



AUTOMATION

ADVANCED CONTROL SOLUTIONS FOR MINING

HOW BRAINWAVE IS REVOLUTIONIZING THE INDUSTRY

ANDRITZ

ENGINEERED SUCCESS

CONTROL YOUR PLANT	3
WHAT IS BRAINWAVE?	4
STABILIZE PROCESSES WITH BRAINWAVE	5
FULLY OPTIMIZE WITH ACE	6
BRAINWAVE CRUSHING	7
BRAINWAVE SAG MILL	8
SUCCESS STORY: ANTOFAGASTA PLC	9
BRAINWAVE BALL MILL	10
BRAINWAVE FLOTATION	11
BRAINWAVE LEACHING	12
BRAINWAVE THICKENING	13
BRAINWAVE HB FILTER	14
BRAINWAVE DRYER	15



Control your plant so that it runs at peak efficiency

In today's economic climate, your facility faces more challenges than ever before. Your plant must run at optimal performance. Product consistency is a must. And utility and chemical costs must be kept to a minimum to maintain profit margins. That's why ANDRITZ offers a portfolio of advanced control solutions—BrainWave—for mining and mineral process operations.

ANDRITZ' BrainWave solutions are revolutionizing control at plants around the world, helping producers large and small remove bottlenecks, reduce energy and chemical consumption, produce higher quality products more consistently, and lower production costs—all of which result in significant savings.

Historically, advanced process control technologies have been deployed only at large scale petrochemical plants where the high cost of implementation and maintenance could be supported.

BrainWave will change the way you think about advanced process control. This patented controller can be implemented quickly. It is robust and stable, and is used by operators continuously. With BrainWave, advanced process control can now be applied in an effective and economical manner in the mining industry.

Don't see your solution listed? No problem—our control experts not only implement our solutions, but can audit your operation and devise a custom control strategy for you.



What is BrainWave?

BrainWave is a patented advanced controller that outperforms conventional Proportional-Integral-Derivative (PID) control 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 changes in process conditions, 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. 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.

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

“I haven't touched my BrainWave controller since we installed it seven years ago and it is used all of the time by our operators.”

TOM BARKER

DCS Manager, FMC Phosphates, Green River, WY





Stabilize your processes with BrainWave

ANDRITZ offers a complete suite of BrainWave advanced control solutions for industrial operations with the following features:

REDUCED VARIABILITY

BrainWave has been proven to reduce variability from 30% to 95%. This allows for more consistent production and products and reduced operating costs.

GUARANTEED RESULTS

BrainWave projects include a performance guarantee to ensure results are achieved. All costs are known and defined in advance.

RAPID DEPLOYMENT

In most cases, the initial results of BrainWave are obtained in just a few weeks.

EASY CONNECTION

BrainWave easily connects to existing control systems and allows migration to new systems. In addition, BrainWave can be used across an enterprise in which a customer may own a variety of DCS components from various suppliers.

REPORTING

ANDRITZ offers full reports on the results of BrainWave, including economic benefits obtained, additional benefits realized and opportunities for further improvement. ANDRITZ provides solutions for all areas of a pulp and paper operation where more stable operation is desired.

If you have a specific need that's not been listed here, be sure to contact our sales staff.

BENEFITS

- Remove bottlenecks
- Reduce energy use
- Produce higher quality product
- Easily integrate with existing control systems
- Usually deployed within a few weeks



Optimize fully with Advanced Control Expert (ACE)

Once you have achieved outstanding success stabilizing your process with BrainWave, you can take your operations to the next level with Advanced Control Expert (ACE). ACE is an automated “expert operator” that works in conjunction with the BrainWave solution to fully optimize a process. The expert operator in ACE is always at full attention, never distracted, and achieves optimum conditions for your mill.

BrainWave makes sure your process gets to set point and stays there. But how do you know if you have the best set point to run your process? Which set point will help you save the most energy? Will changing the set point improve your product quality? Will it help you save money?

That’s where ACE comes in. Once BrainWave has stabilized your process, then ACE can be implemented to determine the best set points, so that the process can operate at maximum efficiency. Unlike the “black box” solutions offered by others, ACE communicates to

the operators in their native language, advising them about changing strategies and goals, constraints, and operational issues.

