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1) Effect of contaminant carbonaceous matter on the sorption of gold by pyrite

H. Tan, D. Feng, J.S.J. van Deventer, G.C. Lukey

International Journal of Mineral Processing, Volume 77, Issue 3, *Pages 123-138* (November 2005)

Abstract: The effect of carbon or graphite coating on the adsorption of gold cyanide on pyrite was investigated with pure pyrite and a pyrite concentrate. In the carbon or graphite-contaminated pyrite systems carbon and graphite not only acted as gold sorbents, but also enhanced gold adsorption on pyrite. The carbon coating enhanced gold adsorption on pyrite to a larger extent, in comparison with the graphite coating. The carbon or graphite coating on pyrite reduced the negativity of the pyrite surfaces, and hence improved the physical adsorption of gold cyanide on pyrite. In addition, the highly conductive coating of carbon or graphite on pyrite could enhance electron transfer in the electrochemical reactions occurring in the chemical adsorption of gold and gold reduction on pyrite. The preg-robbing by pyrite or the graphite-coated pyrite was reduced and further eliminated at higher cyanide concentrations. However, gold adsorption on the carbon-coated pyrite could not be prevented even at higher cyanide concentrations due to gold adsorption on the carbon coating. In comparison with pure pyrite, the pyrite concentrate had a higher capacity adsorbing gold, due to the presence of carbonaceous matter in the pyrite concentrate. Fine grinding intensified the smearing of carbon or graphite on the mineral particles, resulting in a larger extent of enhancement in the preg-robbing of the concentrate by the carbon or graphite coating.

A diagnostic elution of the preg-robbing pyrite samples indicated that the reduction of gold at the pyrite surfaces was the dominant mechanism for gold adsorption on pyrite, followed by physical and chemical adsorption. Surface topological studies by SEM/EDX showed that gold adsorbed at defect sites on pyrite surfaces. For the pyrite with a 5% carbon coating, gold was observed to adsorb not only at the defect sites, but also at the smooth surfaces with carbon present. For the pyrite with a 5% graphite coating, carbon was also found at the pyrite surfaces, but gold was only detected at the defect sites. XPS studies revealed that part of the gold physically and chemically adsorbed on pyrite or pyrite coated with carbon or graphite. Some gold cyanide was reduced at the pyrite surfaces, with the sulphide ions of pyrite being oxidised to elemental sulphur.

2) On the cathodic reaction coupled with the oxidation of xanthates at the pyrite/aqueous solution interface

A López Valdivieso, A.A. Sánchez López, S. Song

International Journal of Mineral Processing**,** Volume 77, Issue 3, *Pages 154-164* (November 2005)

Abstract: The adsorption of ethyl, propyl and butyl xanthates on pyrite has been studied through electrokinetics, batch adsorption tests, and quantification of Fe^{2+} ions in solution. Adsorption isotherms for the three alkyl xanthates indicate that their adsorption to dixanthogen produces Fe^{2+} ions in solution and decreases the pyrite zeta potential negatively. It seems that the oxidation reaction of xanthates to dixanthogen on pyrite is coupled with the reduction reaction of surface-ferric hydroxide to ferrous ions, leading to the dissolution of hydrophilic ferric hydroxide and growth of hydrophobic dixanthogen on the surface of pyrite. Flotation of pyrite is presented as a function of pH using various ethyl xanthate concentrations. The floatability results are explained in terms of the surface coverage relationship between ferric hydroxide and dixanthogen, which is pH dependent.

3) Simultaneous optimization of the performance of flotation circuits and their simplification using the jumping gene adaptations of genetic algorithm

Chandan Guria, Mohan Verma, Santosh K. Gupta, Surya P. Mehrotra

International Journal of Mineral Processing, Volume 77, Issue 3, *Pages 165-185* (November 2005)

Abstract: The elitist non-dominated sorting genetic algorithm with the modified jumping gene operator (NSGA-II-mJG) is used to optimize the performance of froth flotation circuits. Four example optimization problems (Mehrotra and Kapur, 1974; Green, 1984; Dey et al., 1989) [Mehrotra, S.P., Kapur, P.C., 1974. Optimal–sub-optimal synthesis and design of flotation circuits. Sep. Sci. 9, 167–184; Green, J.C.A., 1984. The optimization of flotation networks. Int. J. Miner. Process. 13, 83–103; Dey, A.K., Kapur, P.C., Mehrotra, S.P., 1989. A search strategy for optimization of flotation circuits. Int. J. Miner. Process. 26, 73-93.] of varying complexity are solved using single-objective functions. In one example, the overall recovery of the concentrate stream is maximized for a desired grade of the concentrate and a fixed total cell volume. The interconnecting cell linkage parameters (fraction flow rates) and the mean cell residence times are the decision variables. In all these cases, the optimal solutions obtained using NSGA-II-mJG are superior to those obtained by earlier techniques (which converged to local optimal solutions). Thereafter, a few two-objective optimization problems are solved. In these, the performance of the circuit is optimized, and simultaneously, the number of connecting streams is minimized so as to give simple circuits. Pareto optimal sets of equally good (non-dominating) solutions are obtained. This is probably the first study involving the multi-objective optimization of flotation circuits with one aim being to simplify them.

