BrainWave
Control solutions for SAG mills

The challenge: To control your SAG mill so that it runs at peak efficiency

The solution: Measure. Control. And profit.

BrainWave SAG mill is a unique control package using patented model-based predictive adaptive control technology.

It is well known within the mining industry that effective grinding in a SAG mill depends largely on the loading of the mill. A mill containing too much material does not allow for adequate movement of the ore and balls within the mill. A mill that does not contain enough material does not take advantage of the autogenous grinding mechanism. In either case, grinding effectiveness is suboptimal and production cannot be maximized. To maximize production, it is necessary to maintain the mill load at the point of optimum grinding. Although the mill weight provides a reasonable and reliable indication of mill loading, it is known to be a challenge to control.

Expert systems have typically been used to manage the mill load. However, these rule based techniques can only react after the mill is overloaded, and therefore must oper-

ate more conservatively. The mill is unable to achieve maximum production due to this control limitation.

Fortunately, the patented BrainWave controller has a unique ability to model SAG mill behavior so that responsive, precise control is possible. BrainWave accounts for changes in mill rotation, recycled pebbles, and ore quality to maintain mill weight and maximize production. As the weight controller adjusts the set point for fresh ore feed, a second BrainWave controller adjusts the feeder speed to ensure that the right amount of material is delivered to the mill.

Using its model-based predictive control algorithm, BrainWave can effectively account for dead time inherently present both in the ore feed system and within the mill itself. Additionally, BrainWave can automatically adjust its control settings to allow for different operation due to changes in ore hardness over time. With improved SAG mill control stability, the mill load can be optimized to increase crushing performance and production capacity.

Along with the potential for greater production, BrainWave also allows you to operate your mill at maximum efficiency. Because a large amount of power is used just to keep the mill and its ball charge moving, any increase in production yields a corresponding reduction in specific energy per ton.

What is more, stabilizing the load in the mill also stabilizes power draw. This enables the operator to manage power usage, eliminating the energy waste that comes with a variation in the power draw.

Feature	PID	BrainWave
Controls long dead-time processes	✗	✓
Reacts before being pushed off-target	✗	✓
Handles nonlinear processes	✗	✓
Adjusts to process disturbances	✗	✓
Learns while process is running	✗	✓

What is BrainWave?

BrainWave is a patented advanced controller that outperforms conventional Proportional-Integral-Derivative (PID) control. BrainWave outperforms PID systems because of its two main components: an adaptive model and a predictive controller.

BrainWave builds its own live models during normal plant operations, a powerful feature not offered by conventional Model Predictive Control systems. BrainWave's predictive controller accurately forecasts process responses and accounts for multiple objectives. It adapts to process conditions such as changes in production rate or operating point, keeping your process on target. BrainWave can also accept measured disturbance inputs, like raw materials properties, and takes corrective action before your process is pushed off target (PID, by comparison, must wait for the error to occur, then react).

Because it uses a standard OPC connection, BrainWave easily integrates with an existing control system. In addition, BrainWave's patented Laguerre technology means an average implementation time of just a few weeks, saving a remarkable amount in operating costs compared to conventional methods. Best of all, your own staff can support and deploy BrainWave, making it a technology that you can live with—and one you can't afford to live without.

Benefits

- Automatically account for changes in variation of particle size or ore hardness
- Minimize production disturbances
- Maintain optimal production by minimizing changes to mill speed
- Maximize production rate while providing consistent grinding
- Maximize energy efficiency

