Fly-Ash Level Measurement Solutions Using Guided Wave Radar

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September 13, 2006

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Reliable Flyash Storage Monitoring

Flyash is derived specifically from the combustion of coal. Typically in a coal-fired power plant flyash is transported from the firebox through the boiler by flue gases. It is a by-product of the coal combustion process. Coarse ash, referred to as "bottom ash" or slag, falls to the bottom of the combustion chamber while the lighter fine particles, the flyash, remain suspended in the flue gases. Prior to emitting the flue gas the flyash is removed by particulate emission control devices. These devices are typically electrostatic precipitators or dust collection baghouses.

As we turned the century mark more than 61 million metric tons were being generated each year. During much of the 20th century this flyash was simply collected and disposed of in waste dumps and collection ponds. While this may still be done in some cases, the U.S. EPA decided that dumping flyash wasn't "environmentally friendly" and many industries have found vital and valuable uses for flyash and research continues in this area. Such industries to have discovered productive uses of flyash include cement production and concrete production.

The production of cement requires a source of silicon (such as clay or sand). Flyash can and often is used as a silicon source. While flyash is sometimes used as a source of silica in cement production, and has environmental and cost benefits, a more common use of flyash is in concrete mixture as a substitute for some of the cement. Flyash can readily be substituted for 15% to 35% of the cement in concrete mixes, according to the U.S. EPA. For some applications flyash content can be up to 70%.

Flyash today is estimated to account for about 9% of the cement mix in concrete, with benefits as follows. Flyash reacts with any free lime left after hydration and increases concrete strength, improves sulfate resistance, decreases permeability, reduces the water ratio required, and improves the pumpability and workability of the concrete. Some coal-fired power plants produce better fly ash for concrete than other plants, because of lower sulfur and lower carbon content in the ash as a result of differing environmental regulations affecting power-generating plants.

Characteristics that challenge measurement of flyash level in storage vessels

With the increased productive use of flyash within the cement, concrete and other industries, more and more flyash is ending up in silos and storage vessels. Storage of this "commodity" requires monitoring the amount of material present, or the level of the material, within the silo storage vessel.

The use of different coal types and the use of flyash by cement and concrete producers from multiple sources can present measurement challenges when using continuous level measurement technologies. In particular dielectric constants can vary from 1.5 to 2.6.

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Flyash particle size can vary from below 1 to 200 microns or greater. It is estimated that about 40-60% of flyash particles is below 1 micron. This means that flyash would be classified a “powder” similar to that of cement. This means that during the filling of storage vessels, flyash will be heavily dispersed in the internal vessel environment (it will be extremely dusty). Flyash is easily transported into and from storage vessels via pneumatic conveying and this means that dust cloud dispersion and concentration will be very heavy.

Variable dielectric constants, low dielectric properties, heavy dust due to fine micron size particles and pneumatic conveying into and from storage presents challenges for nearly all sensor technologies that might be used for the measurement of the level of the flyash in a storage silo.

Technologies considered

RF Capacitance: This technology is never a good choice for continuous measurement of the level of powders and bulk solids and this application is no exception. Flyash comes from different sources and stratification can occur within the storage vessel as different sources of coal produce different flyash characteristics and may still be stored in the same vessel. The changing dielectric constant through the various strata of flyash within the vessel will introduce measurement error.

Ultrasonic: Dust. Did we say dust? You bet we did, and with the heavy dust produced by this fine micron size particle powder, especially during pneumatic filling, reliable and accurate results are elusive.

Weight & Cable: The state-of-the-art smart weight & cable level sensors can provide acceptable operation. However, if true continuous measurement updates are required you must still remember that these devices are designed for periodic measurements and even the latest generation of units still have moving parts. However, they are viable and should be considered if periodic measurement is acceptable to you. Insist on a unit with extremely high resolution (at least 0.01ft), electronic braking, split compartment design, easy access maintenance and electronics meeting all international standards.

Laser: This technology is not suitable for any powder application due to the nature of the heavy dust within the vessel. Lasers are light-based and affordable units are severely challenged with dusty environments, even in plastics. Those units that may provide some degree of reliability in dusty environments can also be very expensive.