4) Floatability of rare earth phosphors from waste fluorescent lamps

T. Hirajima, A. Bissombolo, K. Sasaki, K. Nakayama, H. Hirai, M. Tsunekawa

International Journal of Mineral Processing, Volume 77, Issue 4, *Pages 187-198* (1 December 2005)

Abstract: Zeta-potential measurements were made to determine the electric state of phosphor materials on the basis of which a feasibility study could be performed for the use of flotation in the recovery of fine ($d_{50} < 13$ μm) rare earth phosphors from waste fluorescent lamps. Tests were carried out with pure specimens of white (calcium halo-phosphate), red, green and blue (rare earth) phosphors, with a 17 : 1 : 1 : 1 ratio of their mixture, and with actual waste phosphor materials. The effects of a cationic (dodecyl ammonium acetate, DAA) and two anionic (sodium dodecyl sulfate (SDS) and sodium oleate (NaOl)) collectors on the floatability of materials, as well as that of Na_2SiO_3 dispersant on the separation characteristics, were investigated at different pH ranges. The process, applied to actual discarded waste phosphors gave, in a two-stage separation scheme, sink products assaying 17.7–23.8% and 21.5–25.9% rare earth phosphors for DAA and SDS flotation, respectively. The recovery and Newton's efficiency were about 70–90% and 0.26–0.37, 66–82% and 0.18–0.20, respectively for DAA and SDS flotation.

5) The effect of anionic dispersants on grindability of different rank coals

G. Atesok, M. Ozer, F. Boylu, H. Dıncer

International Journal of Mineral Processing, Volume 77, Issue 4, *Pages 199-207* (1 December 2005)

Abstract: The effect of PSS (Sodium Polystyrene Sulphonate) and NSF (Naphthalene Sulphonate Formaldehyde Condensate) chemicals used to control the pulp rheology on the grindability of coals was studied. Zonguldak region bituminous coal and Istanbul region brown coal samples that high and low rank were used. Wet grinding tests with two coal samples were performed with or without PSS and NSF under constant grinding conditions: solid ratios ranged from 50% to 60% with 0–60 min grinding periods.

In the present study, grinding conditions of coal with high pulp solid ratio were improved through the lowering of the viscosity of the coal by using the dispersing agents, PSS and NSF, during the grinding stage and evaluation were made by using the “efficiency factor”. It is possible to increase the amount of finely ground bituminous coal from Zonguldak by 20% and 16%, if optimum concentrations of PSS (0.3%) and NSF (0.7%) are used, respectively. Whereas, the increase in the case of finely ground lignite from Istanbul was 32% and 20%, respectively.

6) Oxidation of chalcopyrite by extended milling

C.J. Agnew, N.J. Welham

International Journal of Mineral Processing, Volume 77, Issue 4, *Pages 208-216* (1 December 2005)

Abstract: Chalcopyrite has been milled for up to 50 h in oxygen, air and argon atmospheres using a laboratory ball mill. No phase changes were evident in argon but the XRD peaks were weaker and broader indicating crystalline refinement. In oxygen, even after 1 h milling peaks for $CuSO_4{\cdot}5H_2O$ were present and these became predominant after 20 h milling where the chalcopyrite peaks were absent. In air, partial oxidation to $CuSO_4{\cdot}5H_2O$ was evident after 50 h. Leaching of the resultant powders with water showed 80% dissolution after 50 h milling in oxygen, significantly greater than the 20% and 6% dissolution after milling for 50 h in air and argon respectively. Solution analyses showed the Cu/Fe ratio increased with milling time in oxygen suggesting selectivity may be possible. The insoluble residue was found to consist of haematite, elemental sulphur and unreacted chalcopyrite.

7) A comparative study of three turbulence-closure models for the hydrocyclone problem

Jose A. Delgadillo, Raj K. Rajamani

International Journal of Mineral Processing, Volume 77, Issue 4, *Pages 217-**230*** (1 December 2005)

Abstract: In the computational fluid dynamics study of hydrocyclones, the air-core dimension is key to predicting the mass split between the underflow and overflow. In turn, the mass split influences the prediction of the size classification curve. Three models, the renormalization group κ–ε model, the Reynolds stress model, and the large-eddy simulation model, are compared for the predictions of air-core dimension, mass split, and axial and tangential velocities. The large-eddy simulation model, since it produces some detailed features of the turbulence, is clearly closer in predicting the experimental data than the other two. It is shown that particle tracking done with the velocity field obtained from the large-eddy simulation model accurately predicts the experimental size–classification curve.