SAG mill control schematic ▼
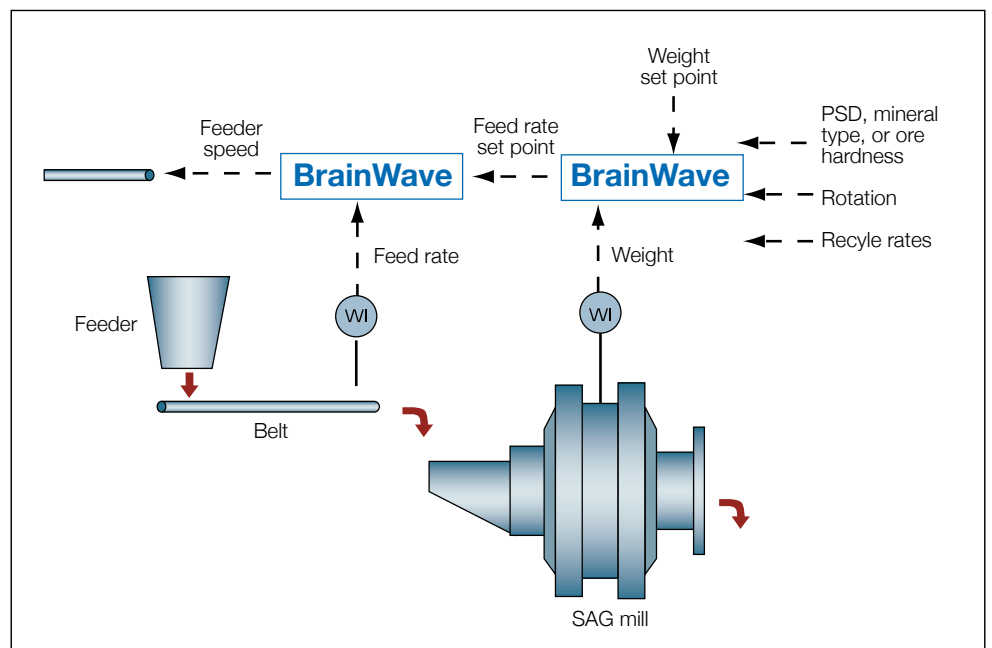
SAG mill success stories

Customer: Taseko Mines

Control objective:

- Maintain the desired mill load, ensuring optimal mill operation
- Automatically account for changes in ore properties
- Provide increased SAG mill stability
- Maximize production rate while providing consistent grinding
- Control system: DeltaV

Taseko Mines installed BrainWave at the Gibraltar mine in British Columbia, Canada, to ensure that its 34-foot fixed-speed SAG mill is properly loaded.

The copper-molybdenum operation uses a 'total precrush' strategy, in which ore entering the mill has already been reduced to a size that is much smaller than typical for SAG mill feeds. The benefit is that it allows the mill to process a greater throughput of ore than with a typical feed size; however, high throughput means that small changes in ore properties can cause big changes in mill loading to happen very quickly.

Fortunately, with BrainWave monitoring mill load, changes in feed properties are recognized quickly and action is taken before mill load can deviate significantly from its target.

Using BrainWave, Gibraltar has been able to steadily increase mill production and improve the stability of its operation.

"BrainWave has worked exceptionally well to provide critical stability to complicated control loops and significant dead time control loops at our operation," said Ted Kenny, Superintendent, Process Engineering, at Gibraltar. "Both of our applications continue to provide critical stability and control over these unit operations."

Gibraltar has estimated that BrainWave SAG mill gives them 1.5M USD in benefits annually.

Customer: Freeport–McMoRan Copper & Gold

Control objective:

- Maintain the desired mill load, ensuring optimal mill operation
- Automatically account for changes in ore hardness
- Provide optimal compensation for pebble mill disturbances to minimize production disturbances
- Maximize production rate while providing consistent grinding
- Control system: Bailey

Freeport-McMoRan's Minera Candelaria is located near Copiapó in Chile's Atacama Desert. This +300M lb/yr copper producing operation was the first to choose BrainWave SAG mill to help them improve their operations. With only two weeks of work at the site, an ANDRITZ AUTOMATION engineer was able to fully commission the BrainWave system, ensuring that it was integrated with the existing expert system and DCS-based controls.

