Case history

Moisture sensor's performance doesn't fall flat

A flat-plate moisture sensor improves a livestock mineral supplement's moisture content and quality.

Too much or too little moisture adversely affects our products' quality, so we're constantly adjusting the drying process parameters to keep the moisture content between five and ten percent," says Kyle Brokken, director of research and development at QualiTech Inc., a Chaska, Minn., company that produces livestock feed supplements. "In the past, we used a combination of microwave and air-oven testing to check the moisture content, but it would take fifteen minutes to more than an hour to get the results. And by that time, the atmospheric or drying process conditions could have changed from when we took the samples, so it seemed like we were always behind the curve. We needed to find a way to get the moisture content results more quickly."

Brokken is discussing one of the company's product lines, sequestered trace mineral (SQM) products that contain zinc, manganese, magnesium, copper, or iron. To make an SQM product, the company reacts a polysaccharide source with the appropriate sulfate trace mineral in an aqueous solution. The product discharges from a mixer to a drying process that removes most of the moisture, leaving a granular SQM product that contains 5 to 10 percent moisture. The product is then conveyed to a hammermill where it's reduced to a uniform particle size of about 60 mesh. The product discharges from the hammermill to a bagging machine that loads it into 50-pound-capacity bags.

In the past, to verify that a product's moisture content was between 5 and 10 percent, an operator took random material samples as the product discharged to the bagger. The operator carried the material samples to a test lab and performed microwave and air-oven tests to determine the moisture content. Based on the test results, the operator then adjusted the drying

For this application, the moisture sensor is mounted in the base of a box, allowing the company to use it as a benchtop unit for material testing.

process parameters to either increase or decrease the product's moisture content.

Moisture content testing causes problems

The lagtime between taking the material sample and adjusting the dryer was a problem," says Brokken, "because the atmospheric or drying process conditions could have changed enough to make the adjustments inappropriate, which made the drying process less accurate."

This affected the product's quality. "As the product's moisture content goes up or down three to four percent, the product's potency changes," says Brokken. "And because each product is sold at a given potency, we want to keep the moisture content, and therefore the potency, as constant as possible."

Another problem occurred when the hammermill reduced the dried product. If the product discharged from the drying process with less than 5 percent moisture content, the hammermill would reduce it to particles smaller than 100 mesh. This created excess dust in the plant and decreased the product's functionality and appearance.

Because of these problems, the company decided to look for a device that would allow them to immediately know a product's moisture content as it discharged to the bagger.

Searching for a moisture sensor

In February 2003, after seeing an ad in *Powder and Bulk Engineering* for a flat-plate online moisture sensor, Brokken contacted AgriChem, Ham Lake, Minn., for more information. The supplier manufactures and supplies moisture sensors and moisture monitoring and control systems for food and agricultural processors. Brokken arranged to test the flat-plate sensor, and, because the supplier is located only 45 minutes away from the company, Dave Greer, AgriChem president, delivered one sensor to the company for testing.

The sensor is designed to be mounted in a system with a continuous material flow at least 4 inches deep. However, the material bed-depth in the company's discharge line didn't meet this requirement, so the company decided to turn the sensor into a benchtop unit. The company built a metal box about 6 inches wide by 8 inches long by 6 inches tall and mounted the flat-plate sensor in the bottom.

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The monitor receives a signal from the sensor and converts it to moisture content and temperature readings that are displayed on an LCD screen.

"It sits on a table next to the bagging machine so that the operator can take a material sample right out of the material stream, dump it into the sensor box, level it off, and get the required four inches of material every time," says Brokken.

After the sensor determines the sample's moisture content, the operator dumps the material back into the process and makes the required adjustments to the drying process.

"We found the sensor easy to calibrate," says Brokken, "and the results are as accurate and precise as the microwave and air-oven tests that we were using, so we decided to purchase and install one."

The flat-plate moisture sensor

The FP-1 flat-plate online moisture sensor is a capacitance-type moisture sensor powered by a 110-volt power source. To avoid power surges caused by other equipment, the sensor is connected to an independent instrument-quality circuit. The 5-inch-wide-by-7-inch-long-by-1-inch-tall sensor can measure the moisture content of various materials, including fine powders, whole grains, and even chunks of coal up to about 1.5 inches across, providing a moisture content reading continuously and instantaneously.