8) Nanobubbles, hydrophobic effect, heterocoagulation and hydrodynamics in flotation

Heinrich Schubert

International Journal of Mineral Processing, Volume 78, Issue 1, *Pages 11-21* (15 December 2005)

Abstract: It has been shown in recent years that the long-range attractive interaction forces between hydrophobic surfaces in aqueous systems are caused by the capillary forces of gas bridges which form at the coalescence of nanobubbles adhering on the surfaces. The coalescence of nanobubbles on selectively hydrophobized particles with coarser bubbles initiates the jump into the three-phase contact at the attachment events in flotation. Therefore, one should no longer speak of hydrophobic forces in these events but of hydrophobic effects because they are caused by capillary forces. However, in the selective hydrophobization of particles by long-chain collectors (surfactants), there is another situation. Here, the association of nonpolar groups in the adsorption layers plays an important role in the energy balance of adsorption. This association is caused by "truly" hydrophobic interactions, which support the spotty distribution of the adsorbed collector ions on the particle surfaces and promote the formation of nanobubbles. This paper is intended to show to what extent the results obtained by basic research on the nanobubble formation as well as the force–distance dependence of collision events can be applied to flotation processes. This particularly requires the consideration of the highly turbulent flow conditions in the impeller stream of the flotation machines, in which the attachments almost exclusively occur. Various phenomena which occur in these machines and affect the reagent regime and the hydrodynamics point to the fact that nanobubbles can form, exist and even grow into microbubbles in that region. Therefore, so-called combined attachment events should predominate as already imagined several decades ago. The highly turbulent pressure fluctuations in the impeller stream in addition to the dispersion of the bubbles effect also their oscillations in size and shape, so that adsorption equilibria in the interfaces liquid/gas cannot be supposed. However, the pressure fluctuations present the possibility to overcome potential barriers in the wetting films at attachment events.

9) Separation of small nonferrous particles using an angular rotary drum eddy-current separator with permanent magnets

Mihai Lungu

International Journal of Mineral Processing, Volume 78, Issue 1, *Pages 22-30* (15 December 2005)

Abstract: The paper presents a method for separating the small metallic nonferrous particles from two component nonferrous mixtures using a new type of dynamic eddy-current separator with permanent magnets. The so called Angular Drum Eddy-Current Separator (ADECS) consists of a horizontal rotary drum covered with permanent magnets, alternately N–S and S–N oriented. The rotor is placed oblique, under the superior part of a horizontal conveyor belt, coplanar with its surface. The axis of the drum and the direction of displacement of the belt make a certain angle, depending on the physical properties of the particles subjected to the separation process. The separator functions on the basis of the jump effect of the strongly conducting particles which assume different trajectories in the active zone of the field, namely, upper part of the drum. The experimental results and comments regarding the values obtained for grade and recovery for wastes consisting in Cu–Pb and Cu–Al mixtures are given.

10) Development and implementation of a new flowsheet for the flotation of a low grade nickel ore

G.D. Senior, S.A. Thomas

International Journal of Mineral Processing, Volume 78, Issue 1, *Pages 49-61* (15 December 2005)

Abstract: Low grade nickel ores containing large amounts of serpentine minerals have historically been difficult to process efficiently. The Mt Keith ore was no exception with recoveries in the first five years of operation averaging just 60%.

In this research, the factors limiting performance have been identified and a new process has been devised that raises recovery significantly. The process exploits the particle size

dependence of nickel sulphide flotation and the different ways that pH change and pulp density influence the response of coarse and fine particles.

Implementation of the new process at Mt Keith has raised nickel recovery by 10%. In turn, nickel production has increased by over 6000 t.p.a. and the net present value (NPV) of the operation has increased by over A$300 m. These outcomes illustrate the large commercial benefits that can be gained by understanding particle size effects in flotation.

11) Kinetics of copper removal from acidic mine drainage by a liquid emulsion membrane

F. Valenzuela, J. Cabrera, C. Basualto, J. Sapag-Hagar

Minerals Engineering, Volume 18, Issues 13-14, *Pages 1224-1232* (November 2005)

Abstract: Copper was removed from an acidic mine drainage (AMD) using a liquid emulsion membrane contactor. The acidic drainage was a harmful natural acidic solution generated by bioleaching and chemical leaching of copper and iron sulfides, with average pH between 2 and 4. Normally the content of copper in AMD is low, which makes its recovery by SX uneconomical. The kinetics of copper removal in a stirred transfer cell was studied, using a salicylaldoxime as mobile carrier extractant and Span-80 as surfactant. It was found that the initial extraction rate of copper was affected by the carrier concentration in the liquid membrane and by the pH and metal content in the mine water. A minimum content of surfactant in the organic phase was required to stabilize the emulsion. A transport mechanism based on a diffusion model, which includes the extraction chemical reaction between the metal and the carrier extractant is discussed.

