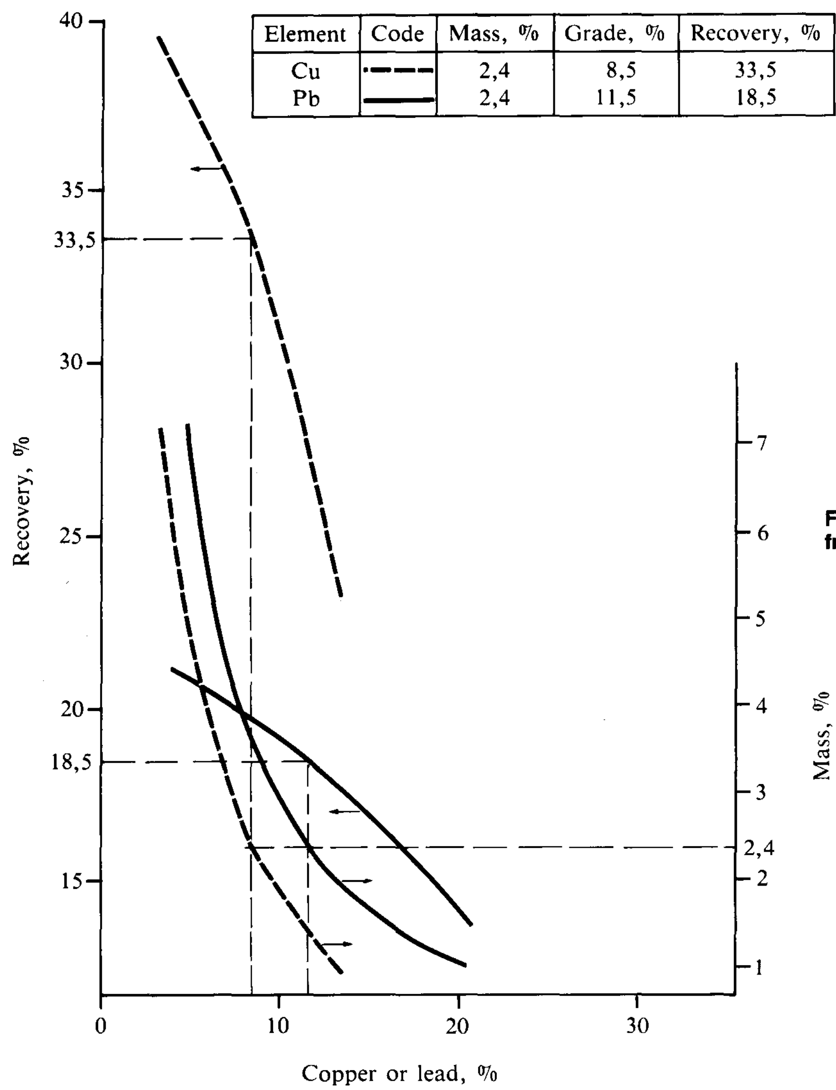

Fig. 7—Results of tabling test on magnetic material from the continuous test on the cyclone underflow from Tsumeb

TABLE II
OVERALL RESULTS AS PERCENTAGES OF THE OXIDE TAILINGS

Feed	Secondary concen-trator	Mass %	Copper %	Copper Recovery %	Lead %	Lead Recovery %
Batch mags	Table					
U/F (Mintek)		2,68	9,0	36,8	11,0	26,3
U/F (Tsumeb)		2,48	8,4	26,7	11,6	21,6
Continuous mags	Spiral					
U/F (Mintek)		2,13	8,5	26,4	11,5	22,6
U/F (Tsumeb)		0,44	7,6	6,7	12,4	4,7
Continuous mags	Table					
U/F (Mintek)		2,55	9,0	35,5	11,0	27,0
U/F (Tsumeb)		1,32	8,5	18,4	11,5	10,2
O/F (Tsumeb)		0,45	6,5	7,1	13,5	5,6
Spiral conct.	Table					
U/F (Mintek)		2,55	7,7	28,3	12,7	27,3
U/F (Tsumeb)		2,20	8,0	25,9	12,0	23,8
O/F (Tsumeb)		0,43	8,0	3,8	12,0	2,8

Note: The results are calculated at a combined copper-lead metal grade of 20 per cent

extent the complex nature of the orebody at Tsumeb, where the mineral composition of the feed varied fairly frequently.

