

SPOTLIGHT

on Developments in Froth Flotation

by J-P. FRANZIDIS*

The International Colloquium on Developments in Froth Flotation, which replaced the Annual University of Cape Town (UCT)/University of Stellenbosch (US) Minerals Processing Symposium, was held at the Van Riebeeck Hotel in Gordon's Bay on 3rd and 4th August, 1989. The Colloquium attracted 150 delegates from the mining, metallurgical, and chemical industries, including 9 from overseas.

Altogether, 27 papers were presented over the two days. The first day was concerned mainly with developments in flotation reagents and processes, while the second day was devoted largely to developments in column flotation.

First Day

The Colloquium was officially opened by the President of The South African Institute of Mining and Metallurgy (SAIMM), Mr Gene Fivaz, who welcomed the delegates and congratulated the Western Cape Branch on being the first local branch of the SAIMM to organize an international colloquium. In his address, he emphasized the importance of the mineral industry to the South African economy, and the role of flotation in concentrating ores, and looked forward to the many and varied papers that were to be presented over the two days.

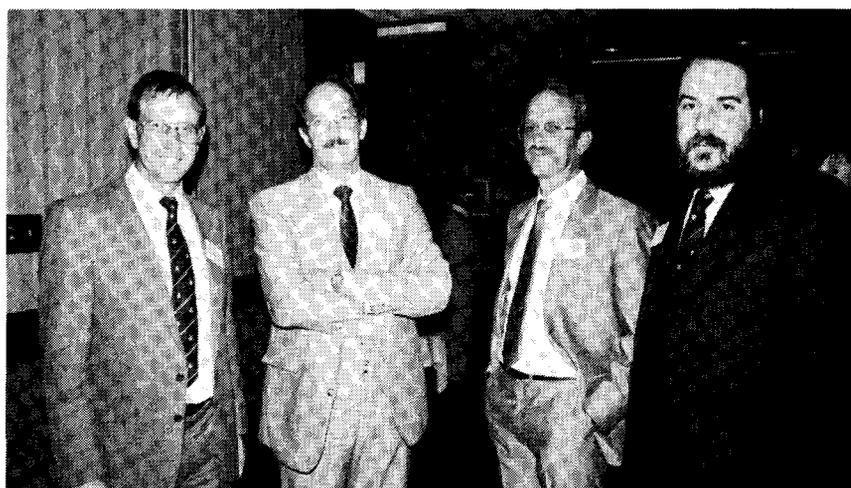
The keynote address was delivered by Professor Ted Woodburn of UMIST, Manchester, UK. In a stimulating presentation, Professor Woodburn asserted that an optimal froth structure exists for the beneficiation of ultrafine coal by flotation, and that this structure can be identified on-line by vision-based image analysis. He described his own work on the characterization of froth structures by measurement of frequency distributions of bubble size and ellipticity in an overflowing froth, and

suggested that this could form the basis of a feed-back control mechanism for the operation of coal-flotation cells.

The next presentation was an invited review paper entitled 'Reagents for the minerals industry' by Dr Richard Klimpel, of Dow Chemicals, Midland, Michigan, USA. In this thought-provoking paper, Dr Klimpel noted that there has been a long period of stagnation in the development of new reagents for the mineral industry. He listed five areas of technical challenge that could result in a dynamic period during which new reagents are introduced. These include the use of new sophisticated techniques of surface characterization to improve the use of existing reagents and to develop new ones; the development and improvement of appropriate on-line instrumentation equipment; a better understanding of the fundamental engineering aspects of mineral processes that would permit reliable scale-up of equipment from laboratory scale to full-scale plant; a re-evaluation of the potential of solution-chemistry approaches to mineral processing; and the development of more-selective flotation reagents that are efficient at the natural pH values of slurries.

The remainder of the day was devoted to papers describing the development and use of new reagents and processes in flotation. A wide range of ores was reported on, from gold, copper, lead, and tin to coal, arsenic, and osmiridium.

Bryson and Harris (Mintek) had tackled the problem of low copper recoveries at Palabora Mining Company that were caused by the presence of valleriite. By use of a combination of carboxy-methylcellulose (CMC) as a slimes dispersant, and a polyethoxylated alcohol (PEA)



Cyril O'Connor (University of Cape Town), Ben Schoeman, Jules Aupiais (Karlochem), and J-P. Franzidis (University of Cape Town)

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as a collector extender, in conjunction with a xanthate collector, copper recoveries had been enhanced significantly.

On the subject of coal flotation once more, Prinsloo *et al.* (Potchefstroom University and Sastech R&D) outlined fundamental studies of coal surface properties that can be used in the selection of appropriate flotation reagents. The contributions of functional-group composition, aromaticity, and mineral content had been investigated.