12) A model for heap bioleaching of chalcocite with heat balance: Bacterial temperature dependence

M.J. Leahy, M.R. Davidson, M.P. Schwarz

Minerals Engineering, Volume 18, Issues 13-14, *Pages 1239-1252* (November 2005)

Abstract: A three-phase computational fluid dynamics model for heap bioleaching of chalcocite is investigated to identify and understand the thermodynamic processes in a heap. The study uses an existing one-dimensional model of liquid flow, bacterial transport (including attachment/detachment of bacteria to ore particles), and the depletion of a copper-sulphide, coupled with a model of heat flow in the heap, with bacterial temperature dependence. The model is used to investigate aspects of heat balance in regard to the temperature dependence of the bacterial concentration and the temperatures reached in a typical heap. The heap is found to leach in a top–down manner, due to the ability of the incoming liquid to cool the heap at the top, and to allow bacteria to grow under optimal temperature conditions. As the top leaches, the temperature there drops and progressively cools the heap as the leaching front moves down through the heap to leach the whole bed.

13) Solution filtration in cobalt removal process: Detection of varying process conditions

Jari Näsi, Kauko Leiviskä

Minerals Engineering, Volume 18, Issues 13-14, *Pages 1253-1258* (November 2005)

Abstract: This paper presents the results from a statistical study of a continuous zinc-solution purification procedure. The purpose of the work was to compare varying process conditions and to find out the correlation between the process parameters and the filter pumping pressures in different circumstances. In the first case, a filtration problem is slowly generated and optimal conditions are not found. The second, longer time period consists of clear changes and possibly different process operating ranges. The third part consists of a time period with small pressure changes and conditions close to optimal.

Secondly, variations in the direction and strength of the affecting parameters are studied. For this, correlation values between pressure and certain chosen variables are evaluated. According to the results, the correlation of pressure with process parameters is greatly dependent on the process conditions. In addition, significant variables differ between sets of data and it is easy to find parameters apparently affecting the process.

14) The influence of microwaves on the leaching kinetics of chalcopyrite

M. Al-Harahsheh, S. Kingman, N. Hankins, C. Somerfield, S. Bradshaw, W. Louw

Minerals Engineering, Volume 18, Issues 13-14, *Pages 1259-1268* (November 2005)

Abstract: The influence of microwave heating on the leaching kinetics of chalcopyrite has been investigated. Microwave-assisted leaching has been investigated in an attempt to improve the yields of extracted metal and reduce processing time. This is especially pertinent in view of the increased demand for more environmentally friendly processes.

The data from both microwave and standard leaching tests were best fitted by a shrinking core model in which, the surface reaction controlled the rate. It was found that the activation energy calculated for microwave leaching (76.5 kJ/mole) as calculated from the data was slightly lower than that for standard leaching (79.5 kJ/mole): however, the difference lies within the limits of experimental error.

Enhanced recovery of copper was noted for samples leached within the microwave field. Previous work has suggested that this may be due to a "microwave effect". For the first time this work proves that higher recoveries in microwave systems occur as a result of selective heating of the mineral particle over the solution. It is postulated that the reaction interface has a higher temperature than that of the bulk solution, leading to a higher reaction rate. In addition, it is suggested that high loss leaching solutions will develop a superheated layer close to the periphery of the reaction vessel (due to the small penetration depth) which creates localised heating compared with the measured bulk solution temperature. If leaching takes place within this layer, an apparent rate increase will be noted with respect to the measured bulk temperature.

15) Silver recovery from synthetic photographic and medical X-ray process effluents using activated carbon

K.G. Adani, R.W. Barley, R.D. Pascoe

Minerals Engineering, Volume 18, Issues 13-14, *Pages 1269-1276* (November 2005)

Abstract: Adsorption of silver from synthetic photographic and spent fix solutions on granulated activated carbon in a batch process has been investigated. The synthetic

solutions prepared had similar properties to medical X-ray and photographic process effluents. Sodium and ammonium thiosulfates are the major lixiviants used in the dissolution of silver halides present in photographic and medical X-ray films. The resultant solutions contain substantial amounts of recoverable silver complexes in the form of thiosulfates. The as received carbons were alkaline in nature when contacted with deionised water. These carbons showed very low silver recoveries. However, when these carbons were pre-treated with 0.5 mol/dm^3 sulphuric and nitric acids at 25 °C, it had resulted in significant silver recoveries of 98.5% and 95% from sodium and ammonium thiosulfate solutions, respectively. These results were achieved in a narrow range of pH between 3 and 4. Batch atmospheric stripping of adsorbed silver by 2.0 mol/dm^3 HNO_3 at 85 °C was also investigated.