Pilot-plant Tests

Magnetic- and gravity-separation equipment from Mintek was used at Tsumeb in the construction of a pilot plant (Fig. 8). A portion of the final flotation tailings, cut by the on-line Courier system, was deslimed in a 100 mm polyurethane cyclone supplied by Multotec. The underflow was pumped to a four-way splitter, from which one stream was fed to the carousel magnetic separator and a second was run over the spiral, the excess material being discarded.

The magnetic fraction and part of the middlings were cleaned on one full-scale shaking table and the spiral concentrate and middlings on another. The mass of the primary concentrates produced was too small for the capacity of the tables, and their decks were in poor condition. The recoveries were therefore lower than had been expected.

The variability of the pilot-plant feed affected the reproducibility of the results. The conditions of the feed were generally varied to suit the WHIMS machine, whereas no variations were made specifically for the spiral.

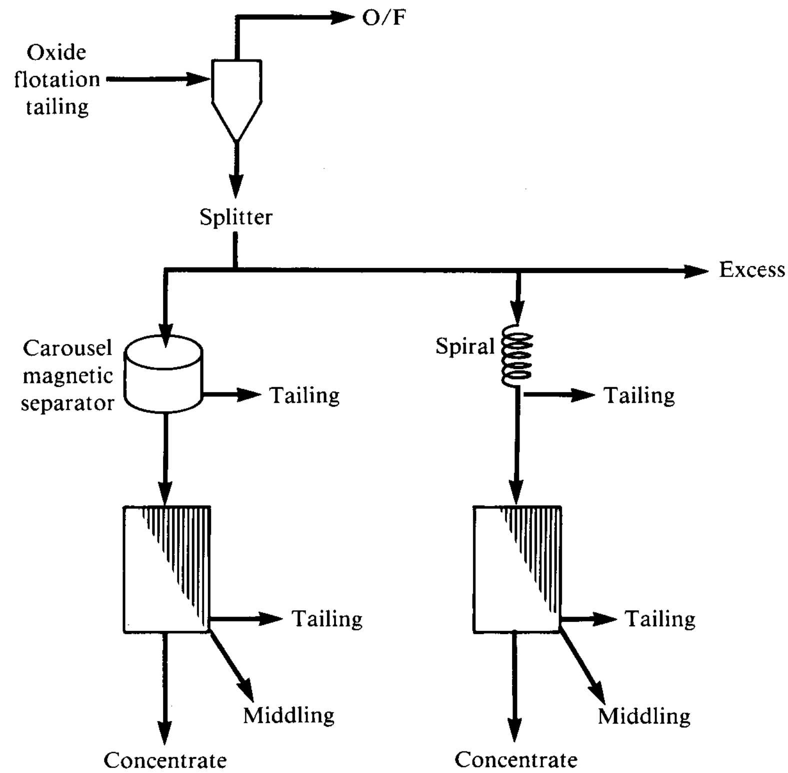

Fig. 8—Schematic representation of the pilot plant at Tsumeb

TABLE III
SUMMARY OF PILOT-PLANT RESULTS

Test	Recovery at combined grade of 20%		Calculated head, %		Assay head, %	
	Cu, %	Pb, %	Cu	Pb	Cu	Pb
Pre-concentration by WHIMS						
Mintek underflow*	41,8	31,8	0,64	1,05	0,53	1,09
Tsumeb underflow*	33,5	18,5	0,52	0,90	0,51	1,14
Run 19	31,4	22,6	0,62	0,88	0,58	0,92
Run 20	44,9	33,7	0,94	1,21	0,64	0,84
Run 22	38,3	29,4	0,82	1,10	0,58	0,90
Run 25	25,0†	20,0†	0,52	0,81	0,48	0,80
Run 25 (batch table)	32,0	35,0				
Run 28E (spiral cleaner)	33,2	36,6	0,50	0,84	0,6	0,8
Run 29A (spiral cleaner)	42,1	45,0	0,69	1,15	0,6	1,1
Run 29D (spiral cleaner)	38,0	26,1	0,40	0,90	0,6	0,9
Pre-concentration by spiral						
Mintek underflow*	33,3	32,1	0,62	1,15	0,53	1,09
Tsumeb underflow*	47,0	43,2	0,66	1,13	0,51	1,14
Run 21	37,1	54,5	0,94	1,81	1,16	1,54
Run 22	29,5	31,0	0,82	1,10	0,58	0,90
Run 25	26,5	28,6	0,52	0,81	0,48	0,80
Run 25 (batch table)	39,3	37,5				

* Results of tests at Mintek in the second phase of the project
† The combined grade of the final concentrate was only 10,7 per cent
Note: The secondary concentration step was done on a shaking table in all the runs except runs 28 and 29, in which a spiral was used

The results of a number of pilot-plant runs are compared with those of the tests at Mintek in Table III. The recoveries are based on the feeds to the individual concentrators, and the results demonstrate the variations in the composition of the ore being mined at the time.

