Optimization of Comminution Circuit Throughput and Product Size Distribution by Simulation and Control

Quarterly Technical Progress Report

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Abstract

The goal of this project is to improve the energy efficiency of industrial crushing and grinding operations (comminution). Mathematical models of the comminution process are being used to study methods for optimizing the product size distribution, so that the amount of excessively fine material produced can be minimized. This will save energy by reducing the amount of material that is ground to below the target size, and will also reduce the quantity of material wasted as "slimes" that are too fine to be useful. This will be accomplished by: (1) modelling alternative circuit arrangements to determine methods for minimizing overgrinding, and (2) determining whether new technologies, such as high-pressure roll crushing, can be used to alter particle breakage behavior to minimize fines production.

In the third quarter of this project, plant studies were continued at the plants operated by the industrial co-sponsors of this project. Plant studies have concentrated on examination of historical operating data, and collection of samples from critical points in the comminution circuits. These samples will be subsequently analyzed to determine size distribution, density, chemical composition, surface area, and percent solids, and this data will be used to set up the process model to predict the performance of the mill.

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Introduction

While crushing and grinding (comminution) of various feedstocks is a critical operation in mining, as well as in a range of other industries, it is both energy-intensive and expensive, with tremendous room for improvement. A neglected route in optimizing the comminution process is the minimization of overgrinding. Since grinding particles to finer than the target size both wastes energy and produces unusable product, such overgrinding must be minimized in order to improve energy efficiency.

Optimization of full-scale comminution processes by direct experiment is difficult and expensive because of the cost of modifying and operating the circuits to conduct these experiments. Mathematical simulation of the process is therefore necessary in order to make a preliminary determination of the most promising routes for optimizing the processes. The research needed to develop the models will also determine what effects can be used to alter not just breakage rate, but also the manner in which breakage occurs, and to use this information to improve control over product size.

Executive Summary

The goal of this project is to use comminution modelling to study methods for optimizing the product size distribution, so that the amount of excessively fine material produced can be minimized. This will be accomplished by: (1) modelling alternative circuit arrangements to determine methods for minimizing overgrinding, and (2) determining whether new technologies, such as high-pressure roll crushing, can be used to alter particle breakage behavior to minimize fines production.

Previous to the current quarter of this project, a mathematical model was completed and implemented as an Excel spreadsheet. The model was then validated to demonstrate that it appropriately predicted comminution performance of laboratory-scale machines. The model is applicable to two classes of comminution machines that are widely used in industrial practice:

- A Roll mill, consisting of two counter-rotating steel rollers with variable spacing, and
- A Ball mill, consisting of a cylindrical shell filled with steel grinding media.

The investigators also met with professional staff an the Cleveland Cliffs Iron Co., J. M. Huber Inc., and Badger Mining Co. to develop details of the research plan, and to prepare samples and plant operating data from their respective operations.

In the current quarter, plant sample collection was begun at the Cleveland Cliffs Iron Co. facility. The investigators also consulted with plant personnel to determine what factors have the most affect on comminution performance. These studies include sampling of the grinding circuit of an operating iron ore concentrator, thorough analysis (chemical and physical) of plant products, and analysis of historic data collected from the concentrator.

Experimental

Project personnel traveled to an iron-ore concentrator operated by the Cleveland Cliffs Iron Co., and participated in sampling campaigns carried out by plant personnel. Samples were weighed, dried, and transported to Michigan Technological University for further analysis. Historical plant operating data was also provided by plant personnel

Results and Discussion

The plant sampling campaign is currently underway, and results are expected to be available for the next progress report.

Two technical publications have been prepared that are related directly to this project, and are in press.

Conclusions

Plant sampling is underway and is proceeding satisfactorily.

References

H. J. Walqui, Mathematical Modeling of Coal Pulverizers using Population Balance Models, M.S. Thesis, Michigan Technological University, submitted August, 2001

H. J. Walqui, T. C. Eisele, and S. K. Kawatra, Development of Mathematical Models for Coal Pulverization, To be presented at the SME Annual Meeting, Phoenix, AZ, Feb. 25-27, 2002