Feature	ANDRITZ	DCS Vendor	Brand X
Advanced regulatory control	Always	Sometimes	No
Learning feedforwards	Always	No	No
Solutions hard-coded in DCS dependent on programmer skill for success	Never	Yes	Yes
Black box supervisory layer	Never	Yes	Yes
Common structure for all solutions to minimize training time	Always	No	No
Best possible solution/excellent uptime	Yes	No	No



BrainWave crushing



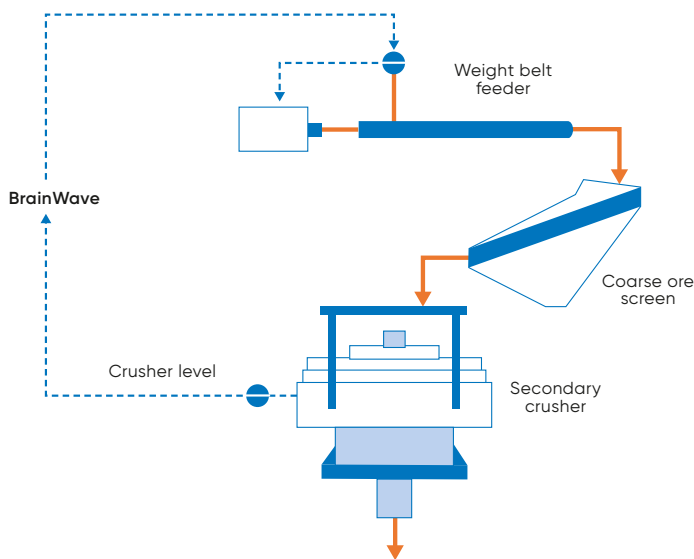
Stabilize and improve your crushing operations. BrainWave is a proven control system that stabilizes the operation of primary, secondary and tertiary crushers, resulting in improved crusher capacity.

BrainWave crushing is a unique control package using patented model-based predictive adaptive control technology, widely used by many primary processing industries. BrainWave is able to stabilize the level of ore in the crusher by using its patented integrating control algorithm to make direct adjustments to the ore feed rate.

BrainWave is also able to take into account the transportation time present in the crushing process due to the

various feed and conveyor systems, and still maintain a stable level in the crusher.

Maintaining the crusher in a choked condition allows ore to be crushed more efficiently, since there will be more rock-on-rock crushing. This also results in less wear on the crusher itself. Owing to this improved crushing performance, BrainWave has the added benefits of increasing crusher capacity and stabilizing the production of fines.



Secondary crusher feed control schematic

BENEFITS

- Maintain the correct level in the crusher to improve crushing, resulting in higher fines content
- Stabilize operations of the crushers, improving operation of downstream processes
- Reduce crusher wear by promoting rock-on-rock crushing
- Increase crushing capacity and stabilize the production of fines



BrainWave SAG mill

Stabilize and improve your SAG mill operations. BrainWave stabilizes the operation of the SAG mill, resulting in improved operation and increased production.

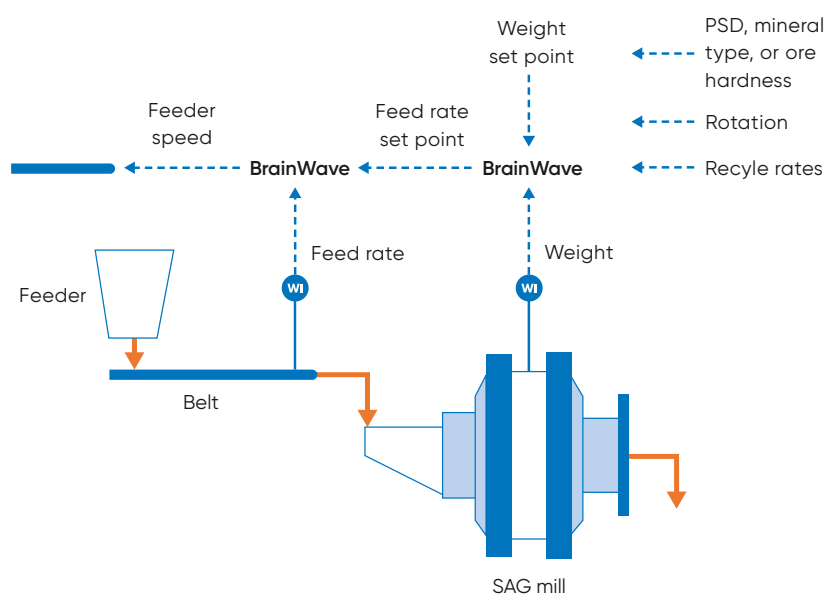
BrainWave SAG mill is a unique control package using patented model-based predictive adaptive control technology. It is well known within the mining industry that effective grinding in a SAG mill depends largely on the loading of the mill. A mill containing too much material does not allow for adequate 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.