Jannie van Deventer (University of Stellenbosch) and San Chander (Pennsylvania State University, USA)

Returning to copper, Pang and Chander (Pennsylvania State University, USA) presented new results to explain the role of oxygen in the flotation of a chalcopyrite. Cyclic voltammetry, a.c. impedance spectroscopy, and contact-angle measurements had been made in the presence and absence of oxygen and xanthate collector.

Thompson *et al.* (Pennsylvania State University, USA) described the flotation of natural and synthetic galena produced in different ways, with different electrokinetic properties. They showed how the genesis of galena profoundly influences its flotation behaviour with xanthate reagents.

Stonestreet and Franzidis (UCT) reported progress on the development of an unusual method for the recovery of coal, by reverse flotation of the ash material. The staged addition of quaternary amine collectors had given good gangue selectivity and coal depression in artificial

coal-quartz and coal-kaolin mixtures.

Zhou and Chander (Pennsylvania State University, USA) described a voltammetric detector that can be used for determining the concentration of thiol collectors in flotation pulps. With this instrument, very low concentrations of xanthates and dithiophosphates can be measured.

Several papers were presented on the flotation of other minerals from pyrite. In the first of these, O'Connor *et al.* (UCT and Karbochem) reported on the development of a novel process using a mixture of dithiophosphates and dithiocarbamates to float arsenopyrite from pyrite. Very good selectivity had been obtained.

Theron and Aupiais (Karbochem) described a method to float gold from pyrite in plants reclaiming gold from tailings dams. In these plants, the gold recoveries are restricted by the grade of the pyrite concentrate. By pre-flooding the gold that is amenable to cyanidation, and only then floating the pyrite, the overall gold recoveries can be increased.

Conway *et al.* (Mintek) presented the results of an investigation into the role of poly-oxy-ethylene compounds (POEC) in the flotation of sulphides. Adsorption studies and small-scale flotation tests had been carried out on a range of pure sulphide and gangue minerals in the presence and absence of xanthate collector. The use of POEC in the flotation of sulphide minerals was found, under certain conditions, to improve recoveries.

Klimpel and Isherwood (Dow Chemicals) identified new families of collector chemicals with chemistries that are quite different from those of existing commercial sulphide-mineral collectors. These new chelating collectors offer greater selectivity between mineral species while reducing the need for the high pH conditions required for pyrite rejection.

On the side of practical plant experience, Broekman and Penman (AngloVaal) described developments in the depression-deactivation of lead and zinc in copper flotation at the Prieska Mine. These have enabled the plant to accept feed that would previously have been untreatable.

The industry's current interest in flash flotation was illustrated in two papers. In the first of these, Fickling



Mike Richardson (AAC, Zimbabwe), Ted Woodburn (UMIST, UK), and Frank Aplan (Pennsylvania State University, USA)

et al. (Black Mountain) reported on work with a unit cell to reduce losses of lead from the copper concentrate and lead tailings. Very favourable results had been obtained.

Osmiridium is often recovered as a byproduct of the production of gold by gravity methods. De Ruijter (Genmin) described some novel work on the flotation of osmiridium at the Beatrice Mine, where there is no gravity-concentration system.



Charles Alexander (NCP) and Peter Harris (Mintek)

Second Day

The second day of the Colloquium was devoted mainly to column flotation.

In an invited paper, Dr Juan Yianatos, of the University of Santa Maria, Valparaiso, Chile, reviewed the development of column-flotation technology over the past decade. He outlined the characteristics of flotation columns, and discussed some of the important design variables, such as column height, froth depth, gas

rate and holdup, bubble size, wash-water rate, and concentration of solids in the feed. He went on to give particulars of the modelling and scale-up of flotation columns, and listed many applications of column flotation around the world. He concluded with some general remarks on the use of columns in cleaner-scavenger versus rougher applications, the use of pilot units in plant testing, and the advantages and disadvantages of flotation columns as compared with conventional mechanical cells.

Moys (Multotec Cyclones and University of the Witwatersrand) presented a paper on further developments in the control of the interface level in flotation columns. Ways of improving the accuracy and reliability of a technique based on conductivity measurement were discussed.

Turning to gold and pyrite flotation, Nieuwoudt *et al.* (US and Mintek) reported on the use of an air-sparged hydrocyclone for the flotation of a low-grade ore. The air-sparged hydrocyclone has been considered by some researchers as a swirl-flow or centrifugal flotation column, and has produced some very useful results. The paper examined the influence of cyclone design variables on flotation efficiency.

In their paper, Goodall and O'Connor (UCT) described the use of salt solution to monitor the liquid residence-time distribution in a laboratory column-flotation cell, and of radioactively labelled ore to trace the solids. They showed that the common assumption that the residence-time distribution of the liquid can be used to describe that of the solids is incorrect.

Ross (Mintek) discussed a novel technique for the determination, from the data of only one batch flotation test, of the contributions made by true flotation and by the entrainment of mineral particles. He compared the new technique with the methods previously used for laboratory-scale flotation tests on mixtures of pyrite and gangue.