Plant staff, after extended testing and rigourous data analysis, determined that BrainWave reduced load variability by 14% while increasing production by 1.5%. This was a great success for everyone involved.
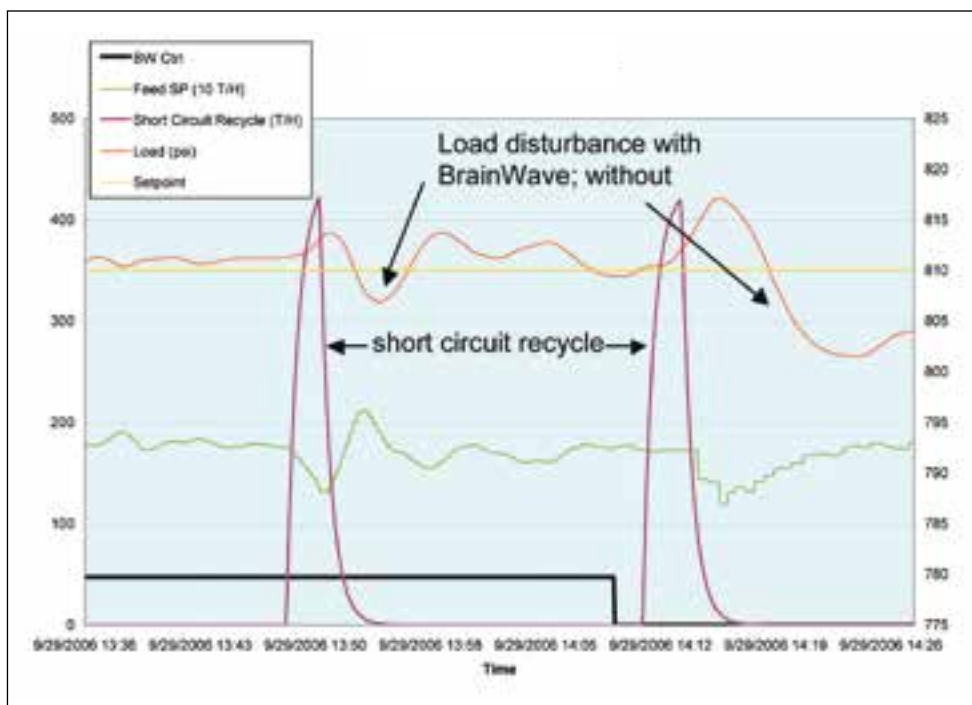
Assuming a copper price of 4 USD/lb, ANDRITZ AUTOMATION estimates that BrainWave SAG mill led to an extra 12M USD worth of annual copper production at the Candelaria mine.

SAG mill #1 load control ▼

SAG mill success stories

Customer: BHP Billiton

Control objective:

- Maintain the desired mill load, ensuring optimal mill operation
- Automatically account for changes in ore properties
- Provide optimal compensation for pebble mill disturbances to minimize production disturbances
- Increase production
- Maximize production rate while providing consistent grinding
- Control system: Bailey

Minera Escondida is the largest copper producing operation in the world and the SAG mill at the Laguna Seca plant grinds approximately half of the mine's sulphide ore. Although plant staff was reasonably satisfied by the performance of an expert system that was controlling their mill, they suspected that improvement was still possible. They decided to try BrainWave SAG mill. After a quick installation and set-up of
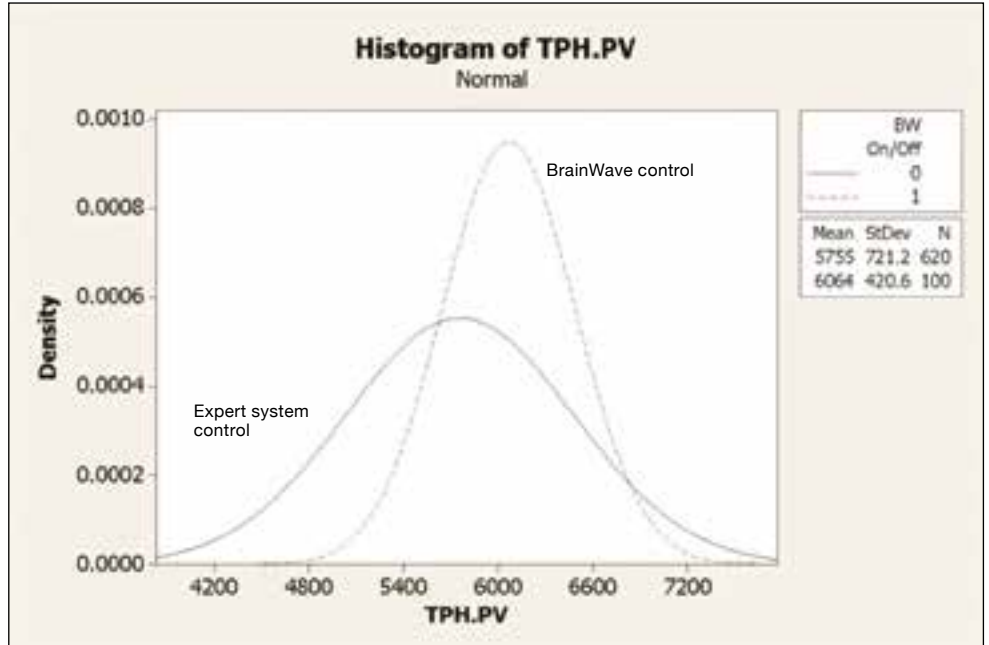
▲ Chart demonstrating improvements in control of mill feed rate (tons per hour) after installation of BrainWave

