Case history

Continuous level sensor functions accurately in dusty environments

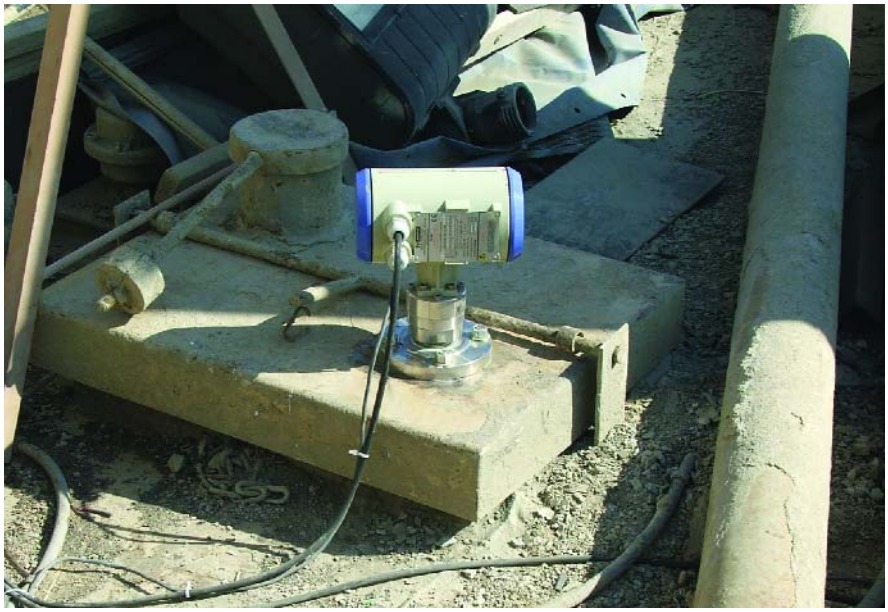
A concrete production plant installs a continuous level sensor in a cement powder silo and a fly ash silo to continuously monitor each silo's material level in real time.

Valley-Batavia LLC, headquartered in Shorewood, Ill., operates a concrete production plant in Montgomery, Ill., that can load two concrete mixer trucks simultaneously, each with a different concrete mix. In the past, the plant used point level sensors to indicate the material high levels in its silos holding cement powder and fly ash, two of the concrete ingredients. Operators manually kept track of the material amount discharged from each silo to calculate the material's low level. Then about 2 years ago, a supplier of various monitoring instruments talked to the plant about installing a continuous level sensor in the cement powder and fly ash silos to continuously monitor each silo's material level in real time during both refill and discharge. Since the company had had previous positive experiences using the supplier's equipment in other applications at other plants, it decided to install the sensors.

Filling the concrete mixer trucks

When the company fills a concrete order, a concrete mixer truck first pulls into one of the Montgomery plant's two loading stations. About 70 percent of the required water is filled into the truck's rotating mixing drum, followed by the required amounts of dry materials (cement powder, fly ash, sand, and rock). Each dry material is transferred from its respective storage area to the loading station in a predetermined sequence. The remaining 30 percent of the water is then added, completing the concrete mix. The driver exits the loading station and activates the truck's rotating drum, which mixes the water and dry materials together during transport to the work site. The plant is designed so that two trucks can be filled with 8 to 10 yards of dry materials about every 2½ minutes.

The plant stores the cement powder in two 325,000-pound-capacity silos and the fly ash in two 135,000-pound-capacity silos. When a silo runs low, an operator calls for tanker trucks to deliver more material to the plant. After a tanker truck pulls into the plant's off-loading station, it's connected to a pneumatic conveying system that transfers the material from the tanker truck to a silo's top in about



The continuous level sensor's electronics, which are protected by a NEMA 4X (IP66) aluminum housing, are installed on top of a silo.

30 minutes. The plant typically refills the cement and fly ash silos at the same time the cement powder and fly ash are being discharged into the concrete mixer trucks.

Experiencing difficulties maintaining inventory

The plant found that it could only use point level sensors in the silos to indicate a material's high level and alert the operators to shut down the pneumatic conveying system. Fred Thompson, the company's operations manager, says, "The cement powder and fly ash have very fine particles, and they create excessive amounts of dust inside the silos during refill, making it difficult, if not impossible, for us to use standard noncontact radar or sonar sensors to accurately measure a material's height at the same time a silo is being refilled."

The plant's method of manually monitoring the material amount discharged from each silo and calculating the remaining material amount was cumbersome. "This caused problems if the operator's math was wrong or if he calculated the numbers for the wrong silo, because then we had a situation where there was less material in a silo than the numbers said," Thompson says.

"When that happened, we faced the possibility of having to shut down a loading station if we couldn't get some tanker trucks to the plant to refill the silo. To prevent this, we'd look at the next day's orders to see how much material we'd be using, then we'd order the tanker trucks based on that usage amount. But a day can change because of weather or other factors, and more material might end up going out than we planned for. Then we'd have to scramble to call more tanker trucks, which isn't a very efficient way to run a plant."

Finding another sensor technology

In fall 2005, Andy Bowman, chief application engineer at Monitor Technologies, talked with Thompson about a new continuous level sensor technology the supplier had recently acquired that could help improve the Montgomery plant's silo-refilling process and make it more efficient. Monitor Technologies LLC, Elburn, Ill., supplies level measurement instrumentation to a range of powder and bulk solids industries.

