SPOTLIGHT

on electrometallurgy and electrochemistry

by W.K. BRINSDEN*

The Electrometallurgy and Electrochemistry Workshop organized by Dr Ian Corrans was held at two venues:

- Perth on 9th May, 1990, attended by 30 people
- Kalgoorlie on 11th May, 1990, attended by 28 people.

The workshop had four speakers: Dr Roger Paul, Director of the Process Chemistry Division at Mintek, who introduced the course with the theory of basic electrochemistry and electrowinning; Dr Peter Spencer of Bactech, who spoke on direct slurry electrolysis; Professor Ian Ritchie of Murdoch University, who spoke on zinc cementation; and Mr Mike Costello of Minproc, who gave an address on practical aspects of gold electrowinning in Australia. Dr Paul spoke throughout the first session and shared the remaining sessions with the other speakers.

Theory of Electrochemistry and Electrowinning

Dr Paul's theoretical lectures covered an appreciation of electrode currents and electrode potentials, the relationship between i and E, electrode kinetics, mass-transport effects, electrolyte effects, and how the above factors interact during electrowinning and electrorefining processes.

The derivation of the Faraday was explained, which is the amount of electricity associated with one equivalent of electrochemical reaction. This was then used to show that the current required to plate out 1 g of gold per second is 500 A of electricity at 100 per cent current efficiency.

Concepts of electrode potentials, Nernst equations, overpotential, Tafel curves, and mass-transport effects were explained as an introduction to the subsequently described practical implications in electrowinning.

Possible options for reducing the codeposition of copper during the electrowinning of gold include the selective stripping of copper from loaded carbon using a cold cyanide wash prior to elution, and electrowinning at low current densities in the presence of high cyanide concentrations. The former is the preferred option since the problem is largely eliminated at source.

Practical Applications

Dr Paul then described the three main elution–electrowinning circuits: Zadra, AARL, and Micron. The Zadra procedure appears to be more popular in South Africa and the USA than in Australia. In this procedure, the electrowinning is in closed circuit with the elution column. The AARL process breaks the link between the electrowinning cell and elution. It is more popular than Zadra in Australia because metallurgists prefer to electrowin separately from the elution cycles. A disadvantage of the AARL system is that it requires demineralized or good-quality water. Micron technology uses methanol and is frequently employed in small plants. It produces a solution of higher grade than either the Zadra or the AARL process.

Pressure electrowinning is occasionally used in Australia and has the advantage of being more secure than in open cells.

The question of combining a number of electrowinning cells in parallel or in series often gives rise to confusion. Careful analysis of all the controlling factors is necessary for optimum design of the circuit. If a multiple-pass system is used, a parallel configuration will usually outperform a series configuration.

Frequent smelting of the cathodes is preferred in South Africa (in order to generate a steady cash flow), rather than once a week, which is common in Australia.

Problem areas included an incorrect concentration of sodium hydroxide in the eluate since the pH always decreases around the anode and must be kept above 12. Organic contaminants also give problems, usually originating from the collectors and frothers used during flotation. There may be little an operator can do to correct this problem.

Poor electrical contacts and gold slimes on the cell floor give rise to minor problems. Gold will redissolve if cathodes are left in the cell after the current is switched off.

Dr Paul gave credit to KCGM for reversing their cathodes as they are moved up the electrowinning bank. The recommended number of cathodes is 6 to 21 per cell; 6 cathodes per cell is commonly used in South Africa, whereas 9 is more typical of Australian practice.

Direct Slurry Electrolysis

Dr Peter Spencer discussed the basic requirements for the four types of slurry electrolysis (Cymet, Dextec, Clear, and Intec Processes).

- The suspended particles must be able to conduct an electric current.
- They must be soluble in the electrolyte.
- The electrolyte must be able to conduct an electric current between elecrodes.

The Cymet and Dextec processes use slurry anodes to oxidize copper minerals, and concentrated chloride solutions to complex the copper as copper chloride species.

Metana uses the Intec process at Rothsay, which relies on the formation of copper ions at the anode and the recovery of copper from copper chloride at the cathode. Copper is extracted first, although it could be extracted simultaneously with gold. Carbon is added later, and gold loadings can approach 100 kg/t before the gold is extracted. Intec's process is capable of eliminating the smelting of copper by producing copper at a grade of 99,995 per cent. However, this target has not yet been achieved anywhere.

* Flat 65, 20 Dean Street, Claremont, Western Australia 6010.

