Case history

A flat-plate moisture sensor easily cracks this nut

A company installs a flat-plate moisture sensor in a process line's belt dryer to achieve and maintain a more uniform moisture content in pecan kernels.

If you've ever had a warm piece of pecan pie, then you know how good pecans taste. But have you wondered about the process that removes the shells so you can enjoy them without breaking your teeth? If you have, then you might want to take your next vacation in Las Cruces, N.M., where Young Pecan Co. operates a plant that shells, packages, and ships pecans to major food manufacturers who use them to make finished products. Don't forget to ask about the new moisture sensor the company recently installed in the process line's belt dryer to reduce production costs and improve the process line's efficiency.

Processing the pecans

Bulk loads of in-shell pecans are delivered to the company's plant by truck and are stored in large bins before processing. From the storage bins, the in-shell pecans are conveyed into the plant and discharged into a blancher that sanitizes them. The pecans absorb moisture while in the blancher, which prevents the kernels (or *nut meats*) from shattering when the shells are cracked and removed later in the process line. By regulating the blanching time, the company can control the amount of moisture the pecans absorb.

"The pecans that discharge from the blancher need to have a consistent moisture content because the downstream dryer's operating parameters are set to remove a certain amount of moisture from the kernels," says Paul Koenig, the company's general manager. "If the pecans leave the blancher with a moisture content that's too high, the kernels will discharge from the dryer with too much moisture, and vice versa."

To ensure that the pecans' moisture content stays constant, every 30 minutes an operator takes a sample from the blancher, carries it to the company's test lab, and uses a moisture analyzer to determine the sample's moisture content. Based on the results, the operator either increases or decreases the blanching time to maintain a consistent moisture content in the pecans.

After the appropriate time, the pecans discharge from the blancher and are

The flat-plate moisture sensor's hinged mounting device enables the sensor to ride over the kernels' tops, regardless of the material-bed depth.

conveyed to a rotary cracking machine that cracks the shells. The pecans are then conveyed to a sheller that removes the shells from the kernels. The kernels are sorted by size and color before being conveyed to an auger that feeds them into a belt dryer.

The auger evenly distributes the kernels onto the dryer's conveying belt at a constant rate, forming a 4-inch-deep material bed across the belt's width. The dryer's temperature and belt speed are set to dry the kernels to a predetermined moisture content. For kernel halves, the optimum moisture content is 5 to 5.5 percent, and for kernel pieces, it's 4 to 4.5 percent.

In the past, to determine the kernels' final moisture content, an operator took a material sample every 30 minutes as the kernels discharged from the dryer. The operator walked the sample to the test lab and determined the moisture content using the moisture analyzer. The operator then adjusted the dryer's belt speed to either raise or lower the kernels' moisture content. To raise the kernels' moisture content, the operator slightly increased the belt speed to shorten their residence time in the dryer, and vice versa. Additionally, if a sample's final moisture-content reading fell outside a certain range, the operator also had to adjust the blanching time to ensure that the kernels arrived at the dryer with the proper moisture content.

From the dryer, the kernels are conveyed to an infrared shell detector that

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The sensor monitor continuously displays the kernels' moisture-content and current-status readings as they discharge from the dryer.

removes any remaining shell pieces and a laser scanner that detects and removes discolored and flawed kernels. The kernels are then conveyed to a large sorting table, where workers manually inspect and sort the kernels before packaging them in 30-pound boxes or 1,000-pound bins that are shipped to customers.

Difficulties maintaining moisture content

The company experienced difficulties maintaining a consistent moisture content in the kernels discharging from the dryer. A round-trip for each moisture test took about 10 minutes, so there were times when the operator returned to the dryer and the operating conditions had changed enough that the belt-speed adjustment had no effect or the wrong effect on the kernels' moisture content.

And because the auger feeds the kernels onto the dryer's belt at a constant rate, the belt speed has to remain fairly constant to maintain a consistent material-bed depth. "If the operator increased the belt speed too much, the material-bed depth decreased and the kernels discharged from the dryer with too little moisture," says Koenig. "And if the operator decreased the belt speed too much, the material-bed depth increased and the kernels discharged from the dryer with too much moisture."

If the kernels discharged from the dryer with too much moisture, workers had to place them on small table dryers to reduce their moisture content to the appropriate level. This increased production time and costs. And kernels that discharged from the dryer with too little moisture had unacceptably low final weights or poor flavor qualities or both. This raised production costs because the company had to put more kernels in a container to achieve the specified shipping weight and discard the kernels that didn't meet quality standards.

To improve production costs and reduce the time between taking a sample and adjusting the dryer, the company decided to look for a sensor that would allow the operators to immediately know the kernels' moisture content as they discharged from the dryer.