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 effectively accounts for dead time inherently present both in the ore feed system and within the mill itself. Additionally, BrainWave automatically adjusts 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.



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

SAG mill control schematic





Success story: Antofagasta PLC

Antofagasta PLC's Minera Los Pelambres has one of the largest open pit mines in Chile and produces approximately 320,000 tonnes of copper concentrate annually. When copper prices are high, producers look to increase production by eliminating process bottlenecks. At Minera Los Pelambres, as at many mines, SAG mill throughput was limiting overall production. Antofagasta's wanted to:

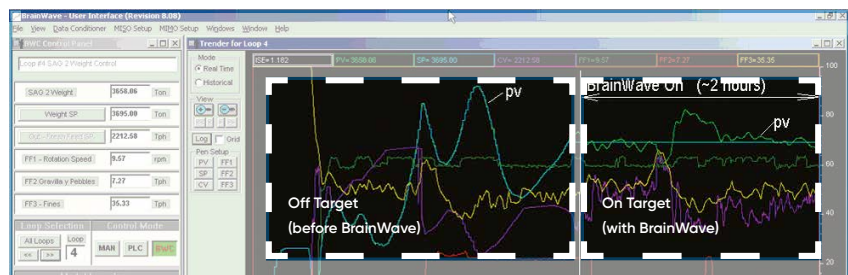
- Maintain the desired mill load, ensuring optimal mill operation
- Automatically account for changes in ore hardness
- Provide optimal compensation for pebble mill disturbances to minimize production disturbances
- Maintain optimal production by minimizing changes to mill speed
- Maximize production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

ANDRITZ' 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%.

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 complete solution for both SAG mills was installed in two weeks, with some remote follow-up. 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 handled easily by the controller.

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



User interface from Los Pelambres implementation

In the trender area on the right side, the mill weight can be seen as a green line 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 purple and show BrainWave's responsiveness and precision.

BrainWave ball mill

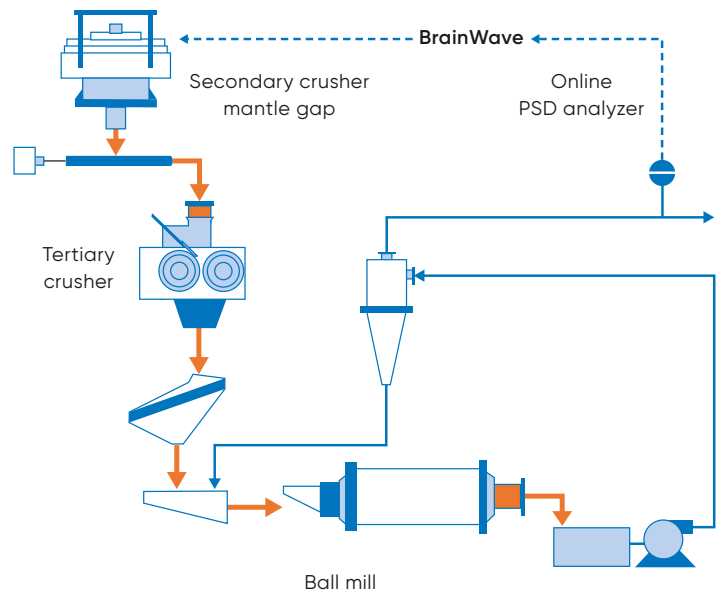
Stabilize and improve your ball mill operations. BrainWave stabilizes the operation of the ball mill, resulting in improved particle size distribution and increased fines production.

BrainWave ball mill is a unique control package using patented model-based predictive adaptive control technology, widely used by many primary processing industries.

BrainWave is able to stabilize the particle size distribution by continuously adjusting the mill load, typically achieved by adjusting the secondary crusher mantle gap to regulate production rate for the crushing plant. Using its model-based predictive control algorithm, BrainWave can effectively account for the transportation and dead time inherently present in the milling process.

