CYCLONES DON'T DO ANY GRINDING

By Brian Putland: Orway Mineral Consultants (W.A) Pty Ltd

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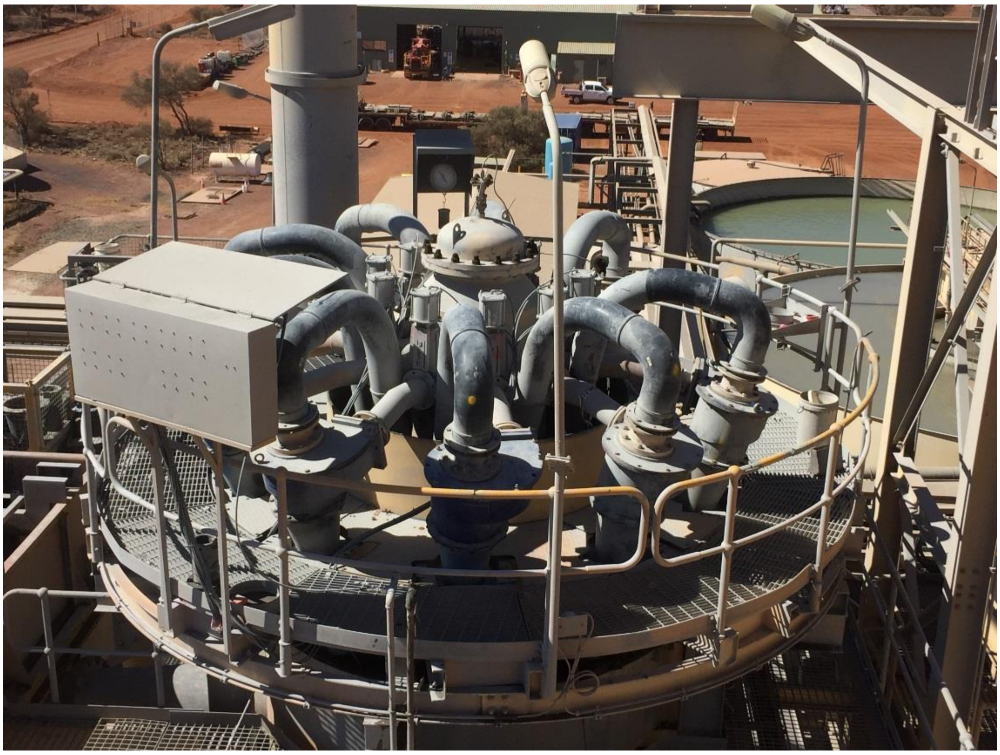
Over the hundreds of grinding circuit optimisations undertaken by OMC, a number of common problems are encountered time after time.

One re-occurring problem is cyclone control. There seems to be a misconception in the industry that cyclones undertake grinding of the ore because as soon a circuits product size is out of specification many control systems adjust the water balance in the circuit to constrain the product size.

Now in reality we know that cyclones do not grind the ore, it only undertakes classification, so why should adjustment of the cyclone be undertaken to control the grind? The answer is the cyclones shouldn't be used to try and control grind. The major factors that influence the grind-size are the feed PSD, ore characteristics (both the coarse breakage (Axb/DWi/WSAG etc), and fine grinding (BWi) parameters), grinding power, grinding media, classification efficiency and throughput rate.



In operation you must deal with these variables. You influence and adjust these variables as best you can, and the cyclones should be set up to efficiently classify at whatever grind size that can be stably generated by the grinding circuit.

There are two primary control schemes for operating closed grinding circuits based around the characteristics of hydrocyclones. The cut-point of a cyclone is influenced by both the flow (pressure-effect) and slurry density (hindered settling-effect). This gives rise to operation using one of the two primary philosophies, either constant flow and variable feed density, or constant feed density and variable flow. In each case the aim is to stabilise both variables, one with water the other circuit control (capacity, feed rate etc.), however, the reaction of the circuit to changes in each of the two systems is very different.

CONSTANT DENSITY

Operating the cyclones at constant feed density and with variable flow rate has been the trend in new grinding circuit installations over the last two decades. In this configuration, the water addition to the discharge hopper is varied to maintain a constant feed density to the cyclones. The pump speed is modulated to maintain the level in the mill discharge hopper. In a system, if the ore hardness or throughput increases, the achievable grind size increases. However, in this system, the cyclone cut point, dictated by the selected cyclone feed density does not change. Instead the circulating load increases.

This increases the flow to the cyclones, which increases cyclone feed pressure. The increase in pressure in turn decreases the cut point of the cyclone (becomes finer), causing the circulating load to increase even more.