Goritzke and McPhail (Isacor and Durnacol) presented a paper describing tests on a pilot-scale pneumatic flotation cell of the type developed by Professor Bahr in West Germany. This work, conducted on several Isacor coals, had indicated considerable metallurgical improvement in the treatment of fine material, and had led to the installation of a production unit at Durnacol.

Yianatos and Levi (University of Santa Maria, Valparaiso, Chile) showed how gas holdup, average bubble diameter, and the apparent density of mineralized bubbles in industrial flotation columns can be estimated from simple plant measurements. These values are useful in the design and control of flotation columns.

Burger (Mintek) described a mathematical model of the pulp phase in a flotation column. The model uses particle-size analyses and flotation rate constants from experimental data to predict the upgrading profile with increasing height in the column.

Harris and Franzidis (UCT) presented results of trials on a column-flotation plant at the Rooiberg tin mine. The column was operated in parallel with the plant rougher, and was found to produce higher grades of concentrate at similar tin recoveries in significantly shorter residence times.

Atkinson (O'okiep Copper) reported on an investigation into the flash flotation of copper sulphides at the Carolusberg Concentrator in the northern Cape. A flash-flotation unit positioned prior to the secondary mill recovered over 40 per cent of all the sulphides, which, under normal circumstances, would have been over-ground. Remarkable payback benefits had been obtained.

Imhof (Erz und Kohleflotation GmbH, West Germany) also reported on the use of pneumatic flotation for coal and other ores. The importance of the aerator unit in producing very fine bubbles was stressed. The attachment of hydrophobic particles to bubbles also takes place in this unit. A quiescent separating vessel with a residence time of 2 to 3 minutes was found to be sufficient for recovering the product.

In the final paper, Reuter and Van Deventer (USA)



Mike Moys (Multotec Cyclones and University of the Witwatersrand), Denise Moys, and Juan Yianatos (University of Santa Maria, Valparaiso, Chile)



Juan Ylanatos (University of Santa Maria, Valparaiso, Chile), J-P. Franzidis (Chairman of the Western Cape Branch), Wolfgang von Ommen (Maschinenfabriek Andritz, Austria), San Chander (Pennsylvania State University, USA), Mike Richardson (AAC, Zimbabwe), Dick Klimpel (Dow Chemicals, USA), Ted Woodburn (UMIST, UK), Frank Aplan (Pennsylvania State University, USA), and Simon Isherwood (Dow Europe)

outlined the use of linear programming in the design of flotation circuits incorporating regrind mills. A general routine to optimize the recovery and grade of the valuable component in the concentrate was illustrated by three sample problems.

The day ended with a panel discussion, chaired by Professor Frank Aplan of the Pennsylvania State University, USA. On the panel were Professor C.T. O'Connor (UCT), Dr R.R. Klimpel (Dow Chemicals, USA), Dr R. Imhof (Erz und Kohleflotation GmbH, West Germany), Dr J. Ylanatos (University of Santa Maria, Valparaiso, Chile), Dr M. Moys (Multotec Cyclones and University of the Witwatersrand), and Professor E.T. Woodburn (UMIST). Written questions had been received throughout the day, and Professor Aplan chaired a lively discussion among the panel members.

The Colloquium was brought to a close by Mr Richard

Beck, Vice President of the SAIMM, who thanked the organizers, the authors of papers, and the chairmen of sessions, and paid special tribute to the secretarial staff (Mrs M.E. Winter, Mrs P. Bettison, and Miss P. Binstead) for their sterling work.

Acknowledgements

As with all such technical encounters, the Colloquium would not have been the same without its social side. Many fruitful interactions took place over cocktails, lunch, and dinner. The Western Cape Branch of the SAIMM acknowledges the generous sponsorship of Karbochem and NCP (who sponsored the Banquet), Dow Chemicals and Multotec Cyclones (who sponsored the cocktail parties), and Maschinenfabriek Andritz (who sponsored a lunch).

Expo-Mineria '90

Expo-Mineria '90, the third version of this mining conference, services, and equipment venture will be taking place during 23rd to 26th May, 1990, at the Conference Centre of the Holiday Inn, Crown Plaza Hotel in Santiago, Chile. It will include an important addition, APCOMIN (Applied Computing in Mining), which is a specialized segment of the Conference and Exhibition that is exclusively devoted to computer applications for mining. This will be organized by the Mining Faculty of the University of Santiago, which has joined forces with Expo-Mineria '90.

The Chilean mining industry has proved to be an extremely fertile area, opening a multitude of export opportunities for South African companies supplying mining equipment and technology. Expo-Mineria '90 is

a gateway to these markets, and SAFTO has been offered the opportunity by the organizers of the Fair, Editec Ltda, to assist a group of South African companies in exhibiting at the Fair.

Those interested in exhibiting, or participating in a group visit, or wishing to receive further information on Expo-Mineria '90 should address their enquiries to

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