Controlling the particle size distribution at the ball mill will improve the operation and stability of the flotation cells so that chemical costs can be reduced. In addition, the mine operator can specify the coarse material content to meet tailings dam structural requirements.

Since BrainWave makes adjustments to the secondary crusher mantle gap, BrainWave ball mill works effectively in conjunction with BrainWave crushing to maintain smooth and stable operations. Stabilizing the operation at this point allows for improved processing capacity downstream.



Ball mill PSD control schematic

BENEFITS

- Improve product quality by maintaining correct particle size distribution and maximizing particle recovery
- Stabilize ball mill operation, which will optimize operating points and chemical addition rates in the flotation process to maximize processing efficiency
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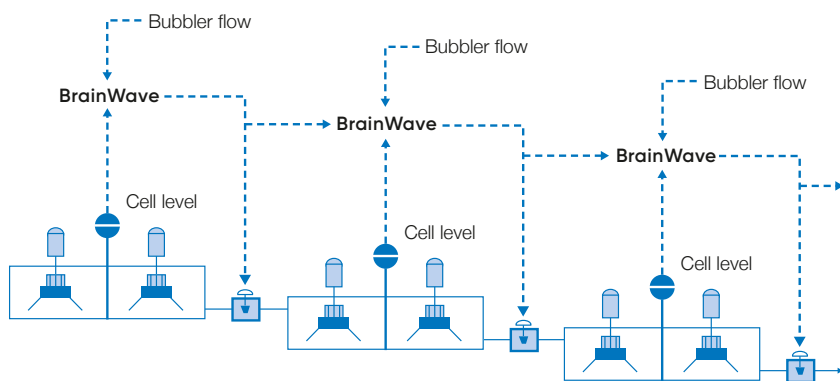
BrainWave flotation

Improve mineral recovery with more efficient flotation operations. BrainWave stabilizes the operation of all types of rougher, cleaner and scavenger flotation cells, resulting in more efficient operation and improved mineral recovery.

BrainWave flotation is a unique control package using patented model-based predictive adaptive control technology, widely used by many primary processing industries.

BrainWave is used to maintain the level in each of the flotation cells. By using its model-based predictive control algorithm, coupled with its unique integrating control algorithm, BrainWave will reduce the variability in the cell level control so that cell operation can be optimized. BrainWave is able to account for the level interaction between the cells by monitoring the flow control adjustments being made on the upstream side of the cell.

BrainWave can anticipate the effects of these changes on the cell level and take corrective action before the cell level is disturbed. BrainWave is also able to further improve the cell level control by using its feedforward rejection feature to account for other process disturbances such as production rate or bubbler flow rate.



Flotation cell level control schematic

BENEFITS

- Lower frother consumption through improved level variability, raising set point for pulp level in rougher flotation cell
- Improve cleaner operation and improve grade recovery by reducing gangue volume reporting to the cleaner circuits
- Achieve faster start-up of the rougher flotation circuit following upstream disturbances



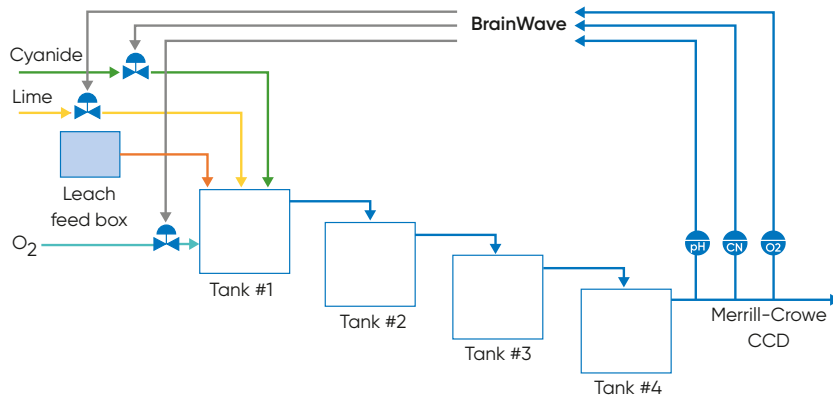
BrainWave leaching

Achieve consistent quality in leaching operations. BrainWave stabilizes operation of the cyanide leaching process, resulting in improved operation and consistent quality.