The primary products from run 25 were also upgraded on a small laboratory shaking table. The recoveries were 10 per cent higher at a combined grade of 20 per cent. This illustrates the results that can be expected from properly matched equipment in good condition.

With a few exceptions, the two head values are in reasonable agreement, and show to some extent the variability that can be expected in flotation tailings.

Economics

A brief economic study was carried out early in 1985. Budget prices were obtained for the major items of equipment, the cost of the pumps and available Deister tables being ignored in the calculations. The equipment was of a size to treat 70 t of final flotation tailing per hour.

The estimated capital cost of an all-gravity circuit, consisting of cyclones, spirals, and Duplex concentrators to treat the cyclone overflow, was R325 500. A magnetic-separation circuit with cyclones and two Eriez separators would cost R660 000, and a magnetic circuit combined with a GEC Duplex separator to clean the magnetic concentrate would cost R715 000.

It was decided to proceed with the installation of an all-gravity plant when escalations in price ruled out the installation of a WHIMS plant, which would yield only marginal improvements to offset its additional cost.

Conclusions

The testwork showed that primary magnetic or gravity separation followed by efficient cleaning of the concentrate on a shaking table is likely to recover about 25 per cent of the copper and lead from the final oxide flotation tailing at a combined copper and lead grade of 20 per cent.

A scavenging plant of this nature would have the added benefit of acting as a monitor or as a 'policeman' on a plant that received a fairly variable feed. Losses of the valuable minerals due to sudden changes in the feed grade or composition could be reduced considerably.

Magnetic separation, when used for both primary and secondary separation, did not produce a concentrate of sufficiently high grade, and gravity techniques were necessary for upgrading.

Magnetic separation recovers copper minerals more efficiently than lead minerals, and can recover very much finer particles than standard gravity separators. Some of the finer particles recovered by WHIMS are lost during upgrading on the shaking table. A thin film separator, such as the Duplex, would increase the recovery in the cleaning stages.

Efficient desliming of the feed was found to be beneficial to the process, particularly when the magnetic-gravity circuit at Mintek was used. This trend was not as obvious for the material treated by the pilot plant at Tsumeb. Whether this was due to a difference in the ore or to a more constant feed to the plant during the tests at Mintek is not known.

Acknowledgements

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Reference

1. Svoboda, J., Guest, R.N., and Venter, W.J.C. The recovery of copper and lead minerals from Tsumeb flotation tailings by magnetic separation. *J. S. Afr. Inst. Min. Metall.*, vol. 88, no. 1. (This issue.) pp. 9–19.

Computers in welding

The Second International Conference on Computer Technology in Welding will be held in Cambridge, England, on 8th and 9th June, 1988.

Rapid advancements in the field of computer technology have brought a spectrum of actual and potential applications to the field of welding technology at an extraordinary rate. Countries throughout the world have been involved in the development and exploitation of the new technology in a wide range of subject areas concerned with fabrication and welding.

The capability of handling large amounts of data quickly and with flexibility has proved to be advantageous in several key facets of welding. For example, advanced welding systems involving sensing of conditions in and around the weld, and subsequent adjustment of parameters, require a high order of speed and flexibility. Computers are also being used for the storage, retrieval, and manipulation of vast amounts of welding engineering and design data.

The advantages offered by computer technology have created a demand for knowledge of both current achievements and future potential. Following the success of the First International Conference on Computer Technology in Welding in 1986, the time is now opportune to launch the second international conference on this advancing area of technology. The Conference will allow presentation and discussion of the use of computers in welding and fabrication technology in its broadest sense, and will bring together authors from various fields: computer hardware specialists, software writers, fabricators, welding-system designers and manufacturers, welding engineers, and information scientists. A most important state-of-the-art review of current applications, available equipment, and possibilities for the future will be presented.

The Welding Institute invites the offer of papers from industry, research and development organizations, and academic institutions.

As a guide to potential authors, the following is a list of some of the topics that will be covered during the Conference:

- Hardware: mainframe, mini, and micro
- CAD and CAM software
- Finite element analysis
- Information technology
- Welding process automation and control
- Expert systems
- Instrumentation and QA.

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