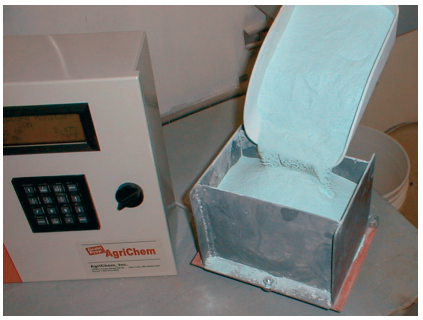
To determine a material's moisture content, the sensor measures the energy input required to maintain the electric field between the two plates.

The sensor consists of two capacitor plates separated by a ground; the positively charged plate is called the transmitting plate and the negatively charged plate is called the receiving plate. The sensor's surface is coated with Teflon to prevent material from sticking to it. Depending on the material and application, the sensor's surface can have different coatings or covers.

To create an electrical field between the two capacitor plates, a 1-million-cycle-per-second alternating current is applied to the transmitting plate. (A typical household alternating current is about 60 cycles per second.) A horseshoe-shaped electric field is established between the transmitting and receiving plates, extending about 4 inches perpendicularly from the sensor face. To measure a material's moisture content accurately, there must be at least 4 inches of material above the sensor. More material won't impair the sensor's accuracy, but less material will skew the results.

Since installing the sensor, the company has learned that the SQM products are slightly hygroscopic if overdried and that they'll rehydrate to an equilibrium point.

To determine a material's moisture content, the sensor measures the energy input required to maintain the electric field between the two plates. If the testing box were placed under vacuum, which is a perfect insulator, there would be no energy transferred between the plates because there would be no conductor. Because no energy input would be required to maintain the field, the sensor would read 0 percent moisture. If a material containing a certain percentage of moisture is added to the testing box, energy dissipates at a rate proportional to the material's moisture content. The greater the moisture content, the more energy it takes to maintain the field, and vice versa.



The sensor and monitor are located on a table next to the bagging machine, allowing an operator to quickly determine a product's moisture content.

The sensor is calibrated based on a material's characteristics, such as density and dielectric properties, and can be calibrated to handle multiple materials. A sensor monitor, located next to the testing box, receives the sensor signals and converts them to moisture content and temperature readings that are displayed on an LCD screen. The monitor can also generate an analog signal for transmission to a computer for database storage or trending reports or for starting and stopping equipment or sounding an alarm.

Sensing success

Since installing the sensor, the company has learned that the SQM products are slightly hygroscopic if overdried and that they'll rehydrate to an equilibrium point. "The sensor allowed us to learn some things like this about our products that we didn't know," says Brokken. "We also learned that after a product discharges from the drying process it may continue to dry for a while as it releases the heat stored within it."

The sensor improved the SQM products' quality. "We can get moisture content readings two or three times an hour with little or no hassle," says Brokken. "It takes about thirty seconds to take a material sample to the sensor to determine a product's mois-

ture content, which allows us to make adjustments to the drying process parameters that immediately affect the product's moisture content. And when we can dry a product at the same moisture content every time, the product's potency is much more consistent and its particle size is much more uniform when it discharges from the hammermill. This has also improved the plant environment by decreasing the amount of dust the hammermill generates."

In addition, the sensor has improved the drying process's fuel efficiency. "We're saving fuel costs because we can immediately adjust the drying process's airflow and temperature to avoid wasting energy overdrying the product," says Brokken. "The sensor is quick, trouble-free, reliable, and easy to use. Anybody in the plant can operate it with very little training, and the plant operators love it because it's efficient and accurate, and it can be calibrated for multiple products. We have a food division, and I think they may eventually be interested in this type of sensor, because knowing moisture and water activity is critical in the food products they make." **PBE**

Note: To find other articles on this topic, go to www.powderbulk.com, click on "Article Index," and look under the subject heading "Moisture analysis," or see *Powder and Bulk Engineering*'s comprehensive "Index to articles" in the December 2002 issue.

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