Conclusions

The experimental work, which involved the validation and application of an electrochemical technique for monitoring the reaction during the leaching of pyrolusite, demonstrated that the major influences on the leaching rate under the conditions studied are the ferrous ion concentration and the reaction temperature. The relationships between the chemical species measured corresponded very closely to the stoichiometric values for the manganese dioxide reaction. The demonstration that this was the only important reaction occurring reinforced the validity of the redox-measurement technique. The shape of the leaching curves, which show a very fast initial rate of extraction decreasing rather abruptly, is similar to that reported for a number of leaching systems.

The modelling carried out using the shrinking-core model and Brittan's activation-energy model illustrated the significant improvement in accuracy that was achieved through the adoption of the distributed-rate-constant approach.

In terms of the shrinking core model, the reaction is controlled by solid-layer diffusion, as evidenced by the value of the activation energy. Although the kinetics were mixed, the contributions of the film-diffusion and reaction terms were negligible, with the consequence that no attempt could be made to improve the fit by altering the order of the reaction. This model did not adequately account for the variation in ferrous ion concentration.

The structure of Brittan's model, while relying on a more abstract (though intuitively acceptable) concept of a varying activation energy, allows for more flexibility. The model was able to provide an excellent fit to the data, reproducing the variation of rate with both temperature and ferrous ion concentration with a high degree of accuracy.

Acknowledgements

This paper is published by permission of Mintek. The support given by Mintek to one of the authors (J.C. Zachariades) is gratefully acknowledged.

References

1. Brittan, M.I. Variable activation energy model for leaching kinetics. *IJMP,* vol. 2. 1975. pp. 321–331.
2. Cornelius, R.J., and Woodcock, J.T. Pressure leaching of a manganese ore. Part 1: kinetic aspects, Part 2: leaching aspects. *Proc. Australas. Inst. Min. Metall.,* 1958. pp. 65–133.
3. Koch, D.F.A. Kinetics of the reaction between manganese dioxide and ferrous ion. *Australas. J. Chem. Engng,* 1957. pp. 150–159.
4. Majima, H., Awakura, Y., Sasaki, Y., and Teranishi, T. Reductive dissolution of manganese dioxide in the presence of ferrous ions. *Nippon Kogyo Kaishi,* vol. 97, 1981. pp. 267–271. (In Japanese.)
5. Dry, M.J. A model for the leaching of a low-grade matte. University of the Witwatersrand, Ph.D. thesis, 1984.
6. Atkins, P.W. *Physical chemistry.* Oxford University Press, 1978.
7. Harris, D.C. *Quantitative chemical analysis.* New York, Freeman, 1982.
8. Brittan, M.I. A kinetic model of copper segregation and its application to TORCO plant design. *Trans. Instn Min. Metall., Sec. C,* vol. 80. 1971. pp. C262–272.
9. Levenspiel, O. *Chemical reaction engineering.* New York, Wiley, 1972.
10. Wadsworth, M.E. *Rate processes of extractive metallurgy.* Sohn, H.Y., and Wadsworth, M.E. (eds.). New York, Plenum Press, 1979.
11. Smith, J.M. *Chemical engineering kinetics.* New York, McGraw-Hill, 1981.
12. Numerical Algorithms Group. *NAG Fortran library,* Revision 13, Oxford.
13. King, R.P. Estimation of parameters in systems defined by differential equations. *S.Afr. J. Sci.,* 1967, pp. 91–96.
14. Law, V.J., and Bailey, R.V. A method for the determination of approximate system transfer functions. *Chem. Eng. Sci.,* 1963, pp. 189–202.

Book news

Publications of the IMM

These two titles have just been published as part of the popular series of Special Reference Lists being issued by the Institution of Mining and Metallurgy, 44 Portland Place, London W1N BR, England.

- *Carbon technology for gold extraction.*

This book contains over 350 references selected from the IMMAGE database, giving the title, author, publication details, and abstracts of over 350 technical articles, reports, conference proceedings, and books. The references are arranged in four sections: carbon-in-pulp, carbon-in-leach, carbon-in-solution and carbon-in-column, and carbon reactivation. There are subject and author indexes for each section.

- *Metallurgical processes.*

This volume contains over 550 references from the IMMAGE database. Processes with five or more references each are listed in individual sections: Arseno, Bayer, Caron, Clear, CMT, Dextec, Elred, Goethite, Hall Heroult, Hematite, HYL, Imperial Smelting, INRED, Isa, Isasmelt, Jarosite, Kennecott Cuprion, KHD–Contop, Kivcet, Magnatherm, Merrill–Crowe, Midrex, Mitsubishi, Nitrox, Noranda, Outokumpu, Plasmasmelt, Plasmared, Purlex, QSL, Sherritt ammonia leach, Sherritt zinc, Sherritt–Cominco copper, Sherritt–Gordon pressure leach, Sirosmelt, SL–RN, TL leaching, Waelz, and zinc processes. References to about 100 other processes are listed in sections on pyrometallurgy, hydrometallurgy, and electrometallurgy.

As with previous publications listed in Special Reference Lists, *Carbon technology* and *Metallurgical processes* are available as printed publications and as ASCII text files on floppy disk at a price of £30.00 per copy. In addition, *Carbon technology* and *Metallurgical processes* are available as stand-alone databases with comprehensive retrieval software suitable for running on PC or MS–DOS microcomputers at a price of £70.00.