TUESDAY, AUGUST 24, 2004, A.M.

SESSION 22: FIFTH UBC-MCGILL INTERNATIONAL SYMPOSIUM ON PARTICLE SIZE ENLARGEMENT IN MINERAL PROCESSING

HYDROPHOBIC AGGREGATION IN FINE PARTICLE BENEFICIATION /FLOTATION
Sponsor: Mineral Science and Engineering Section, The Metallurgical Society of CIM
Room: Chedoke C
Chairmen: J.A. FINCH, McGill University, Montréal, Québec, Canada, and
R.S.C. SMART, University South Australia, Adelaide, Australia

PAPER 22.1 — 8:30
UPGRADING OF CARBONACEOUS MATERIALS USING SELECTIVE HYDROPHOBIC COAGULATION.

R.Q. HONAKER, University of Kentucky, Lexington, Kentucky, U.S.A.,
G.H. LUTTRELL, Virginia Tech, Blacksburg, Virginia, U.S.A., and
R.-H. YOON, Virginia Tech, Blacksburg, Virginia, U.S.A.

It has been shown that naturally hydrophobic carbonaceous materials such as coal and graphite can be selectively coagulated and separated from hydrophilic impurities without using oily agglomerants, flocculants or electrolytes. The coagulation occurs at ζ-potentials significantly higher than those predicted by the classical DLVO theory, suggesting that it is driven by the hydrophobic interaction. In the present work, the energy barriers for the coagulation of a hydrophobic coal sample have been calculated using the extended DLVO theory which incorporates the hydrophobic interaction energy in addition to the dispersion and the electrostatic energies. For the coagulation of minerals present in the coal, the classical DLVO theory has been used for the energy barrier calculation. The results of these calculations provide an excellent correlation with the results of a series of Selective Hydrophobic Coagulation (SHC) tests conducted with run-of-mine coal and graphite samples.

PAPER 22.2 — 8:55
EFFECT OF CAL SURFACE WETTABILITY ON AGGREGATION OF FINE COAL PARTICLES IN AQUEOUS SUSPENSIONS.

F.A. MELO, M. PAWLIK and J.S. LASKOWSKI, University of British Columbia, Vancouver, British Columbia, Canada

Fine coal aggregation in concentrated coal-water suspensions was studied through steady-state rheological measurements. The wettability of coal particles was modified by dry oxidation of a bituminous coal. The degree of hydrophobicity was monitored using film flotation. The rheological measurements revealed that hydrophobic coal particles aggregate in aqueous suspensions, over a wide pH range, and produce slurries with high yield stresses. As the degree of coal oxidation increases, the coal particles become more hydrophilic and such suspensions exhibit lower yield stresses values. The yield stress values for suspensions prepared from oxidized/hydrophilic coal become a strong function of pH and correlate well with the surface charge as determined through electroacoustic measurements. These results indicate that the yield stress of aqueous suspensions of coal, and hence coal particles aggregation, is strongly affected by the wettability of coal particles.

PAPER 22.3 — 9:20
FROTHER INDUCEMENT OF THE BUBBLE ATTACHMENT TO HYDROPHOBIC SOLID SURFACE.

M. KRASOWSKA, M. KRZAN and K. MALYSA, Polish Academy of Sciences, Krakow, Poland

The paper presents fascinating, in our opinion, observations on mechanism and course of processes occurring during bubble collision with hydrophobic and hydrophilic solid surface. Hydrophobicity of particle surface is a necessary condition for the particle attachment to bubble. We have observed that even in the case of such hydrophobic solid surface as Teflon, the bubble attachment didn't occur at first collision. In distilled water the bubble bounced a few times without attachment. Influence of α–terpineol and n-pentanol on bubble local and terminal velocity and the phenomena occurring during bubble collisions with hydrophobic and hydrophilic solid surfaces was studied. Bubble collisions with the solid surfaces were monitored and recorded using the high-speed (1182 frames per second) camera. It was found that in distilled water the velocity variations of the "approach-bounce" cycles were identical for Teflon and glass. Four distinct "approach-bounce" cycles were detected both at Teflon and glass surfaces. Moreover, the

amplitude and frequency of the velocity variations were identical on collisions with the hydrophobic (polished) and hydrophilic surface. There was no immediate three phase contact formation, with the hydrophobic Teflon surface, what we found really astonishing. Roughness of Teflon surface seems to be important parameter, which affects probability of the bubble attachment as a result of a presence of micro- and/or nano-bubbles at the surface. It was detected that the presence of the micro-bubble affected attachment of the colliding bubble even in distilled water. Presence of a small amount of α–terpineol or n-pentanol affects dramatically the bubble velocity, but their role in mechanism of the bubble attachment needs further study.

PAPER 22.4 — 9:45

SILVER RECOVERY AND CONCENTRATE GRADE IMPROVEMENT FOR SCAVENGER CONCENTRATES THROUGH REGRINDING AND SELECTIVE AGGREGATION.