16) Uranium stripping from tertiary amine loaded solution by ammonium sulfate

Carlos A. Morais, Luiz A. Gomiero

Minerals Engineering, Volume 18, Issues 13-14, *Pages 1277-1281* (November 2005)

Abstract: Uranium in sulfuric acid medium is selectively extracted by tertiary amine. Uranium stripping from the loaded solvent (tertiary amine) can be carried out by many salt and acid solutions. The stripping agent choice depends on several factors, such as organic composition and economic viability. In the present work, the uranium stripping by $(NH_4)_2SO_4$ was investigated in order to substitute the NaCl used in the production of uranium concentrate by “Indústrias Nucleares do Brasil (INB)”. The $(NH_4)_2SO_4$ concentration, the equilibrium pH effect and the presence of chloride ion in the loaded organic phase were investigated. It was observed that the presence of chloride ion in the loaded organic phase makes the $(NH_4)_2SO_4$ stripping process unfeasible. In this case, only 65% of the uranium was stripped. In the absence of chloride, it was possible to obtain a pregnant strip solution with 33 g/L U_3O_8 and an unloaded organic solution with 0.006 g/L U_3O_8 using five mixer-settler stages.

17) Cementation for metal removal in zinc electrowinning circuits

S.J.G. Casaroli, B. Cohen, A.R. Tong, P. Linkson, J.G. Petrie

Minerals Engineering, Volume 18, Issues 13-14, *Pages 1282-1288* (November 2005)

Abstract: Step changes in technology, including adoption of new process configurations and chemistry, require modelling and experimental work for establishing process feasibility and process optimisation. In this work the results of such modelling and experimentation as applied to purification via zinc dust cementation of a zinc-bearing leachate are presented. The novelty of the process, developed by Intec Ltd, lies in the use of a mixed halide leachant over the traditional sulphide leach. The process has the advantages of operation at low temperatures and atmospheric pressure, and regeneration and recycle of leachant. Thermodynamic modelling results demonstrated that feasible removal of major and trace metals via cementation is possible down to levels suitable for electrowinning. A challenge in this respect is accounting for the competing evolution of hydrogen. Experimental work provided guidance in identifying the optimal quantity and method of zinc dust addition required to achieve removal, and will be used to guide the

development of a suitable operational strategy for the plant. Comment is offered on opportunities for selective recovery of valuable metal species.

18) Leaching of chalcopyrite and sphalerite using bacteria enriched from a spent chalcocite heap

S.E. Keeling, M-L. Palmer, F.C. Caracatsanis, J.A. Johnson, H.R. Watling

Minerals Engineering, Volume 18, Issues 13-14, *Pages 1289-1296* (November 2005)

Abstract: Native bioleaching microbes were recovered from a spent chalcocite/chalcopyrite/pyrite heap located at Nifty Copper Mine in Western Australia. As part of the study, methods were developed to enrich and isolate iron and/or sulphur oxidising microbes that thrive in low pH environments. Phenotypic characterisation of native isolates revealed diverse substrate utilisation (chalcopyrite, pyrite, ferrous ion, reduced sulphur as tetrathionate and glucose) as well as displaying growth temperatures between 30 and 50 °C. Their tolerance to changes in pH, temperature, salinity and the presence of metals was also examined. The potential for single isolates to assist the leaching of chalcopyrite and sphalerite concentrates was evaluated. Copper and zinc recoveries from the respective concentrates were greater when native isolates were employed, compared with the use of laboratory reference strains or abiotic conditions.

19) Optimisation of nickel extraction from laterite ores by high pressure acid leaching with addition of sodium sulphate

J.A. Johnson, B.C. Cashmore, R.J. Hockridge

Minerals Engineering, Volume 18, Issues 13-14, *Pages 1297-1303* (November 2005)

Abstract: Extraction of nickel from Western Australian laterite ores via sulphuric acid leaching at 250 °C has been optimised by the addition of sodium sulphate. Leaching of a nontronitic nickel laterite ore in fresh water, with a sulphuric acid loading of 420 kg/t ore extracted 93% of nickel from the ore. When limonitic nickel laterite ore was leached in fresh water with an acid loading of 310 kg/t ore, 92% of the total nickel was extracted. The nickel extractions were optimised at 96% for the nontronitic ore and 95% for the limonitic ore, at the above acid loadings, when process water sodium ion levels were increased to 4 g/L and 2 g/L, respectively. Further addition of sodium ion resulted in a gradual decrease in overall nickel extraction, as the leach liquor free acidity decreased. At higher acid loadings, the process water sodium ion levels required for optimum extraction were also higher, so as to prevent dissolution of aluminium.