Sensing a solution

The company began its search for a sensor by traveling to a nearby potato-chip manufacturer to observe a high-tech food-grade moisture sensor that detects the moisture content in potato chips as they discharge from a dryer. The sensor did just what the company required. However, after reviewing its specs and pricing, the company decided to continue looking for a less-expensive sensor more suited for pecans.

The company contacted an electrical supply company that it had worked with in the past on various plant upgrade projects. "Two of their reps traveled to our plant and looked at the pecan process line and belt dryer to see if there was anything they could do to help," says Koenig. "Unfortunately, they couldn't do anything. But one of the reps said that he'd do some research on moisture sensors and contact us with the results."

After reviewing information about a flat-plate moisture sensor, Koenig called the supplier to discuss specific details about the sensor and testing it in the belt dryer.

A few weeks later, the rep called Koenig with contact information for AgriChem, Ham Lake, Minn., which manufactures and supplies moisture sensors and moisture monitoring and control systems for food and agricultural processors. Koenig immediately sent the sensor supplier an e-mail requesting basic information about the supplier's moisture sensors. After reviewing information about a flat-plate moisture sensor, Koenig called the supplier to discuss specific details about the sensor and testing it in the belt dryer.

"We wanted to install and test the sensor near the dryer's discharge to detect the kernels' moisture content as they exited the dryer, and the supplier said that it would work fine there," says Koenig. "We also talked with the supplier about their thirty-day test-and-return policy. At the end of the trial period, if the sensor performed well, we would purchase it, and if it didn't work well, we could return it without charge."

Testing the sensor

A couple of weeks after talking with the supplier, the company received a flat-plate moisture sensor and a sensor monitor to test for 30 days. To install the sensor in the dryer's discharge end, the company built a mounting device that hangs from a hinge mounted on the underside of the dryer's top. The sensor is attached to the mounting device's lower end with the sensor's bottom plate parallel to the conveyor belt. The mounting device extends down to just above the belt and allows the sensor to continuously ride over the tops of the kernels like a sled, regardless of the material-bed depth. It also keeps the sensor from touching the belt if there are no kernels running through the dryer. To ensure an accurate moisture-content reading, the company must maintain a minimum 4-inch-deep material bed.

The sensor monitor receives signals from the sensor and converts them to moisture-content readings that are displayed on an LCD screen. The company had to calibrate the monitor to account for the kernels' material characteristics: An operator took a sample from the dryer and determined its moisture content using both the existing moisture analyzer and the new flat-plate sensor. The operator then compared the moisture analyzer's result to the sensor monitor's moisture-content reading and adjusted the monitor accordingly. The operator repeated this until the moisture analyzer and monitor showed the same reading.

The company mounted the sensor monitor near the dryer's discharge so operators can easily keep an eye on the kernels' moisture-content readings. The sensor monitor continuously shows the discharging kernels' moisture content with a number and the current status with the word "high," "OK," or "low," depending on the reading. The monitor also has an alert light that flashes a distinctive pattern assigned to each current-status reading. Additionally, the monitor displays temperature readings transmitted from a temperature sensor located on the moisture sensor.

After the 30-day trial period proved successful, the company purchased the flat-plate moisture sensor and sensor monitor.

The 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 coal chunks up to about 1.5 inches across, providing a moisture-content reading continuously and instantaneously.

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. Depending on the material and application, the sensor's surface can have different coatings or covers. At Young Pecan, the sensor's surface is coated with Teflon to prevent kernels from sticking to it.

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 below the sensor. More material won't impair the sensor's accuracy, but less material can skew the results.

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 sensor 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 placed beneath the sensor, 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 is calibrated based on a material's characteristics, such as density and dielectric properties, and can be calibrated to handle multiple materials. The sensor monitor converts the sensor signals to moisture-content and temperature readings. 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.

Enjoying the kernels of success

Since installing the sensor and sensor monitor, "We've reduced production costs and decreased production times, because we've been able to maintain a more uniform moisture content in the kernels that discharge from the dryer," says Koenig. "Now, when the moisture content gets out of range, the monitor's flashing alert light instantly signals the operators, and they immediately adjust the dryer's belt speed to correct it. In the past, an operator took a sample every thirty minutes, and it took him at least another ten minutes to analyze the sample and adjust the belt."

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"We've also reduced the drying operation's labor requirements, because the alert light allows the operators to do other jobs around the plant," says Koenig. "They don't have to sit around and watch the sensor monitor's display to know the current status of the kernels' moisture content."

The company is working with the supplier to connect the sensor monitor to a database to collect and store the moisture-content data and provide trending information that the company plans to use to continue improving the process line's efficiency.

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AgriChem, Ham Lake, MN
763-434-6755
www.agricheminc.com