GEOLOGIE EN MIJNBOUW VOLUME 51 (3), p. 419–421 1972

SUMMARY

THE RESEARCH AND DEVELOPMENT DEPARTMENT OF NCHANGA CONSOLIDATED COPPER MINES LIMITED

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The Research and Development Department is part of the Centralised Services Division of Nchanga Consolidated Copper Mines. It is based in Kitwe, in the close proximity of other services departments.

Until recently the Head of R. and D. was assisted by four section leaders, responsible for Mineral Dressing, Pyrometallurgy, Hydrometallurgy and Laboratory Services. This arrangement was altered, and the department operates on a projects basis. A project team will investigate all fields of metallurgy required in the flowsheet. The project leaders are directly responsible to the Head of R. and D.

The laboratory services acts as a service to the whole mining industry. It conducts research in a number of fields requiring specialised equipment and job knowledge, such as x-ray analysis, metallography and mineralogy.

The major part of the work at R. and D. consists of pure metallurgy, related to the improvement of existing processes or the development of new treatment routes. Since each operating plant has a number of metallurgical engineers in charge of plant development, R. and D. is mainly involved in the development of large scale new processes. Particular attention has been paid in recent years to the treatment of waste products such as current tailings, old tailings dams and slags.

A considerable amount of work in R. and D. is conducted on mineral dressing projects. Investigations vary from basic design of mineral dressing plants from ore studies, to testwork aimed at improving the overall metallurgy of existing concentrator installations. Recent projects include the replacement of fatty acid collectors for oxide copper minerals by sulphydric collectors of the xanthate type, and the reflotation of cobalt concentrates using amine collectors. Investigations are at present being conducted to assess the possibility of introducing sands flotation of tailings at all existing concentrators.

Some of the major projects in which R. and D. has been involved are the following: the development of the Torco process in the early sixties, improvements in flotation at Rokana and Chingola, the design of the flowsheet for the Nampundwe and Bwana Mkubwa concentrators and the Chingola Tailings Leach Plant.

The testwork related to the solvent extraction circuit of the Chingola Tailings Leach Plant is used as an example of the type of work conducted at R. and D.

SOLVENT EXTRACTION

The Chingola Tailings Leach Plant will treat tailings and other low grade waste materials. The flowsheet consists of a two-stage leach circuit, followed by counter current thickening and washing and subsequent recovery of copper from dilute solution by solvent extraction. The application of solvent extraction in copper metallurgy is a new technique which has only become possible by the development of the General Mills reagent Lix 64N.

Extensive laboratory and pilot plant testwork was

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conducted on the physical and chemical characteristics of the solvent extraction system.

The following areas were investigated.

Mixer Performance

The considerable effect of mixer efficiency on the performance of the circuit is demonstrated in McCabe-Thiele diagrams. It was observed that the stage efficiency tended to decrease from the first to the last extraction stage due to the increased acidity. Generally, it was found that a stage efficiency of 88-93% could be obtained with a 2 minute mixer residence time.

Diluents

Lix 64N as received has a high viscosity and is diluted prior to application. The following properties are required of the diluent:

1. high flash point and low evaporation rate,
2. low solubility in water,
3. adequate solvency for Lix 64N,
4. low viscosity and suitable interfacial tension after mixing with Lix 64N,
5. non-interference with the basic chemical reactions.

Several kerosenes were tested. It was observed that the chemical characteristics of Lix 64N can be affected considerably by the diluent.

A number of suitable diluents have been selected for further pilot plant evaluation. These kerosenes are predominantly aliphatic/naphthenic in composition, with a flash point (closed cup) of 70-80°C.

Dispersion Band

The depth of the dispersion band is dependent on settler area and Lix tenor. The phase disengagement was found to be more rapid in the strip circuit than in extraction.

Temperature was found to have a considerable effect on the dispersion band; cooling the aqueous feed from 20°C to 15°C, approximately, doubled the dispersion band depth, whilst a rise to 24°C reduced the depth by about 30%.

Phase Continuity and Phase Ratio

During mixing of the organic and aqueous phases, either phase can be dispersed in the other; phase continuity has a considerable effect on the system. An organic continuous mixture has slightly faster reaction kinetics than an aqueous continuous system; the phase disengagement rate is considerably faster in an aqueous continuous system. Phase continuity also affects the entrainment; the entrainment of organic in the aqueous phase is lower in an organic continuous system than in the reverse continuous system.

Pilot Plant operation demonstrated that in the presence of crud, or certain organic reagents, the settler operation is considerably more difficult in the aqueous continuous system.

Operation of the pilot plant was found to be easiest when using a 1 : 1 0/A ratio, with the organic phase continuous. In the strip circuit this was achieved by operating with a recycle of electrolyte over each mixer-settler stage.

Selectivity for Cu^{2+} Ions

It was found that Lix 62N is very selective in its extraction of copper from impure solutions. The most important impurity co-extracted with copper is iron in the trivalent state. The extraction of Fe^{3+} by Lix 64N is very slow; under laboratory mixing conditions equilibrium is only obtained after approximately 30 minutes in comparison with 1-2 minutes for Cu^{2+}

Organic Reagents

The effects of various collectors, frothers, polyacralamide and guar type flocculants, and surfactants were tested. These reagents will be present in the leach liquor.

It was found that certain polyacrylamide based flocculants had a considerable affect on reaction kinetics and phase disengagement at concentrations in the range 10-100 ppm. Predictably, settling tests demonstrated that the flocculants adhere predominantly to the solids, and therefore adverse effects are not expected. In addition, it was found that the flocculants are not organic soluble.

Potentially the most dangerous reagents are the surfactants. In the present Leach Plant tankhouse a foaming agent is used in order to depress the acid mist produced during electrowinning. The foaming agents are organic and aqueous soluble, with a high distributions coefficient (organic: aqueous). These reagents reduce the interfacial tension in the aqueous/organic system, until at concentrations above 10 000 ppm in the organic, the interfacial tension is reduced to zero and a near stable emulsion results. Testwork on a large number of different surfactants is still being pursued actively.

Organic Loss and Entrainment

The causes for loss of the organic phase in a solvent extraction circuit are the following:

a. evaporation;
b. dissolution;
c. entrainment.

Evaporation mainly causes the loss of kerosene. This loss was occasionally found to be a problem in the pilot plant operation, particularly during the hot season. The solubility of kerosene in water was determined by infra-red techniques and found to be 5-10 ppm. No absolute method has so far been found to determine the Lix loss. The organic loss in raffinate was found to be less than 50 ppm. This could not be confirmed by inventory changes, due to the small scale of operation.

Pilot Plant Operation

The operation of the solvent extraction pilot plant was found to be relatively simple provided the aqueous and organic flow rates were controlled accurately. The optimum operating conditions were as follows:

aqueous feed tenor:	2.85 g/l Cu, pH 2.0-2.3
O/A ratio in extraction:	1 : 1
Lix tenor	16-18%
number of extraction stages:	3
spent electrolyte:	30 g/l Cu, 150 g/l H_2SO_4
advance electrolyte:	40-45 g/l Cu, 126-135 g/l H_2SO_4
O/A ratio in stripping:	3.7-5.5:1
number of strip stages:	2
stripped organic:	0.2-0.3 g/l Cu
raffinate:	0.10-0.13 g/l Cu

It should be noted that in the Chingola circuit approximately 70% of the raffinate will be returned to the leach circuit, so that the actual copper loss will be less than the 4-5% incurred during open circuit operation.

It is pointed out that the engineering design and scale-up of the mixer/settler units for the main plant is being conducted by the Power-Gas Corporation Limited.