A summary of water recycling in Canadian mills by Pickett and Joe shows that recycling in gravity and magnetic concentration circuits as well as single flotation circuits can and is being used in the majority of cases. Serious problems arise in Pb-Zn and Pb-Zn-Cu selective flotation circuits. The second serious problem exists in the cyanide gold industry. Recycling is limited by build-up of complex chemical compounds which affect metallurgy and sulfates that cause operating problems. Uranium leaching plants have developed expensive but effective recycling systems. The most effective overall answer is a cascade pond system. Often the reclaimed water from thickeners, filters, and tailing ponds can be matched with requirements for each part of the circuit with the most effective combination of the chemical properties of the process, the ore, and the reagents.

Tailings and Reclamation

International experts reported on tailing dam construction and operation, water reclamation, and vegetation of tailings at the International Tailings Symposium in Tucson, Arizona. Representatives from twenty-two countries heard 35 technical papers and inspected two tailings dams. Many of the papers included stabilization techniques. The papers are published in a Tailings Symposium book "Tailings Disposal Today."

References


Electrostatic precipitators such as these remove 96 percent of the dust from converter gases.
has been critically examined in a recent review by Guttierrez on the mechanism of xanthate flotation of galena. At the annual AIME meeting in Chicago, Wells and Van Cleave presented a hypothesis that the hydrophobicity of galena in xanthate solution is due to adsorption and reduction of diethyl dixanthogen on other parts followed by diffusion of dixanthogen to cathodic areas. However, Nicol has claimed that diethyl dixanthogen is not a product at the galena surface. Variation in rest potentials was attributed to changes in the nature of the galena electrode used. Adsorption properties of xanthate species on sulfide minerals have been correlated by Prasad and by Kuhn and M. C. Fuerstenau (annual AIME meeting). The higher stability of dixanthogen on galena than on most other sulfides has been correlated by Prasad with the matching of interatomic distances of galena's mineral lattice to that of the dixanthogen molecule. A study of Eh response of sulfide minerals as a function of pH by Natarajan and Iwasaki shows the measured Eh to approach that of noble metals under certain conditions. This phenomenon is possibly due to the formation of a passive layer on sulfides which in turn could be responsible for a decrease in response of these sulfides to flotation or leaching. Other noteworthy works using sulfides includes that of van Lierde on the depression effect of low molecular weight polyacrylates in xanthate flotation of galena and that of Banerji on the activation of sphalerite using copper ions generated from an electrode instead of CuSO4. The role of sulfide ions in the flotation of malachite after sulfidization is, according to Sato and Laskowski, to reduce flotation. Elimination of sulfide either by aeration in the presence of malachite or by the decantation of supernatant liquid enhances flotation.

Chemistry of flotation and flocculation was discussed at a special symposium on this topic at the 47th National Colloid symposium. Discussions at this symposium started with a plenary lecture by M. C. Fuerstenau on the mechanism of surfactant adsorption on oxides and silicates. For copper oxide-carboxylate systems Coelho and Poling presented spectroscopic evidence for the presence of carboxylate anions as a major component in the first adsorbed layer on copper oxides and copper carboxylates and organic acid species as the major components in subsequent layers. Aplan et al. demonstrated the significance of point defects, at least in the case produced by Cd in AgCl, on the flotation of AgCl using amine as collector. The use of hydrocarbon gases in flotation was discussed by Somasundaran and Moudgil. Saturation of the collector solution with hydrocarbon gases was found to

In the laboratory, a chemist prepares liquid samples for atomic absorption (spectrophotometer) and related testing.
cause a significant increase in sulfonate flotation of alumina but not in that of hematite, which floats with sulfonate, or in that of quartz, which does not float. Thus, the possible use of hydrocarbon gases for improving selectivity in flotation is suggested.

of adsorption have been examined by Mellgren, et al., at the Tenth International Mineral Processing congress, by Predali, et al., at the Tenth International Mineral Processing congress and Instrument Exhibition in Particle Technology in Chicago, by Austin and Faruja, et al., at the Tenth International Mineral Processing congress, by Snow, presented at the International Conference and Instrument Exhibition in Particle Technology in Chicago, by Austin and Faruja, et al., has shown rather clearly the shortcomings of traditional design schemes (e.g. Bond's approach) and suggests that a scheme based on the more detailed models will yield significant improvements in the accuracy of design. Other work with these models as described at the Eleventh International Symposium on Computer Applications in the Minerals Industry, by Root and White and by Horst, et al., suggests that they may provide an ideal framework for identifying new grinding circuit optimization strategies and testing them off-line by simulation. Flotation research in South Africa (NIM) has resulted in what appears to be a practical phenomenological model for use in the design and control of complex flotation circuits. Similar applications oriented flotation modeling has been continued in 1973. Research concerned with the scale-up design of the large mills, suggesting efficiency increases with increasing mill diameter to about 12.5 feet after which increased size no longer yields increased efficiency. Energy size-reduction relationships remained a topic of research.

