Improving Grinding Efficiency with the IsaMill™

M. Larson[1], R. Morrison[1], F. Shi[1] and M.F. Young[2]
[1]*University of Queensland, JKMRC, QLD*
[2]*Xstrata Technology, QLD*

Introduction, Background and Objectives

As mining companies have been called on to process ever finer grained deposits they have had to turn to new technology to economically treat these ores. One example of this is the IsaMill™. The IsaMill™ was originally developed to grind fine grained Mount Isa and McArthur River lead/zinc ores to sizes finer than 7 micron.

The IsaMill™ is a horizontal stirred mill that takes advantage of high rotational speeds and fine inert media to efficiently grind to liberation sizes that were previously uneconomical, at best, and sometimes were simply not achievable.

Methodology / Experimental Technique

A laboratory investigation was conducted to determine the effects of the IsaMill™ operating variables on power draw and power efficiency, using a 4 litre M4 IsaMill™ at the JKMRC. The results of the test work were used to construct a preliminary IsaMill model.

The laboratory standard signature plot is used to characterize IsaMill performance and grinding energy requirements (Weller and Gao, 1999). This has been shown to reliably translate laboratory scale results to mine site operations. Laboratory testing was undertaken with the M4 IsaMill to determine which operating variables affect the grinding energy efficiency and to what extent they impact the grinding energy efficiency. A campaign of test work was conducted using copper concentrate from the Mount Isa Mine that had a F80 =64 microns. Variables tested included the mill speed, feed pump volumetric flow rate, grinding media type, grinding media size, media filling and feed pulp density. In addition viscosity was investigated as it relates to the feed pulp density and grinding energy efficiency

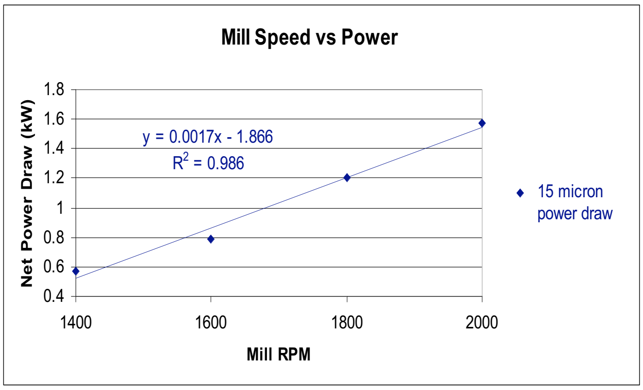

Figure 1: *Mill speed vs. net mill power draw (at constant media load).*

Key Results / Findings

The feed pump volumetric flow rate did not have an effect on grinding energy efficiency. Regardless of the pump speed the same signature plot will still be created. The mill speed did not have an effect on grinding energy efficiency and it was found to be a reliable indicator of net mill power draw between 1400 and 2000 RPM, as shown in Figure 1. Less residence time was required to grind to a given target size as the mill speed was increased.

Similarly, a linear relationship was a good fit for the net power draw when the media load was varied (Figure 2). The two relationships should provide a means in the future to better predict the outcomes of varying operating conditions while performing signature plot tests

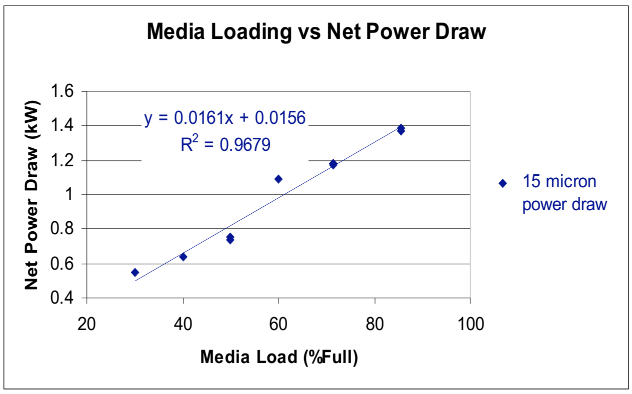

Figure 2: *Media loading vs. net mill power draw (at constant mill speed).*

The overall grinding efficiency tends to increase as the media volume increases in the mill, with the most dramatic effect occurring from the low end of filling to the beginning of the generally accepted operating range of 60-80% full, when grinding to a target of P80=10 microns, as shown in Figure 4. The media volume is the bulk volume of the media at rest divided by the net volume of the mill (volume of shaft and grinding discs subtracted from total mill volume). The inefficiency was most clearly seen when the mill had very low media filling. When the mill had low media filling the initial discharge density was lower than the feed density indicating there was a build up of solids inside the mill. The solids that build up in the volume that would normally be filled with grinding media could cause increased power draw and be reducing the power efficiency.

M4 IsaMill Model

Two simple equations were developed relating the overall efficiency of varying media loads and feed pulp densities, based on the previous grinding energy requirements graphs. The 100% efficiency was set at a media filling of 80% and solids feed pulp density of 45%, then the equations were developed to relate the energy efficiency loss to the changing variables. These equations were applied to a set of six model validation tests.

Table 1: *Model Validation Results using Mount Isa Cu Concentrate.*

Test	Media Volume (L)	Density (%weight)	kWh/t model	kWh/t actual	% error
1	2.8	39	68.5	69.5	1.44
2	2.3	54.4	86	84.8	1.42
3	1.9	35	90.5	83.7	8.12
4	2.6	52	76.6	75.6	1.32
5	2.5	45	75.5	77	1.95
6	2.7	57.1	80.1	82.2	2.55

Fines Production Model

It was decided to investigate the form of the relationship between new surface area generated and energy input, based on work by McIvor (2007) and later Musa and Morrison (2008). McIvor and Musa both demonstrate that new production of particles finer than a certain target size is approximately linear with energy for rod and ball mills. A similar simple relation was attempted to allow grinding energy predictions with changing the feed size.

The selected micron size for the modelling was chosen as the 50% passing size of the final pass from the Isamill test, and then the percent passing the selected micron size for each pass in the Isamill test was plotted against cumulative energy for the Isamill test to that point.

This did not fit a linear relationship or any variation of a power plot. It was determined however that by squaring the percent passing value and plotting it versus cumulative energy on a normal plot a straight line connecting each IsaMill pass with the feed at the 0 kWh/t could be formed. This would have the advantage over the standard signature plot that the feed material could be included in the line created.

The main disadvantage of the signature plot is that each percent passing line cannot be extrapolated back to the feed size. This imperfection has to be taken into account when estimating the effect of changing feed sizes. With the new method, using the percent passing a particular size, the line should be able to be shifted left or right depending on the change in feed size and using the same slope to estimate the new power requirement. This should be valid for any case where the same media is capable of grinding the new feed size.

Conclusions and Future Direction

The work done thus far shows that through an improved understanding of basic mill operating variables, showing grinding energy efficiency of the Isamill can be predicted and improved. The ability to predict the mill performance with coarser feed sizes using the fines squared function will allow the design of grinding circuits incorporating the IsaMill. This along with the optimization of media size will assist to fully optimize the entire circuit grinding efficiency

Acknowledgements

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