MODELLING OF BINARY MIXTURE COMMINUTION

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***Abstract*— This paper treats on grindability differences of mineral mixtures to achieve a preliminary selective particle size contrast by comminution in order to improve further sorting operation. Quartz and calcite had been chosen as example of binary system. The theoretical basis for this work was inspired by the optimization study carried out by Ray and Szekely (1973), through an algebraic model based on evolution of log-normal distribution of particle size during comminution. On the other hand, the present work has described grindability differences through the classical Rosin-Rammler size distribution. The study of the evaluation of binary mixture differences was realized by sieving analyses and the estimation of Rosin-Rammler sharpness and median diameter. An objective function was conceived stressing the relationship between the expended energy in the grinding process and the optimum residence time. It is possible to use the results as a background for grinding optimization system, since that the penalty function inside objective function can be adequately calibrated as far as technical and economic impacts on further sorting separations are concerned.**

***Keywords*— grindability; granular media; Rosin-Rammler; unit operations.**

I. INTRODUCTION

Currently, it is well known that the selection and break process of the particle in the comminution is obtained by impact breaking, compression and abrasion. Knowledge of the forces acting on particles in the different types of ores can contribute for the improvement of mineral processing. Several models were created to describe forces acting on the particles during the break process. The formalism that has been by far most used is the population balance (King, 2001; Beraldo, 1987).

The critical operation in the processing of minerals is sorting. For their achievement, it is usual to apply comminution to achieve the necessary liberation. Ores constituted of minerals displaying differences in hardness, cleavage, parting and grindability have possibilities of economic gain in a processing plant, by particle size differentiation of the species to be separated. Such an optimum size contrast between the two species meets the compromise among the following parameters: liberation degree, selective size difference of components, concentration efficiency and specific energy consumption.

Modeling of comminution usually is performed employing the population balance approach. This method is based in two stochastic functions: the selection function (linked to probability of each particle being selected in a single comminution event) and the breakage function, which quantifies the progeny's size distribution (Fuerstenau *et al.*, 2003; Beraldo, 1987). So the model can predict particle size distribution of product after comminution. Non linearities in model equations can jeopardize the accuracy of the simulation, as already pointed out by Aboukheshem *et al.* (1986) and Bilgili and Scarlett (2005). Alternatively, using Lagrange's multipliers method, Otwinowski (2006) has applied the maximum informational entropy to determine the breakage function.

Another interesting approach was used by Ray and Szekely (1973), who used a objective function based on maximization of the benefit that a selective comminution gives to the subsequent process with a penalty cost function for comminution. They used the difference between the mean sizes at the exit of the mill as quantification criterion for the benefit. These authors used the **discrete maximum principle** for optimization in systems of decomposed structure. The model is based in the population balance model obeying the log-normal distribution, which is described by:

$$y(d) = \frac{1}{\log\sigma\sqrt{2\pi}} \exp\left\{-\left[\frac{\left(\log d - \log \bar{d}\right)^2}{2\log^2\sigma}\right]\right\} \qquad (1)$$

where $\bar{d}$ is the median diameter of the particle; σ^2 is the variance of size distribution of the material; $y(d)$ is the fraction of material with diameters between d and $d + \Delta d$. Modifying such an approach of mixture comminution modeling the present work has studied the behavior of an binary ore in the grinding process, using a synthetic quartz and calcite mixture. The theoretical results obtained by Ray and Szekely through the interaction of two materials of different grindability (said A and B) were found by using the log normal size distribution and linking the intersection area of the curves for material A and B with the possible separation capability of post-comminution equipment, associated to differences of mean sizes and standard deviations as discriminant parameters.

In parallel to this work Rosa and Luz (2010a; 2010b) had studied selective grinding of binary mixtures, aiming to simulate it by artificial neural network.

II. METHODS

The behavior of a synthetic ore during grinding was studied using the evolution of the mean size and sharpness of the Rosin-Rammler-Sperling-Bennet distribution