Zinc Cementation

Professor Ian Ritchie gave the following as the disadvantages of zinc cementation.

- The zinc consumption is higher than expected.
- Free cyanide is consumed.

He also said that zinc corrodes at high levels of cyanide.

However, some of the disadvantages could be overcome if excess zinc were kept out of the system, so promoting the passivation of zinc. At higher pH levels, more cyanide is needed. Rotating zinc discs and cylinders could be used, but do not have as large a specific surface area as zinc dust. Cementation is probably a diffusion-controlled process and will not work unless free cyanide is present.

The presence of copper has an adverse effect on cementation, whereas silver has a positive effect. Although most operators believe lead to have a positive effect, it is not fully understood. Laboratory tests have indicated that lead may even retard the rate of reaction.

If a plant has installed an AARL elution circuit in a plant where flotation is used prior to the leaching and carbon-in-pulp stage, it may be better to use cementation instead of electrowinning. Rand Mines Milling, near Johannesburg, and President Brand mine, in the Orange Free State, use cementation for this reason.

Gold Electrowinning

Since the basic design and principals of electrowinning had already been described by Dr Paul, Mr Mike Costello proceeded to discuss design criteria as related to operating design.

The current density for the plating of gold is usually 5 to 15 A/m^2; 500 g of steel wool per cathode has an applied current of 500 to 750 A usually containing 10,2 A/m^2. Cathodes are made from mild-steel wool, and have a diameter of 25 to 31 μm. Woven stainless steel is 125 to 274 μm in diameter. The area varies between 205 m^2/g (small) and 19 m^2/g for the larger-diameter wire.

At the Big Bell plant, the presence of silica from contamination by mica found its way through the elution system and became an impurity on carbon. The silica passivated the steel-wool surfaces, and the electrowinning–electrofining system had to be replaced. A return to electrowinning on normal mild-steel wool therefore became necessary. At Granny Smith, the electrowinning–electrofining system worked satisfactorily because of an absence of silica.

At Kaltails, the grades of gold, silver, and copper were 44, 62, and 150 g/m^2 respectively. This plant used the AARL split-elution procedure. Copper was not deposited when the silver and gold dropped to below 1 g/m^3 at 0,4 per cent sodium cyanide and 0,5 per cent sodium hydroxide. Mercury was found to be unexpectedly high in the carbon and eluate, and a retort/calcine had to be included to remove mercury before bullion smelting.

Anodes can be protected by keeping the pH over 12, i.e. by the addition of 0,5 per cent (m/v) sodium hydroxide. The breaking off of anodes can cause the entire electric current to discharge across the top of the cells. This causes overheating and can result in the burning through of 25 to 35 μm wires. Valuable gold and silver then drop to the cell floor, from where they can be recovered by hosing and filtering.

Conclusion

The Workshop proved to be a worth-while technical event accompanied by some lively discussion.

Another significant event in Perth was a solvent-extraction symposium organized by Ammtec and Henkel in July 1990, which will be reported in a later Spotlight.

Environmental databases

The Mineral Industry Research Organisation (MIRO) is setting up an environmental database (MINDER) at the Warren Spring Laboratory (WSL). WSL was selected because it has a long-term involvement in environmental matters, and also because of its previous experience in developing and running databases on behalf of MIRO. These include the flotation-reagents database (FREDA), which has been in operation for 6 years, and the solvent extraction database (SOLVEX), which has been in operation for 13 years.

The MINDER database will be structured specifically to meet the needs of the mineral and metal industries; it will contain only environmental data and will be as complete as possible. MINDER will contain full references to environmental legislation on a global basis, and will include data on heavy metals and mining reagents. The heavy metals data will include the occurrence and genesis of these metals, their release and effect on the environment, and their abatement, reclamation, and disposal.

The database will contain details on existing technologies, as well as on research work currently being undertaken, and will be able to give advice on solving environmental problems. It should prove an essential tool in the preparation of environmental-impact statements. It is also hoped that the database will provide a link between the mineral and metal industries, governmental legislators, and the public.

The database will be user-friendly, and subscribing club members will have free and unlimited on-line access to the data. As with all MIRO databases, the information will be made available only to club members.

Further information about the MINDER database can be obtained from

Mr C.F. Bonney
Research Co-ordinator
Mineral Industry Research Organisation
Expert House
Sandford Street
Lichfield
Staffs
WS13 6QA
UK

Tel: (0376) 521120 or (0543) 262957
Fax: (0376) 511514 or (0543) 262183.