the software, BrainWave was able to take charge of mill load control, precisely adjusting feed rate to keep bearing pressure at set point. Testing and analysis by plant staff

revealed that by adding BrainWave to their operations, they were able to increase production by greater than 3%.

Assuming a copper price of 4 USD/lb, ANDRITZ AUTOMATION estimates that BrainWave SAG mill led to an extra 40M USD worth of annual copper production at Escondida.

Customer: Antofagasta Minerals

Control objective:

- Maintain the desired mill load, ensuring optimal mill operation
- Automatically account for changes in ore hardness
- Provide optimal compensation for pebble mill disturbances to minimize production disturbances
- Maintain optimal production by minimizing changes to mill speed
- Maximize production rate while providing consistent grinding
- Control system: Bailey

Antofagasta Mineral's Los Pelambres operation has one of the largest open pit mines in Chile and produces approximately 320,000 tonnes of copper concentrate annually.

The patented BrainWave advanced controller was successfully installed at the mine's copper concentrator site in order to tightly control the weight in the SAG mill to promote optimum grinding. This strategy has been demonstrated to improve mill throughput by as much as 3%.

When copper prices are high, producers look to increase production by eliminating process bottlenecks. At Minera Los Pelam-

bres, as at many mines, SAG mill throughput limits overall production. While the site already had an expert system in use to help stabilize the process and boost production, the BrainWave advanced controller was able to enhance the overall performance by providing precise control of mill weight. Optimal operating conditions were better maintained without the risk of mill overload. The BrainWave controller was installed on all three SAG mills at the plant. The site work to install each system was completed in two weeks.

Once BrainWave was installed, the improvement was noticeable immediately. Weight was easily stabilized, even under the toughest operating conditions. Previously troublesome

events such as large and sudden changes in recycle were easily handled by the controller.

A SAG mill is an excellent BrainWave application because the improved control performance translates directly into higher profits for customers.

The diagram shows the BrainWave user interface from the Los Pelambres installation. In the trender area on the right side, the mill weight can be seen as a green line (PV) while the set point can be seen as cyan. The last two hours of the trend show BrainWave control holding the weight tightly around the set point. This is in contrast to the first three hours of the trend, where the expert system allows large swings in weight. Adjustments to the fresh ore feed can be seen in the purple line and show the BrainWave responsiveness and precision.

Assuming a copper price of 4 USD/lb, ANDRITZ AUTOMATION estimates that BrainWave SAG mill led to an extra 20M USD worth of annual copper production at Los Pelambres.

Screen capture showing improvement control with BrainWave ▼

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Automation
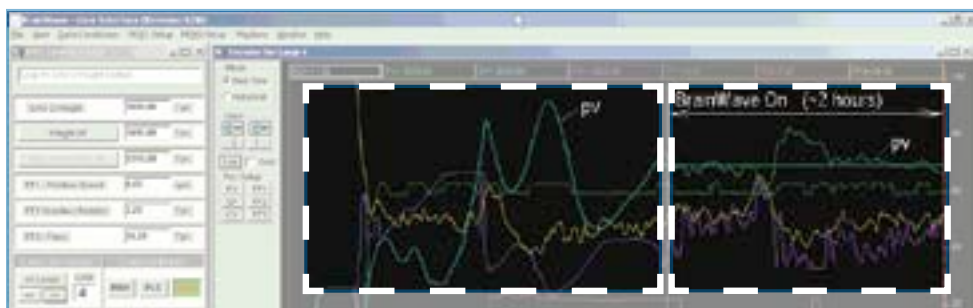
Automation solutions
Release your full potential

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