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Editorial

Editorial for Special Issue "Modeling, Design, and Optimization of Multiphase Systems in Minerals Processing, Volume II"

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The manuscripts published in the 2019 Special Issue "Modeling, Design, and Optimization of Multiphase Systems in Minerals Processing" [1] do not cover all phenomena and problems associated with multiphase systems in mineral processing; hence, a second volume is being released. The ore mineralogical features, operational conditions, and equipment sizing are critical factors in metallurgical processes' performance at all scales. Under this context, this Special Issue aims to facilitate new knowledge for addressing stated topics.

The second volume of the Special Issue includes nine research articles and one communication covering various procedures for designing, modeling, optimization, and analysis in problems of leaching, flotation, grinding, and solid–liquid separation, among others. The manuscripts published can be grouped into unit operation and plant scales.

In the first group, we can find applications of the following approaches: response surface methodology (RSM), computational fluid dynamics (CFDs), machine learning (ML), mass population balance, and uncertainty quantification (UQ), among others. Mineral processing initially involves comminution processes to achieve the liberation of valuable minerals, finely disseminated and intimately associated with gangue. The comminution exhibits a high electric energy consumption, and it comprises crushing and grinding stages, studied in "Milling Studies in an Impact Crusher I: Kinetics Modelling Based on Population Balance Modelling" [2] and "Experimental Uncertainty Analysis for the Particle Size Distribution for Better Understanding of Batch Grinding Process" [3], respectively. In the first work, the operation of a vertical shaft impact crusher (VSIC) is explored because this equipment exhibits a size reduction ratio that can go up to 40:1 compared to 6:1 for the jaw, gyratory, and cone crushers, favoring reductions in capital expenditure and energy consumption. VSIC is modeled via mass population balance, usually used to describe the grinding process, and its simulation reveals that a larger particle size requires a shorter breakage time, whereas smaller feed particles require a longer breakage time. The grinding process presents particularly high uncertainty due to the interacting operating/design parameters set and can be evaluated in different ways, e.g., via particle size distribution (PSD). However, is the PSD a good way of quantifying the uncertainty in the grinding process? This research question is addressed in the second work through a methodology for performing uncertainty analysis (UA), which allows an over/underestimation of uncertainty and variations to be detected depending on the analyzed output. The grinding product is sent to mineral concentration processes where chemical (e.g., surface composition) or physical (e.g., specific gravity, magnetic susceptibility) properties of the minerals are used to achieve their separation. The first property is applied in "Response Surface Methodology for Copper Flotation Optimization in Saline Systems" [4], where optimizing copper flotation in seawater with high pyrite and clay is addressed via RSM. The latter is widely used in various research fields and exhibits poor performance when experimental data display complex behavior, as in the scenario described. Under this context, RSM is improved by integrating it with ML, geostatistical, and UQ tools. The proposed procedure exhibits a remarkable multidisciplinary spirit, one of the aims of the Special Issue. Mineral-specific gravity is applied in "Simulation Algorithm for Water Elutriators: Model Calibration with Plant Data and Operational Simulations" [5], where a one-dimensional model is developed to explore the behavior of a hydraulic classifier. The model includes phenomenological convection/diffusion transport equations, which allow an industrial and laboratory hydraulic classifier to be simulated for separating hematite from quartz, providing clues on manipulating hydraulic classifier operating variables. Coal is a primary energy source used for industrial development, processed commonly by gravity separation and flotation; however, these processes have poor performance for coarse slime with a large particle size range. Within this background, liquid–solid fluidized beds (LSFBs) have appeared as a viable alternative whose behavior is investigated in "CFD Modeling and Simulation of the Hydrodynamics Characteristics of Coarse Coal Particles in a 3D Liquid-Solid Fluidized Bed" [6] by a 3D CFD model, where its simulation reveals that small and light particles are easily fluidized, and inhomogeneity may occur throughout the bed for large ad heavy particles. In order to include various phenomena associated with LSFBs, this model remarkably considers expressions such as momentum equation, as well as the kinetic theory of the granular flow model, the drag model, and the turbulent model. Water recovering from tails and concentrates is crucial for the mining industry's sustainability. Considering the high performance expected in this procedure, continuously operating decanter centrifuges are a reasonable option, and its scale-up is a significant challenge approachable via analytical (mass balance) and the law of similarity ($\Sigma - Theory$) approaches. These latter are compared in "M. Scale-Up of Decanter Centrifuges for the Particle Separation and Mechanical Dewatering in the Minerals Processing Industry by Means of a Numerical Process Model" [7] through experiments on lab-scale, pilot-scale, and industrial-scale decanter centrifuges considering two suspensions. On the other hand, UQ has been used on many occasions, e.g., in global sensitivity analysis (GSA) and UA. The first can be carried out using the Sobol method; however, its application using complex models is impractical owing to their significant processing time. The acceleration of GSA is achieved in "Accelerating Global Sensitivity Analysis via Supervised Machine Learning Tools: Case Studies for Mineral Processing Models" [8] by implementing a methodology based on ML tools and modern experiment design that can be seen as an extension of RSM for computational experiments.

In the second group of articles, we can find applications of the following approaches: ML, optimization, discrete event simulation (DES), and UQ. Uncertainty can be grouped into stochastic (e.g., ore grade and metal price) and epistemic (e.g., unknown operating behavior), and its effect on the operability and design of flotation systems is studied in "Toward the Operability of Flotation Systems under Uncertainty" [9] using mathematical optimization and UA. This work implements some assumptions reported in previous studies [10,11] to reduce the large computational burden without considering the dimension of uncertainty space; an aspect addressed in [12]. Specifically, this work implements ML tools and GSA to reduce the uncertainty space of stochastic optimization problems. It is worth commenting that GSA allows relationships between the input and output variables of the stochastic formulation to be established. On the other hand, some mining projects, such as the Florida mine in Santiago, Chile, integrate flotation and leaching to process gold ore. Initially, the fed ore is processed in flotation systems with previous comminution, whose gold-rich concentrate is subject to cyanidation leaching in tanks. Copper and iron sulfides are harmful to extracting precious metals since they are aggressive cyanide consumers. Therefore, the manuscript "Incorporation of Geometallurgical Input into Gold Mining System Simulation to Control Cyanide Consumption" [13] studied the optimization of cyanide consumption using DES and mineralogical information, demonstrating the importance of standardized operational modes and their potential impact on cyanide consumption control.

This Special Issue considered new problems in various areas of multiphase systems in mineral processing, extending the scope of the previous version by presenting different procedures and tools to solve or face them. We hope that the Special Issue Volume II will contribute to a better understanding of multiphase phenomena and promote future multidisciplinary research in the modeling, design, and optimization of multiphase systems in mineral processing.

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