Ausenco

Case Study: Pebble bypass setup for proportional control
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In the scenario below (Figure 1), SAG mill throughput is severely impacted by the operation of the pebble-bypass gate operation. The ON/OFF operation of the gate incurs significant disturbances to the fresh-feed feed rate to the SAG mill. With a proportional control strategy, the objective is to minimize the disturbance to the SAG mill fresh-feed feed rate, while operating the pebble bypass gate in dynamic control.

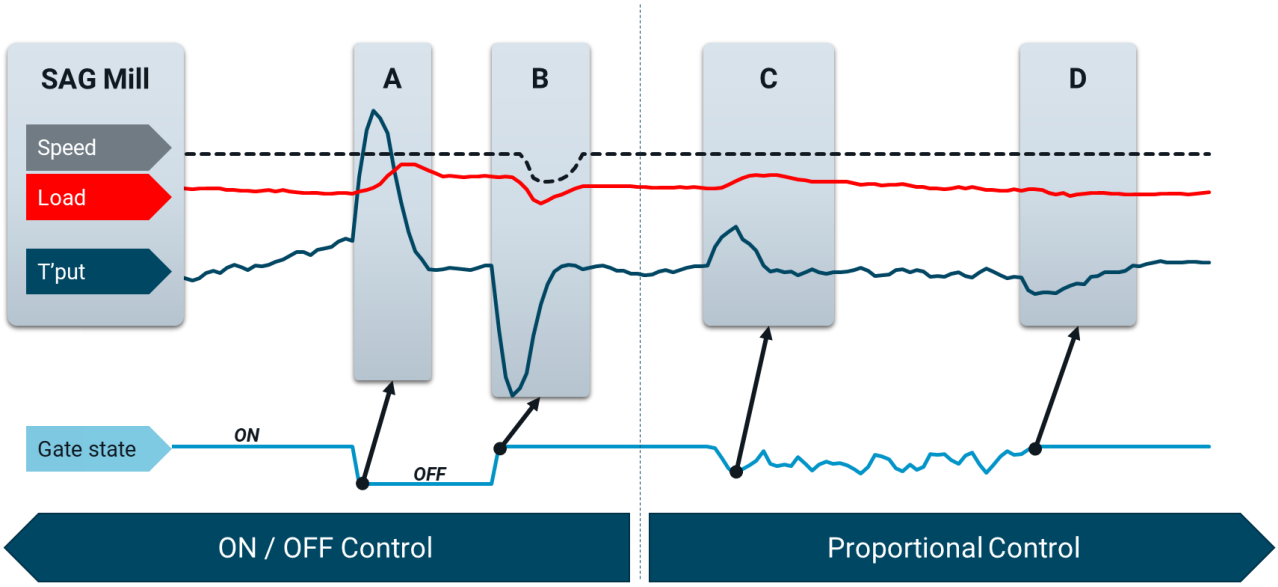

Figure 1 – Improving control stability

ON/OFF state

In the ON/OFF state (marked A and B), the pebble bypass gate sends either crushed or uncrushed pebbles back to the SAG mill when the pebble crusher feed bin level reaches a high and low level. Diverting 100% of the uncrushed pebbles to the SAG mill results in the overshoots of the SAG load target, constraining the SAG mill operation resulting in decreased grinding efficiency and throughput. By the time the controllers adjust for the upset, the high-level condition in the pebble crusher feed bin would clear, and the SAG mill would unload. This would require a decrease in mill speed to protect the liners and a severe drop in total tonnage through the circuit.

A. The action of diverting 100% of the untreated pebble load back to the SAG mill, results in a sudden increase in total tonnage to the SAG mill feed. When this happens, the base layer

controller can't correct for the additional tonnage fast enough, due to the transport delay between the stockpile feeders and the weight scale. This loads up the SAG mill and changes the grinding efficiency of the mill, requiring an adjustment in throughput to return to the optimal load.

B. Once the high level in the bin clears, the bypass gate closes. The return of the pebbles to the bin results in the tonnage to the SAG mill dropping off and causes the SAG mill to unload. With the base layer controller again unable to compensate, the SAG speed is reduced to avoid emptying the SAG and limit shell impacts.

Proportional control state

With modification to the control strategy for the high-level response (marked C and D), a simple proportional control loop was used to reduce the impact on the SAG mill operation. By taking a slower action on the pebble bypass gate position and adjusting based on the pebble crusher feed bin level deviation from the high-level setpoint, the amount of uncrushed pebbles sent to the SAG mill is reduced. This approach allows time for the controllers to adjust with minimal overshoot on SAG mill load, keeping the circuit running efficiently. When the pebble crusher feed bin high-level setpoint clears, the SAG mill sees minimal throughput disturbance impact as the gate position returns all the pebbles to the pebble bin.

C. When the high level in the pebble bin is set to leverage the diverter gate in proportional control (as seen on the right side of the trend), the upset created from the diversion of untreated pebbles is significantly reduced. Although the diverter gate is bypassing for a longer period using this method, overall, the process achieves better stability, while maintaining throughput.

D. Once the high level in the pebble bin is cleared, the bypass gate has already slowly returned to the closed position, resulting in a small upset to the SAG circuit. The controllers are able to compensate for the change, the SAG avoids unloading, and the speed is maintained.

SAG mill circuits are challenging to control in nature, due to constantly changing variables. By understanding the cause/effect of these changes and how they propagate through the circuit, the instrumentation and controllers can be leveraged effectively to take appropriate actions to minimize significant disturbances.

In the example above, additional logic tuning and adding a feed-forward portion to the loop can be carried out further to reduce the impact on the diversion of uncrushed pebble material from the pebble crushers. Completing these steps before progressing to newer technologies allows for operations to achieve better results. ***The implementation of APC becomes simpler, as stability is maintained at the base layer, and enable the system to push the SAG mill's operational limits.***

To learn more, contact Karl Visnovec.