As such, the operator or control system must keep the operation of the mill within a tight range by changing feed rate or cyclone feed density to prevent a total loss of control. Switching cyclones into and out of operation provides short term relief of the symptom of circulating load fluctuations. However, it does not address the real control issue which is that the cut point of the cyclone is not in equilibrium with the grind size achievable by the mill, given the available power, feed particle size distribution and ore characteristics.

The control systems response should be to either reduce throughput or increase the cyclone feed density set point so that the cyclones cut coarser to meet equilibrium. However, due to the spiralling cause and effect response, the action of the control system must be fast when operating under this philosophy. For this reason, adding cyclones are used, however once a cyclone is added it is difficult to shed circulating load and take it offline without effort.

If the pressure goes too high before a cyclone is added the cyclones will rope forcing coarse material out the overflow (grit) relieving the circulating load. If the system operates close to the limit the operators may not even notice this is happening, often only one cyclone (the least worn) will rope bleeding coarse material out of the circulating load into the overflow. Every cyclone opened or closed causes instability and off specification overflow PSD.

CONSTANT FLOW

The alternative and preferred control philosophy (in particular for plants having to deal with variability in ore characteristics and operating parameters) because of the added stability is constant flow and variable feed density. In this configuration, the pump output speed is set to maintain a set cyclone pressure. Water addition to the hopper is modulated to maintain the hopper level set point and the number of cyclones are selected to maintain the O/F density in a set band. Alternatively, the pump speed can be adjusted to maintain the hopper level and water addition to pressure. This provides tight control of the hopper level with the cyclone pressure modulating around the set point.

Using this philosophy, if the circulating load changes because the circuit is out of equilibrium, the cyclone feed density varies, changing the cut point of the cyclone. Under such an operating system, the product size can drift coarser, however the power is always fully utilised and the circuit is stable. The cyclone cut point matches the grinding capability of the mill.

As the circulating load increases, the cyclone feed density increases and associated product size increases. If the circulating load decreases, the cyclone feed density decreases, and a finer product size is produced. The circuit is self-compensating and thereby prevents rapid changes in circulating load. In essence, the circuit will reach an equilibrium product for a given ore type, grinding power and feed rate. The operator or control system can then focus on adjusting the new ore feed rate, mill density etc to achieve the desired grind, therefore always maximising throughput at the target grind for the ore characteristics and available power. At constant pressure, cyclone feed density can be correlated to P_{80}.

When using this control philosophy, the cyclone pressure should be selected so that the cyclone underflow density is high (high 70's low 80's % solids depending on the ore), but below roping conditions. Cyclone underflow density should be measured at regular intervals over a shift or when a blend change has occurred. The pressure set point should be adjusted to achieve the target cyclone underflow density. The ability to optimise underflow density and therefore cyclone efficiency is another advantage of this control philosophy.

Cyclone switching, or the number of cyclones operated, should be adjusted to maintain the cyclone overflow within a target density range. Cyclones should not be taken in and out of circuit based on changes in circulating load. Cyclones should be taken in and out of circuit based on the calculated or measured cyclone overflow density; with a low set point triggering a cyclone to be closed and a high set point triggering the opening of a cyclone.

This is best automated and requires the total water input to be measured, preferably not making any changes more frequently than in 15-minute intervals. Over automating cyclones to switch on and off too often is in most cases much more detrimental than operating a high or low cyclone overflow density.

What we often see is density control within a cyclone pressure band which constrains the product size and often results in an unstable and inefficient circuit. If combined with targeting a low overflow density, extremely high circulating loads causing grinding inefficiency, ball ejection, and high cyclone and pump wear can be seen.

Another scenario often observed is a circuit where water is added to achieve a target overflow density and too many cyclones are operated. This results in artificial circulating loads of fines, high cyclone feed densities, to the point that the cyclones ability change the cut size is compromised.

The product distribution is high in fines for the achieved P_{80} resulting in inefficient application of energy and unstable operation, cyclone roping. This is typically seen when finer grinds are targeted, less than 106 micron and high overflow densities are required, plus 45% solids. Other variants include, controlling both cyclone pressure and density and quasi variable cyclone feed density and pressure while attempting to maintain an overflow density target. Neither of which provide stable flow and operation.

The key point is that you should use your water addition to achieve circuit stability (flow stability) as you have total control of water addition. Then control your circuit to achieve grind size you are targeting. Keep it simple, the most important optimisation step you can undertake is to achieve stability.

For more information visit our website www.orway.com.au or contact us omc@orway.com.au