20) Effects of temperature on the rates of iron and sulfur oxidation by selected bioleaching *Bacteria* and *Archaea*: Application of the Ratkowsky equation

P.D. Franzmann, C.M. Haddad, R.B. Hawkes, W.J. Robertson, J.J. Plumb

Minerals Engineering, Volume 18, Issues 13-14, *Pages 1304-1314* (November 2005)

Abstract: Bioleaching rates are affected by temperature and temperature is a major selective pressure for the organisms that will inhabit a bioleaching operation. The

relationship of microbial activity to temperature is best described by the Ratkowsky equation. Ratkowsky and Arrhenius equations were applied to temperature versus sulfur or ferrous iron oxidation data for selected bioleaching microorganisms. Extrapolated cardinal temperatures for iron and sulfur oxidation, and activation energies were derived from the fitted Ratkowsky and Arrhenius equations. The data provided definition of the temperature operating windows, to a precision not previously available, for the majority of species that are frequently encountered as the biological catalysts in tank and heap bioleaching environments.

21) The use of air tabling and triboelectric separation for separating a mixture of three plastics

G. Dodbiba, J. Sadaki, K. Okaya, A. Shibayama, T. Fujita

Minerals Engineering, Volume 18, Issue 15, *Pages 1350-1360* (December 2005)

Abstract: The paper describes the dry separation of a mixture of three plastics by combining air tabling and triboelectric separation. While air tabling is effective for particles of different density, the triboelectric separation can be used for separation of particles of similar density. Before commencing the separation tests, the effectiveness of the separating devices was evaluated by analyzing the effects of the particle size and the difference in density between components of the mixture.

A two-stage process has been proposed for separation of mixed plastics prior to recycling. Polypropylene (PP), polyethylene terephthalate (PET), and polyvinyl chloride (PVC) were selected for investigation as they are widely used in the manufacture of everyday products. An air table was employed for the first stage of process to collect a PP-rich low-density fraction and a PET/PVC high-density fraction. In the second stage, the PET/PVC fraction was separated by means of a triboelectric separator utilizing differences in surface charge.

22) Collection zone kinetic model for industrial flotation columns

J. Yianatos, R. Bucarey, J. Larenas, F. Henríquez, L. Torres

Minerals Engineering, Volume 18, Issue 15, *Pages 1373-1377* (December 2005)

Abstract: The collection zone recovery of a flotation column was modeled using a rectangular distribution function for the kinetic rate constant and a tank in series model with different vessel sizes for the residence time distribution. It was demonstrated that an analytical expression can be obtained and that data from large industrial columns fits well, keeping the parsimony principle by using a simple and practical solution. An example for the estimation of the maximum kinetic rate constant, useful for scale-up purposes, is shown using data from industrial flotation columns.

23) Influence of aggregate stemming in blasting on the SAG mill performance

T. Kojovic

Minerals Engineering, Volume 18, Issue 15, *Pages 1398-1404* (December 2005)

Abstract: The practice of using aggregate stemming in production blasting has typically been justified in terms of the improvements in fines generation, consistent with the benefits of confining more explosive energy in the rock during blasting. However, at the Red Dog mine in Alaska, ongoing Mine-to-Mill efforts have identified a further benefit from stemming that had previously not been quantified, specifically the marked reduction in SAG feed size and throughput variability. These reductions represent a substantial benefit in terms of flotation circuit stability, which have allowed the Mill Operations to better optimize the grade and recovery. A secondary but important benefit to come out of the change in stemming practice has been the reduced wear in the gyratory crusher, resulting in a significantly longer period between relines. This paper compares the key mill performance indicators when the mine moved from drill cuttings to aggregate as stemming in the blast holes.

24) Particle bed charge decay behaviour under high tension roll separation

M. Ziemski, P.N Holtham

Minerals Engineering, Volume 18, Issue 15, Pages 1405-1411 (December 2005)

Abstract: A new theory of particle discharge in high tension roll (HTR) separation is presented. The discharge dynamics of an isolated charged particle resting on a conducting surface are studied first. The analysis is extended to particle discharge in a homogenous particle bed. Finally, the paper looks at the more realistic scenario of particle discharge in a non-homogenous particle bed. The consequences of the resulting theory on HTR separation are discussed.

Predictions from the new theory are tested against experimental HTR separations at the pilot scale.