Agar and Somasundaran at the Tenth International Mineral Processing congress demonstrated the equivalence of several existing relationships; Austin has discussed ambiguities with the choice of a "characteristic particle size" for use in the general grinding "law" proposed by Walker in 1937, while Bump has proposed a new relationship based on an analysis of comminution results from a fracture physics viewpoint. Jomoto and Majima have presented an empirical relationship between tensile strength, critical drop height and ball mill grindability. In the area of size distribution representation, Harris has presented further arguments concerning the use and interpretation of Weibull distribution plots.

Mathematical Modeling

Interest in the development of mathematical models for mineral processing systems has been high for the last ten years. During this period researchers frequently mentioned, if only in passing, that the ultimate objectives of modeling studies include improvement in the design, optimization and control of mineral processing unit operations. This year several investigators have begun exploring in some detail various industrial applications for these models. Research concerned with the application of physically based, population balance modeling to tumbling mill scale-up design by Herbst, et al., presented at the Tenth International Mineral Processing congress, by Snow, presented at the International Conference and Instrument Exhibition in Particle Technology in Chicago, by Austin and Faruja, et al., has shown rather clearly the shortcomings of traditional design schemes (e.g. Bond's approach) and suggests that a scheme based on the more detailed models will yield significant improvements in the accuracy of design. Other work with these models as described at the Eleventh International Symposium on Computer Applications in the Minerals Industry, by Root and White and by Horst, et al., suggests that they may provide an ideal framework for identifying new grinding circuit optimization strategies and testing them off-line by simulation. Flotation research in South Africa (NIM) has resulted in what appears to be a practical phenomenological model for use in the design and control of complex flotation circuits. Similar applications oriented flotation modeling has been.
described by Steiner at the Tenth International Mineral Processing Congress by Bubin, described at the Eleventh International Symposium on Computer Applications in the Mineral Industry.

In addition to research concerned with the direct use of models for process improvement considerable effort has been devoted to the refinement of existing models and the development of new ones for a variety of unit operations. Two papers have dealt with special solutions of the integral differential equations of tumbling circuits. Studies reported by Gardner at the AIME Annual Meeting in Chicago, involving linear size discretized population balance models have produced analytical solutions for the dynamics of ball mill start-up and the response to a step change in feed size distribution. Further, it has been confirmed computationally that the unequal selection function assumption frequently invoked in the solution of these model equations does not place any practical limitations on their usefulness. The influence of ball mill operating variables (mill speed, ball size, charge, etc.) on the parameters of population balance models has been examined by Herbst and D. W. Fuerstenau (presented at the AIME Annual Meeting in Chicago), by Olsen and Krogh and by Kelsall, et al. with a view toward extending the simulation capabilities of these models. Other studies have been concerned with model comparison and verification in continuous mills; lumped and distributed transport population balance models as well as matrix models have been examined in these studies. A recent computational study by Mika and presented at the International Conference and Instrument Exhibition in Particle Technology has led to the surprising conclusion that in spite of the fact that the population balance equation is a non-linear second order, matrix models can be made to provide an equally good description of steady state grinding circuit behavior. Additional experimental evidence has been presented for the existence of nonlinear breakage behavior in certain tumbling mill systems, and a paper concerned with the use of linear approximations to nonlinear kinetic behavior was presented by Herbst and Mika at the Eleventh International Symposium on Computer Applications in the Minerals Industry. Two other mechanical aspects of tumbling mill behavior (power draft and particle mixing) which are currently modeled in order to develop a completely predictive milling description were also treated in recent studies.

Other modeling research reported in 1973 includes the development of a unified model for classification of particles in fluids reported on by Fitch at the International Conference and Instrument Exhibition in Particle Technology. A paper by Victor and Groeneveld on a method for identifying classifier parameters from experimental data described by Luckie and Austin at the Tenth International Mineral Processing Congress. Efforts in agglomeration have resulted in the development of five distinct mechanisms of formation and growth in wet pelletization (nucleation, coalescence, abrasion, transfer, breakage and snowballing).

Process improvement appears to be a viable means to economic gain in mineral processing operations in the U.S. during the next decade. Since a quantitative understanding of the existing processes is essential to development of effective improvement schemes, research concerned with the fundamentals of Mineral Processing unit operations must be intensified. These required programs can only be carried out with the support and active participation of U.S. industry in this area. Cooperative research efforts of this type between industry, academia and government agencies in several other countries e.g. Australia, South Africa, Canada, Japan and Finland, appear to be yielding significant returns in their respective mineral industries.

References