O.E. ORTEGA, S. SONG and A. LOPEZ VALDIVIESO, Universidad Autónoma de San Luis Potosí, Mexico

A process scheme has been devised to improve the silver recovery and the grade of concentrates from the scavenger concentrate of a silver ore flotation circuit. Based on modal analysis studies it was found that silver sulfide minerals in the scavenger concentrate were associated as simple binary particles and finely disseminated in sulfide and non-sulfide gangues. Fine grinding of the concentrate improved the grade-recovery curve of silver to a very limited extent owing to heterocoagulation between liberated fine silver sulfides and coarse particles of gangue. This heterocoagulation phenomenon was prevented by grinding the concentrate in the presence of the dispersing reagent sodium hexametaphosphate. The silver grade-recovery curve was improved by practicing, before the conventional flotation step, a selective aggregation step for the fine silver sulfide particles using the non-polar oil kerosene, the sulfhydryl collector Aerophine 3418 and conditioning the pulp under strong agitation conditions.

COFFEE BREAK — 10:10 - 10:40

PAPER 22.5 — 10:40

AGGREGATION: CASE OF CA IONS AND MG (OH)2 COATED SILICA.

M. MIRNEZAMI, M.S. HASHEMI and J.A. FINCH, McGill University, Montréal, Québec, Canada

The surface of -30μm silica suspension (2% v/v) treated with 100 ppm Mg^{2+} at pH 11 was fully coated with $Mg(OH)_2$. Under this condition, the silica is strongly positively charged (+30 mV) and the suspension is dispersed. Subsequent addition of Ca^{2+} promoted aggregation and reduced the surface charge. At this pH calcium is present as Ca^{2+} and $CaOH^+$, i.e., positively charged ions interacted with the positive surface. Aggregation by a chemical bridging mechanism is proposed. The observation may be relevant to the widespread practice in mineral processing of adding lime to promote aggregation and settling in concentrate thickeners.

PAPER 22.6 — 11:05

EFFECT OF SULPHATES ON AGGREGATION OF ALUMINA AND PYRITE

M. MIRNEZAMI, M.S. HASHEMI, J.A. FINCH, McGill University, Montréal, Québec, Canada

This study examined the effects of pH and sulphate concentration on the surface charge and stability of alumina and pyrite dispersions. The relationship between these properties was investigated using measurements of electrophoretic mobility and settling velocity. The maximum aggregation for both minerals was observed near the iso-electric point (iep) where the force of repulsion is at a minimum. Aggregation decreased at pH values away from the iep, where an increased surface charge causes electrostatic repulsion between particles. Zeta potential data revealed that sulphate ions were adsorbed only on positively charged surfaces for both minerals. Adsorption of sulphates on the alumina surface increased aggregation by reducing the surface charge from >+25 mV to close to zero. These results indicate an electrostatic bonding of sulphate ions to alumina surface. Preliminary results on the interaction of pyrite and sulphate ions indicate a similar response.

PAPER 22.7 — 11:30

EFFECT OF RESIDUAL HYDROPHILIC POLYMERS ON THE FLOTATION OF INHERENTLY HYDROPHOBIC MINERALS.

S.H. CASTRO, University of Concepcion, Concepcion, Chile, and
J.S. LASKOWSKI, University of British Columbia, Vancouver, British Columbia, Canada

Molybdenite depression by shear degraded polyacrylamide solutions has been investigated. Aqueous solutions of polyacrylamide-type flocculants were subjected to shear degradation under a range of high-speed stirring conditions. Settling tests, carried out with quartz slurries and sheared polyacrylamides, showed reduced flocculant performance with increased degradation. As the sedimentation rate is strongly dependent on the polymer's molecular weight, these results fit well with the shear degradation theory, which predicts the production of shorter chain segments due to breakage of the polymer macromolecules. Microflotation tests on natural molybdenite showed that the depressing ability of a commercial polyacrylamide flocculant remained unaltered after shear degradation, even when the flocculating ability was entirely lost. Practical implications of shear degradation on molybdenite flotation are discussed.

PAPER 22.8 — 11:55

THE ROLE OF POLYMERIC-DEPRESSANT-INDUCED FLOCCULATION IN FINE PARTICLE FLOTATION.

Q. LIU and D. WANNAS, Chemical and Materials Engineering, University of Alberta, Edmonton, Alberta, Canada

Several inorganic reagents and organic polymers were tested as depressants in the single mineral flotation of ultrafine iron oxide and hydroxylapatite with Dowfroth 250 as a frother. It was observed that the inorganic reagents and the low molecular weight polymers generally caused dispersion of the ultrafine particles, and consequently their recovery into froth products more or less equaled the recovery of water. On the other hand, the high molecular weight polymers caused different degrees of flocculation of the ultrafine particles, and their recoveries were much lower than the recovery of water. These observations pointed to a need to re-define flotation depressants in fine particle flotation. The traditional definition of a flotation depressant, i.e., to make particle surfaces hydrophilic by forming a hydrophilic film and/or by removing collector and activator coatings, is sufficient for relatively coarse particles. However, to prevent fine and ultrafine particles from floating, a successful depressant should not only make the particles hydrophilic, but also enlarge the particle sizes so that they do not enter the froth product by mechanical entrainment. Polymeric depressants are ideal for these purposes. The different schemes to use polymeric depressants in the selective flotation of fine and ultrafine particles were discussed. These schemes involve the integration of the polymeric depressants into other size enlargement processes such as shear flocculation, oil agglomeration, etc., for hydrophobic particles.