25) Kinetics and reaction mechanism of gold cyanidation: Surface reaction model via Au(I)–OH–CN complexes

G. Senanayake

Hydrometallurgy, Volume 80, Issues 1-2, Pages 1-12 (November 2005)

Abstract: The current status of the mechanism of gold cyanidation based on diffusion and surface adsorption–reaction models are reviewed. Published rate data based on chemical oxidation from flat gold surfaces in pure aerated cyanide solutions are analysed to show a reaction order of 2.7 with respect to cyanide at low concentrations. At higher cyanide concentrations, the reaction rate reaches a limiting value of $R_{\mathrm{Au(lim)}} = 7.3 \times 10^{-6}$ mol m^{-2} s^{-1}, independent of the cyanide concentration and stirring rate. This chemically controlled dissolution of gold in pure cyanide solutions is considered to be different from the widely reported cyanide or oxygen diffusion controlled dissolution of gold, depending on their relative concentrations. The proposed reaction mechanism to rationalise this behaviour involves the formation of a heterogeneous redox transition state $(Au.H_2O)_2.(CN^-)_{2-3}.(O_2)$ which produces the intermediate $Au(I)(OH)(CN)^-$ on the gold surface. Oxygen is reduced to hydrogen peroxide which may degrade in three ways: (i) oxidize gold to produce the same gold(I) intermediates on surface, (ii) oxidize cyanide to cyanate (iii) disproportionate to water and oxygen. The surface adsorbed Au(I) intermediate reacts with cyanide to produce more stable $Au(CN)_2^-$ in solution. The proposed surface chemical model rationalises the reaction order of ≈ 3 at low cyanide concentrations and calculates an intrinsic rate constant of $k_{Au} = 8.6 \times 10^{-6}$ mol m^{-2} s^{-1} for gold cyanidation by oxygen. This value is in reasonable agreement with the value of $k = 6.9 \times 10^{-6}$ mol m^{-2} s^{-1} based on the model proposed by Wadsworth et al. [Wadsworth, M.E., Zhu, X., Thompson, J.S., Pereira, C.J., 2000. Gold dissolution and activation in cyanide solution: kinetics and mechanism. Hydrometallurgy, 57, 1–11.], which considered the mass transfer away from the active crystalline gold surface site followed by fast charge transfer, combined with two-electron reduction of oxygen on the gold surface.

26) Recovery of nickel, copper and cobalt from low-grade Ni–Cu sulfide tailings

Yanting Xie, Yanbin Xu, Lan Yan, Rudong Yang

Hydrometallurgy, Volume 80, Issues 1-2, *Pages 54-58* (November 2005)

Abstract: Leaching experiments were carried out to identify optimal conditions for the recovery of Ni, Cu and Co from low-grade Ni–Cu sulfide tailings. Mixed nitric–sulphuric acid solutions were found to be capable of leaching these tailings at ambient temperature and atmospheric pressure. Recoveries up to 91.5%, 85.0% and 54.6% for Ni, Cu and Co, respectively, were obtained under laboratory conditions. Effective removal of iron from the leaching mixture was performed by Na-jarosite precipitation and the resulting Ni, Cu and Co were enriched as a mixture of their sulfide precipitates with metal contents of 8%, 7% and 0.24%, respectively. The proposed leaching procedure is operationally simple and economical and may be applicable in the industrial recovery of valuable metals from Ni–Cu sulfide tailings.

27) The contribution of direct and indirect actions in bioleaching of pentlandite

Guangji Zhang, Zhaoheng Fang

Hydrometallurgy, Volume 80, Issues 1-2, *Pages 59-66* (November 2005)

Abstract: The mechanisms of bioleaching of pentlandite by mesophilic *Acidithiobacillus ferrooxidans* and thermophilic MLY were investigated. The experimental results showed that the mechanisms were different when pentlandite was bioleached by the two bacteria. It was found that the direct action of the attached bacteria was more important than indirect action of the free cells in the solution during the *A. ferrooxidans* leaching of pentlandite, and that only the indirect action was significant during the MLY leaching of pentlandite.

28) Leaching of a low-grade niobium–tantalum ore by highly concentrated caustic potash solution

Hongming Zhou, Shili Zheng, Yi Zhang

Hydrometallurgy, Volume 80, Issues 1-2, *Pages 83-89* (November 2005)

Abstract: The recovery of niobium and tantalum from a low-grade niobium–tantalum ore by using highly concentrated caustic potash as an alternative to hydrofluoric acid has been investigated. Experiments on the leaching behavior of niobium and tantalum, as well as other associated impurities, such as titanium, iron, manganese, silicon, and aluminum were carried out. The effect of various parameters including leaching temperature, KOH concentration, leaching time, alkali-to-ore mass ratio and particle size on the agitation leaching was examined. When finely ground ore (− 61 μm) reacted with KOH solution (84 wt.%) in a mass ratio of alkali-to-ore of 7 : 1 at 300 °C for 60 min, almost complete extraction of both niobium and tantalum was achieved while the extraction of titanium was 85% and the extraction of other impurities in the ore was less than 35%.

