Macromolecular mass transfer: a new approach for mining process unit operations

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ABSTRACT: In the present work, a new theoretical interpretation for several minerals processing physical unit operations is presented. This interpretation is part of the *Modelo Operacional (Operational Model),* which was developed by the Author as an attempt to establish a new theoretical basis for mineral processing unit operations. The model considers an analogy between the mass transfer chemical processes and some of the ore beneficiation mechanical processes, configuring a new macrophenomenological interpretation for them. The model aims at establishing new theoretical bases for phenomena taking place in operations such as: Comminution (grinding, crushing) and Separation with Mass Concentration (gravity separation, magnetic separation, cyclones, froth flotation, etc.). In the chemical industry, the direct operations yield two phases from a solution of one phase alone for example by means of the application or extraction of heat (the fractionated distillation and the fractionated crystallization belong to this type). In the mineral area, the *comminution* of particles can be interpreted as a direct operation (irreversible, in this case) in analogy with the fractionated distillation operation. The rock is defined as a solution of particles of interest, in solid phase, inside of a gangue solution. The grain is considered as the macromolecular transport basic unit. This grain is initially inserted in the rock, "dissolved" in gangue and, together with the energy application, this grain follows the rock fragments that are being ground, with larger liberation degree.

The indirect operations involve the addition of another substance and consider, among others, the gaseous absorption and the desorption operations. *Concentration operations* are viewed as a phenomenon of macromolecular transport of mass (particles) between phases (froth and slurry phases, for example, in froth flotation). Mechanisms for mass transport and flow of particles between phases as a function of the hydrophobic potential in each phase are discussed. By establishing the so-called Equilibrium Distribution Curve between phases it is possible to calculate macroscopic balances that are related with metallurgical results, which in turn are a function of the Operational Line that is required by the process itself. The number of cleaning stages and their efficiencies can also be determined by simple laboratory scale experiments.

The concepts of the model can be summarized in some specifics principles and 3 mathematical laws that were derived by the author in 1987, and several industrial demonstrations in Brazil operations have been reported at this time, with reagents, energy and investments reductions. The model here proposed shall become a novel tool for researchers, mining engineering students, process engineers and operators who pursue evaluation, optimization and control of several minerals processing unit operations. The present paper illustrates the concepts of the *Modelo Operacional* and the new Macromolecular Mass Transfer approach introducing for mining process unit operations.

1 INTRODUCTION

1.1 *Necessity of a New Mineral Science*

Differently of that it happens in the field of Chemical Engineering unit operations, which are based on transport phenomena of *amount of movement, energy and mass*, the Mechanical Ore Processing units operations presents several difficulties that have not allowed the basic mechanisms description of these processes and, as consequence, they have limited the simulation models study and have made it difficult, also, the attainment of simple correlations between laboratory studies and industrial continuous operation.

The mass transfer operations observed in the chemical industry are molecular and allways tend to equilibrium, assuming steady state conditions based in transport gradient knowledge in any transversal point of the flow, or flows, generally in homogeneous phases. In this way, its modeling, based on transport gradient and kinetic behavior it approaches perfectly to the industrial reality, almost