Simulation of Power-Draw and Fill Level for a Semi-Autogenous Mill System

(Poster Abstract)

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ABSTRACT
This poster presents a dynamic simulator of a semi-autogenous grinding operation deduced from first principles coupled to an on-line parameter estimation scheme able to simulate industrial operations for future control purposes. The proposed procedure for simulation purposes is as follows: Model equations are based on a conventional non-stationary population balance approach to develop the necessary dynamic model of the semi-autogenous mill operation. The presented models are able to predict the time-evolution of key operating variables such as product flow rate, level charge, power-draw, load position and others, as functions of other important variables such as mill rotational speed and fresh feed characteristics. The set of ordinary differential equations was solved using MATLAB/SIMULINK as a graphic programming platform, a useful tool for understanding the grinding process. Additionally, this work presents results using dynamic simulations from a 1200 t/h copper–ore mill showing the effectiveness of the system to track the dynamic behaviour of the variables.

Categories and Subject Descriptors
G.4 [**Matlab**]: System simulation using blocks.

General Terms
Algorithms, Design.

Keywords
Simulation; SAG milling; Comminution; Modelling.

1. INTRODUCTION
Modelling and simulation of semi-autogenous (SAG) mills are valuable tools for helping to design control laws for a given application and subsequently to optimise its performance and process control. SAG mills (see Figure 1) are presently one of the most widely used alternatives in the field of mineral size reduction as a result of their advantages such as higher processing capacity, lower physical space requirements, and lower investment and maintenance costs, as compared to conventional circuits [1].

Due to the size of SAG mills, pilot plants are usually used for research purposes to improve the control strategies. In cases where a pilot-scale is not available for testing, simulations using models based on data from a wide range of full-scale plants are helpful and can significantly reduce risks for process control purposes. Simulations also provide an additional and very valuable crosscheck against the pilot results [2].

Figure 1. Typical semi-autogenous (SAG) mills.

The remainder of this poster considers theory about specific models for SAG mill processes and simulations for the prescribed application using MATLAB/SIMULINK. The main conclusions of the poster are provided in the final section.

2. SEMI-AUTOGENOUS MILLS
Essentially, the modelling exercise consists in formulating non steady-state material balances in the milling equipment, along with force conservation relations and hydraulic considerations. The methodology used in this study has already been established in literature [2-3] and involves formulating particle inventories for each particle size inside the mill. The input variables are: water flow rate, mineral flow rate and size distribution, grinding media flow rate and the mill critical speed. The model output variables are: power-draw, load level, ball load, mineral discharge rate and size distribution, water discharge rate, ball throughput, bearing pressure, pebble throughput, and toe and shoulder angles of the internal load.

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2.1 SAG mill model

The particles fed to the mill are ground in the milling chamber and subsequently downloaded into the discharge zone, where, according to a classification probability, they are either returned to the milling chamber for further grinding or become part of the mill output stream. For modelling purposes the mill is divided in two zones according to the process taking place. The first zone encompasses the milling chamber where the particle reduction process is identified and modelled. In the second, the output zone, the material is internally classified and the final product is discharged. To complete the system description it is necessary to consider the relationship between the feed stream and mill charge level. This relationship is known as the transport rate and is probably the least developed aspect in models proposed so far [4].

3. SAG IN MATLAB-SIMULINK

The numerical solution of the model mentioned in the previous section, is obtained through a system in MATLAB/SIMULINK (Figure 2). Simulink is a programming system structured in blocks, which allows the solution of differential equations as well as the programming of user-blocks through S-functions. This feature, together with the possibility of using Matlab's specific toolboxes, makes it a powerful platform for the development of prototypes. The present model can be seen as a more complex simulation block compatible with this simulation strategy in [1].

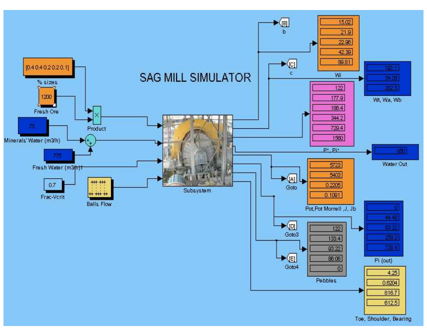

Figure 2. SAG mill simulator in Matlab-Simulink.

3.1 Results

Examples of the simulation results are presented in Figures 3 and 4. These figures respectively show the response of the power-draw and the fill level for the Magne approach [3]. The results are the product of 10% flow change related to the nominal operation conditions (1200 t/h).

4. CONCLUSION

This poster shows advanced simulation using Matlab-Simulink for semi-autogenous mill systems in the context of a simplified models approach that incorporated developments of [1-4] and others authors. A main focus is a comparison of deferments models.

It is interesting to note that despite differences in the theoretical background for these approaches, the results of dynamic simulations under industrial operational conditions are similar. Thus, these results validate adequately the comminution process in the SAG mill, and in the future, these models could be combined for industrial purposes. With these results we believe that is possible to scale-up from pilot plant simulation and to optimise existing circuits for process control purposes using combinations of these models to reduce risks and improve performance.

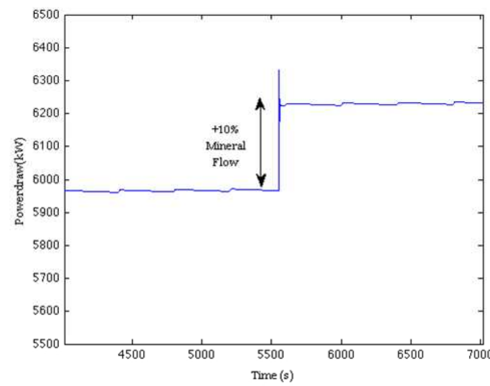

Figure 3. Magne's model power-draw response.

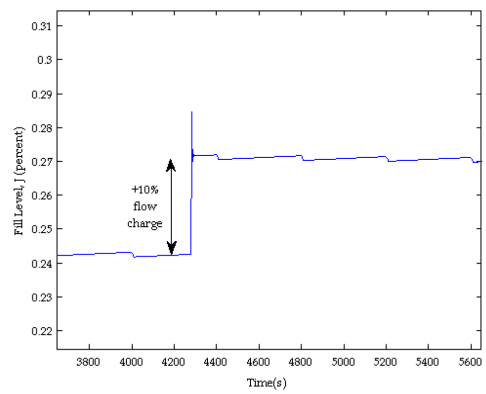

Figure 4. Magne's model fill level response.

5. ACKNOWLEDGMENTS

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