"Andy told me that the new sensor can continuously monitor a material's level in a silo even during refill," says Thompson, "and he wanted to install a sensor in the plant's cement and fly ash silos to show me that the dust generated during refill wouldn't affect the sensor's ability to function properly. If they worked, the sensors would make it easier for our operators to schedule silo refills because they'd always know the material level without having to do any calculations. So I decided to install a sensor in each of the silos."

The continuous level sensor

The Flexar continuous level sensor consists of a NEMA 4X (IP66) aluminum housing that contains the sensor's electronics; a 34-foot-long, 8-millimeter-diameter, Type 316 stainless steel, flexible cable (called the *probe*) with a bottom counterweight; and a remotely mounted monitor with a panel meter that displays the material level inside the silo and can be installed up to 4,000 feet away from a silo. The probe is connected to the housing's underside. A two-wire cable connects the sensor's output to the remote monitor. To install the 4-to-20-milliamp sensor, an operator first makes a small hole in the silo's top about 20 inches away from the silo's side and lowers the probe, counterweight first, through the hole so that it hangs freely down into the silo. The probe's length is specified so that the counterweight hangs about 20 inches above the silo's bottom. The operator then uses flanges to mount the sensor housing over the hole on the outside of the silo's top, creating a seal that prevents water or dirt from getting into the silo.

To indicate the silo's material level, the roof-mounted sensor produces microwave pulses that travel down a 34-foot-long flexible stainless steel probe to the material's top surface and are reflected back to the sensor.

To indicate a material's level inside a silo, the guided-wave radar sensor uses a principle known as time domain reflectometry (TDR).

Before activating the sensor, which is virtually plug-and-play for most applications, the operator follows the installation guide and makes the necessary minor adjustments to the sensor's operating parameters. This includes setting the sensor to the company's preferences, such as to indicate

percent full or percent empty or to indicate the material's height with 0 feet being at the probe's bottom and 34 feet being at the probe's top or vice versa. The operator then turns on the sensor, which is designed to operate continuously without requiring readjustments or recalibrations. The information the sensor captures is displayed on an easy-to-read LCD screen located at the sensor or on the remote monitor.

To indicate a material's level inside a silo, the guided-wave radar sensor uses a principle known as time domain reflectometry (TDR), in which the distance between a point on the probe and the sensor is determined as a function of the time required for a signal to travel from the sensor to the point and back again to the sensor. In operation, the sensor produces microwave pulses that travel near the speed of light down the probe. Upon reaching the material's top surface, the pulses are reflected back to the sensor at an intensity dependent on the material's dielectric constant. (The sensor is manufactured so that few if any setting adjustments are required when used in the majority of applications with materials that have a dielectric constant of 2.0 or greater.)

"For example, after the sensor initiates a pulse, it only takes about forty milliseconds for the sensor's electronics to process and output the pulse-reflection data," says Joe Lewis, vice president of marketing and sales at Monitor Technologies. "So in one second, the sensor processes numerous pulse reflections. However, the sensor doesn't update the display that frequently because it processes the data to create an average reading — called signal smoothing — that's updated on the display about every second."

Improving inventory management

Installing the new continuous level sensors in the cement and fly ash silos has enabled the Montgomery plant to improve its operating efficiency. "The sensors allow the operators to monitor the material levels in the silos in real time, displaying the information on the remote monitors as both percent empty and percent full," says Thompson. "All the operators have to do is glance up at the monitors that are mounted on a nearby wall to immediately know how much material is left in the silos. They no longer have to keep track of everything and manually calculate the remaining material amounts. This has improved our ability to line up tanker trucks in advance to refill the silos, which has made it easier for us to maintain adequate material levels in the silos at all times. And, more importantly, I no longer have to worry about mistakes happening or the plant running out of cement or fly ash. In this business, where you don't know what you're going to get hit with on any given day, you need to know exactly where the material levels are in the silos so you always have enough material on hand."

The sensors accurately monitor the cement and fly ash levels in the silos during both refill and discharge. "Even the dust generated during refill doesn't affect the sensors' ability to indicate the material level inside the silos," says Lewis. "With some sensors, you have to periodically stop the refill and let the dust settle before you can get an accurate reading. But these sensors continuously deliver an accurate material-level reading regardless of the conditions inside the silo."

The sensors accurately monitor the cement and fly ash levels in the silos during both refill and discharge.

The plant still has the point level sensors installed in the silos just in case something goes wrong during the refill process. "However, we haven't had to use them in more than two years because we've never had any problems with the sensors — they're not even affected by the weather,"

The remote monitors allow an operator to know the exact material level inside a silo without having to perform any calculations.

says Thompson. "They're easy to install, require little to no maintenance, and are user-friendly and easy to operate. At this time, I'm in the process of requisitioning two more sensors for the Montgomery plant and four sensors for another plant. We're just waiting for approval." **PBE**

Note: To find other articles on this topic, look under "Level detection" in *Powder and Bulk Engineering*'s Article Index at www.powderbulk.com or in the December 2006 issue.

Monitor Technologies, Elburn, IL
800-601-6319
www.monitortech.com