BrainWave leaching is a unique control package using patented model-based predictive adaptive control technology, widely used by many primary processing industries. BrainWave Leaching is able to control critical areas of the cyanide leaching processing.

Tight pH control is critical for ensuring that no cyanide gas evolves during the process and that pregnant liquor viscosity is stabilized for downstream processing. BrainWave accounts for the inherently slow dynamics in the cyanide leaching process by adjusting the slaked lime feed to the leach tanks, thus stabilizing pregnant liquor pH. Minimizing cyanide consumption will result in cost savings and improved overall process efficiency.

BrainWave monitors the cyanide concentration exiting the leach tanks and manipulates the cyanide flow at the inlet of the tank stream in order to maintain a constant cyanide concentration. Deficient oxygen amounts slow the leaching speed. BrainWave adjusts the blower speed to maintain a target oxygen level in the pregnant liquor, while minimizing the total energy consumption of the air blowers.



Leaching control schematic

BENEFITS

- Achieve tighter pH control through BrainWave's ability to account for the slow dynamics of the leaching process
- Save costs and improve efficiency by minimizing cyanide usage
- Reduce energy consumption in the blowers by maintaining a minimum dissolved O₂ target in pregnant liquor

BrainWave thickening

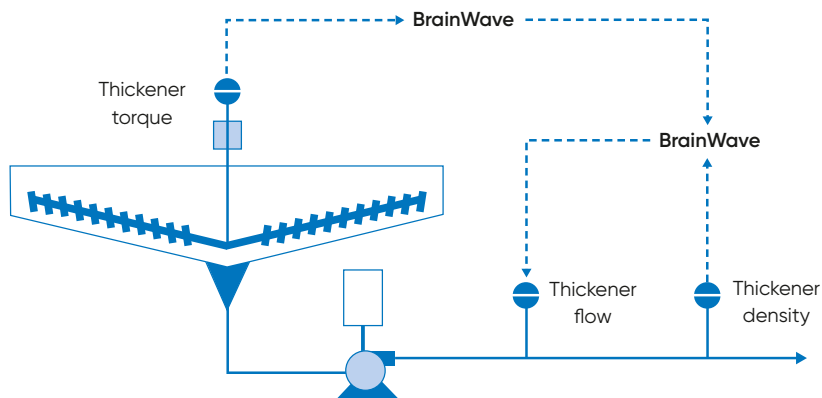
Stabilize and improve thickening operations. BrainWave stabilizes the operation of all types of concentrate thickeners, resulting in improved operation and increased production.

BrainWave is a unique control package using patented model-based predictive adaptive control technology, widely used by many primary processing industries.

Concentrate thickeners pose a challenging control problem, as both a nominal bed depth and product density must be maintained for proper operation. Using BrainWave, both of these objectives can be satisfied. Bed depth is controlled by monitoring rake torque and making continual adjustments to the target density, within a preconfigured range. In turn, the product density is maintained by varying the pulling rate from the thickener unit.

Conventional controllers struggle with handling the slow dynamics that are inherent in concentrate thickeners. BrainWave, however, is able to account for these slow dynamics due to its model-based predictive control algorithm.

Dynamics may slowly vary over time, due to such factors as build-up in the thickener vessel. BrainWave accounts for these changes by using its built-in model adaptation algorithm. This algorithm enables BrainWave to adjust its internal model of the process based on real-time observations of the process and to maintain tight control, regardless of changing dynamics.



Thickener density control schematic

BENEFITS

- Improve efficiency by enabling the thickener to operate at an optimal bed depth to improve dewatering performance
- Improve product consistency and performance of downstream processes through stabilization of density control



BrainWave HB filter

Reduce energy consumption by stabilizing control of hyperbaric filters. BrainWave stabilizes the operation of hyperbaric filters, resulting in improved control of the final product moisture and reduced energy consumption.

BrainWave is a unique control package using patented model-based predictive adaptive control technology, widely used by many mining process areas. One of the main issues in hyperbaric filter control is the over-drying of product, which can increase energy consumption. BrainWave accounts for transport delay times as product moves through the filter to the online moisture measurement sensor.

Further improvements to control are possible by monitoring incoming moisture content, either on- or offline, and including this in the control strategy as a measurable feed-forward. This allows BrainWave to make control corrections as soon as the incoming moisture changes, instead of waiting for the exiting moisture to respond.

