Real time measurement and fast control strategies for the optimal operation of grinding circuits

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ABSTRACT

With the availability of fast and critical measurements of the internal mechanisms of a grinding mill, there is an opportunity to optimally control the comminution stage of processing operations. Traditional sensing such as load cells, bearing pressures, ore and water feed rates, provides information on time scales from many seconds to a few minutes based on the type of measurement and/or the signal noise reduction required to achieve usable control signals. The internal behaviour of the grinding mills can be estimated using models with simplifying assumptions. Mine to mill concepts can also be used to adjust fragmentation of the feed ore to a mill with specialised designed blasting that may reduce the cost per tonne by providing more consistent grinding circuit operation.

Current approaches to control mills in environments with rapidly changing feed rates and properties are constrained by slow and limited information. Extensive orebody characterisation, domaining and blending is required to provide an ore feed that the primary grinding mills can deal with on time scales of minutes. Often an undesirable variable and/or unstable product flow from the grinding stage is the result, and this limits the stability of the flotation separation stage to achieve optimum recovery and grade of the product.

Using well tested and validated advanced non-contact acoustic measurements of mill internal charge behaviour to monitor the variations of feed ore disturbances, corrective actions on time scales of 80 milliseconds are achieved.
A vast range of validated mechanistic time constants have been observed inside grinding mills including:

- trajectory flight times of less than 2.5 seconds
- charge reorganisation times (from milliseconds up to many hours)
- charge toe and shoulder variations (20° in < 80 milliseconds)
- water/rheology changes from seconds to minutes
- influence of mill speed changes (< 1 second)
- steel ball and rock collisions.

A more flexible and responsive operation of the mill and grinding circuit can now be achieved in shorter time scales (corresponding to feed ore lots of much less than one tonne) than are available with conventional control approaches. The control levers now include the addition of water to adjust the in-mill rheology in real-time. The mill speed not only adjusts the mill throughput and deleterious impact on the mill shell but can also be used to control the toe and shoulder angles of the charge.

Using the results from mineral process plant implementations of advanced non-contact acoustic measurements, together with complete grind circuit data, obtained on a fast time scale, the concepts introduced by this paper will be discussed further. Appropriate use of big data analysis techniques that incorporate understanding of the process, will demonstrate the benefits of the faster control now possible.