29) Electrowinning of cobalt from sulphate solutions

I.G. Sharma, Pamela Alex, A.C. Bidaye, A.K. Suri

Hydrometallurgy, Volume 80, Issues 1-2, *Pages 132-138* (November 2005)

Abstract: This paper reports an account of study conducted on optimization of the process parameters for electro-winning of cobalt from cobalt sulphate solution. Effect of parameters such as bath composition, temperature, current density, agitation etc. on the voltage requirement, current efficiency and power efficiency of cobalt electro-deposition was explored. A maximum current efficiency of 97% was attained with an electrolyte composition of 60 g/L Co, 15 g/L Na_2SO_4, at a temperature of 60 °C, a pH of 4.0 and a cathode current density of 400 A/m^2. The energy consumption was 3.0 kWh/kg of Co deposited. The optimum conditions so established were test examined for recovery of cobalt values from leach liquors generated on processing of Alnico magnet scrap, cemented carbide tool scrap and spent hydrogenation catalyst. The cathode current efficiency ranged from 86% to 94% due to lower concentration (25 to 40 g/L) of cobalt concentration in the processed leach liquor.

30) Modelling of zinc transport through a supported liquid membrane

Osman Nuri Ata, Sabri Çolak

Hydrometallurgy, Volume 80, Issue 3, *Pages 155-162* (1 December 2005)

Abstract: The transport of zinc (II) from an aqueous solution containing zinc (II), iron (II), calcium (II) and magnesium (II) through supported liquid membrane using di-2-ethylhexyl phosphoric acid dissolved in kerosene as a mobile carrier was studied. The effects of temperature, rate of feed and stripping phase and concentration of stripping phase on the mass transfer coefficients of aqueous boundary layers and membrane were studied. A transport rate model has been derived taking into account diffusion through the feed side aqueous boundary layer, diffusion of carrier–zinc complex through the supported liquid membrane and diffusion through the stripping side aqueous boundary layer as simultaneous controlling factors. The mass transfer coefficient data of the side of the feed phase were correlated in the form of $Sh = 0.0047\ Re^{1.349}\ Sc^{0.3333}$. This correlation was used to calculate the mass transfer coefficient of the aqueous film at the side of the stripping phase. For some parameters and their levels, the mass transfer coefficients, k_f, k_m and k_s ($m\ s^{-1}$), were calculated.

31) Separation of iron and nickel from a spent $FeCl_3$ etching solution by solvent extraction

Man-Seung Lee, Kyoung-Joo Lee

Hydrometallurgy, Volume 80, Issue 3, *Pages 163-169* (1 December 2005)

Abstract: Solvent extraction experiments were conducted to separate iron and nickel from a spent $FeCl_3$ etching solution. Alamine336, MIBK and PC88A were tested as extractants and the highest extraction percentage of iron was obtained with Alamine336. It was possible to separate iron and nickel by extracting the spent etching solution with Alamine336. In the operation of mixer-settler, seven extraction stages with 1.0 M Alamine336 led to 99% extraction of iron at an O / A ratio of 7. Ten stripping stages with 0.01 M HCl solution resulted in an aqueous solution with 133 g/L of iron at an O / A ratio of 7.

32) A simple theoretical approach to palladium extraction with *s*-decyl derivatives of dithizone using the semiempirical PM3 method

Ismael H. Salazar-Gómez, Rogelio Jiménez-Cataño, M. Guadalupe Sánchez-Loredo

Hydrometallurgy, Volume 80, Issue 3, *Pages 203-210* (1 December 2005)

Abstract: This paper reports a simple theoretical approach aimed at studying palladium extraction with two different dithizone derivatives. In particular, we applied a modelling scheme and the quantum-mechanical semiempirical PM3 method to the description of extractants, palladium chlorocomplexes and Pd(II)–extractant complexes. The results of computer calculation of geometries, conformational energies, formation enthalpies, and reaction enthalpy changes are presented and analysed. Comparison of these results with some available from experiment suggests that the semiempirical PM3 method, a useful tool considering the computational cost, could be used with some caution as an aide for the examination of chelating liquid–liquid extraction systems.

33) Leaching of a sphalerite concentrate with H_2SO_4–HNO_3 solutions in the presence of C_2Cl_4

Peng Peng, Huiqin Xie, Lizhu Lu

Hydrometallurgy, Volume 80, Issue 4, *Pages 265-271* (30 December 2005)

Abstract: The enhanced leaching of sphalerite concentrates in H_2SO_4–HNO_3 solutions and the extraction of sulfur with tetrachloroethylene were studied. Variables of the process were investigated including leaching temperature, reaction time, liquid / solid ratio, and tetrachloroethylene concentration. The number of cycles that tetrachloroethylene could be recycled did not have a significant effect on zinc extraction. The results indicated that 99.6% zinc extraction was obtained after three hours of leaching at 85 °C and 0.1 MPa O_2, when 20 g of sphalerite concentrate were leached in a 200 ml solution containing 2.0 mol/L H_2SO_4 and 0.2 mol/L HNO_3, in the presence of 10 ml C_2Cl_4. Leaching rates were significantly improved under these conditions.