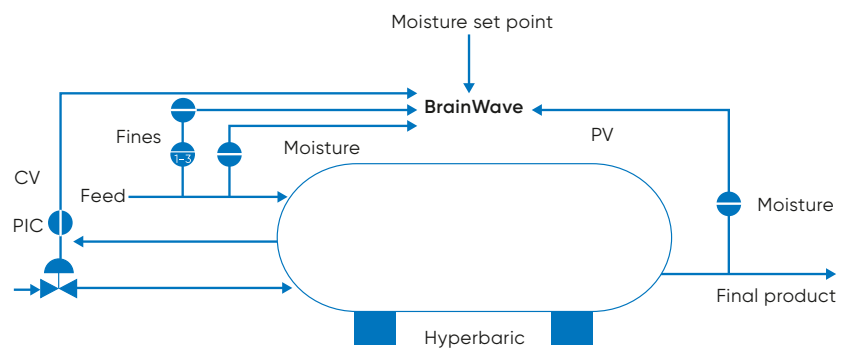
BrainWave is also able to reduce spikes in air pressure, which cause increased wear and excessive maintenance on equipment. BrainWave accomplishes this by stabilizing the measured moisture content at the filter exit by continuously adjusting air pressure.

Variations in fines or particle size cause the filter dynamics to change dramatically—a scenario not addressed by PID control. BrainWave, however, utilizes the particle size distribution, either as an online measurement or as a laboratory input, to adapt the control automatically, further improving filter efficiency, reducing air consumption of the blowers.



BENEFITS

- Improve energy efficiency through tighter moisture control and less over-dried material
- Achieve optimal product moisture through tighter, automatic control of pressure responses
- Reduce equipment maintenance by minimizing excessive pressure variations



Schematic of moisture control system with BrainWave HB filter



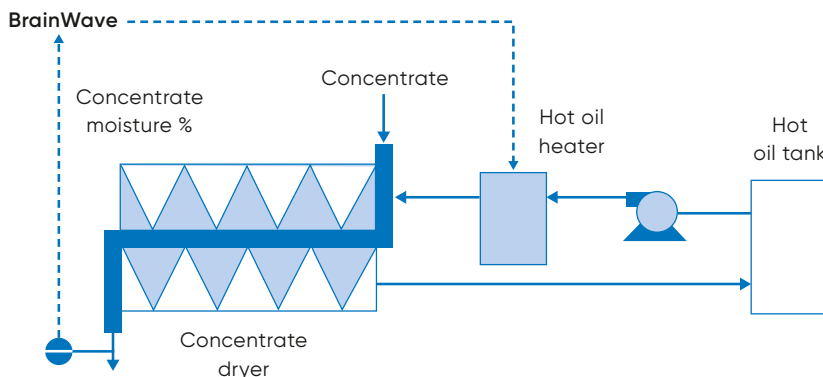
BrainWave dryers

Improve moisture control through stabilized dryer operation. BrainWave stabilizes the operation of all types of dryers, resulting in improved moisture control of the final product and reduced energy consumption.

BrainWave dryer is a unique control package using patented model-based predictive adaptive control technology, widely used by many primary processing industries. BrainWave is able to stabilize the measured moisture content at the dryer exit by continuous adjustment of the dryer temperature.

BrainWave is ideally suited to control this application due to its ability to account for the long transport delay times as the product moves through the dryer to the moisture measurement sensor. Further improvements to control are possible by monitoring incoming moisture content and including this in the control strategy as a measurable feedforward.

This allows BrainWave to make control corrections as soon as the incoming moisture changes, instead of waiting for the exiting moisture to respond. Variations in production rate cause the dryer dynamics to change dramatically. BrainWave is able to compensate for these changes by automatically switching controller configurations as production rate changes, further improving dryer efficiency.



Moisture control schematic

BENEFITS

- Improve product quality by reducing the variability in concentrate moisture content
- Reduce energy consumption by preventing concentrate from being over dried





WHY WORK WITH ANDRITZ

For over 20 years we've been providing modeling and OTS services to customers across a variety of different industry verticals, offering our customers proven OTS solutions that enable them to achieve their operator training objectives. We can connect our clients with any third-party DCS vendor, as well as develop software, offer flexible commercial models, and provide technical support 24/7 thanks to our global presence.

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