Through-Air Radar: This technology is not as problematic as the other “through-air technologies, ultrasonic and laser, in this application. However, given the poor reflectivity of the low dielectric nature of flyash and the cost of through-air radar systems that will work in the long range dusty applications ($4,500+), this may not be the best choice or most cost effective solution.

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Guided Wave Radar (TDR): Time domain reflectometry is used in guided wave radar level sensors. Rather than emitting radar energy into the air, TDR based units send radar pulses guided down a probe (wave-guide) thereby focusing and delivering the energy to the target material surface. The characteristics of TDR make it independent of dielectric constant issues and these units can measure materials with dielectric constants within the range of flyash variability. The probe element is typically an extremely heavy-duty 0.31" (8mm) diameter stainless steel industrial cable that can easily withstand the wear associated with this application and can tolerate pull force up to almost 4 tons. Guided wave radar with TDR technology has proven to be the most applicable and affordable level sensing technology for flyash storage measurement applications.

Flyash level measurement application examples

We will focus on two typical flyash applications. The first is where flyash is used in the batch manufacturing of concrete. Flyash is often used as an ingredient to concrete along with cement, water and aggregate. In this application flyash is used to provide several benefits including for strength and appearance.

In this example the customer, Batavia Concrete located in Montgomery, IL, is just one of many concrete batch plants operated by Prairie Materials in northern Illinois. Like many concrete plants, Batavia had no idea how much flyash and cement they had in their storage bins until a low or high level indicator provide a signal. They needed a better solution to enable them to know how much flyash or cement they had at any given time, during filling and discharge. This would make them more efficient.

Guided wave radar continuous level sensors were introduced to Batavia Concrete in December 2005. The supplier presented guided wave radar as "proven technology". This, combined with the supplier's five decades of bulk solids experience, made it easy for Batavia to adopt this possible solution. At this facility Batavia Concrete uses a multiple compartment batch plant manufactured by Erie Strayer of Erie, PA. The supplier, Monitor Technologies LLC, had worked with Erie Strayer for many years and was familiar with the batch plant and bin design.

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Batavia Concrete and the sensor manufacturer worked together to install and start-up the guided wave radar level sensors. With guided wave radar distance/level is measured by the time-of-flight of the reflection of a microwave signal (transmitted down the wave-guide, which is a heavy-duty 0.3” SS cable with 3.9 ton tensile strength) off the material surface. Cement and flyash both have relatively low dielectric constants and the guided wave radar sensor’s direct measuring mode was successful in providing real-time continuous updates of the material level during filling and drawdown.

Guided wave radar units are installed in the flyash and cement bins with 34’ (10.3m) cable length. The 4-20mA signal from each level sensor is connected to a panel meter in the batch plant control room. Customer observations indicate accurate measurements and they are very happy. Fred Thompson, Regional Operations Manager of Batavia Concrete, has been satisfied with this solution and reports that he desires to install these specific guided wave radar units at other plants within his regional area of responsibility. He prefers the true continuous nature and the reliability of guided wave radar units even during filling of the very dusty materials he needs to measure.

The second typical application where flyash storage levels need be measured and monitored is at a cement production facility. In this situation a cement producer operating a manufacturing plant in the Midwest USA. The cement producer adds flyash to the cement in order to improve the material characteristics of the cement produced at the facility. This is typical in cement production.

The flyash used at this Missouri facility comes from a nearby power plant and is stored in silos at the cement plant site. In order to ensure efficient production of the plant, the cement producer needs to know exactly how much flyash they have at any given time. The cement producer recently added another silo for their flyash storage, increasing the total to two silos. The new silo is about 60ft. (18.3m) high and 21ft. (6.4m) in diameter. The amount of flyash available can impact their production capacity significantly. Recent demand necessitated the additional silo and the cement producer needed a way to accurately measure the amount of material. The other silo has an aging sonar unit and the producer was keen on moving away from this technology to something that would be accurate and more reliable, even during filling when heavy dust exists within the silo.

Guided wave radar continuous level sensor technology, based on TDR (time domain reflectometry) technology, was selected. Installation and start-up was quick and easy. Even though flyash has a low dielectric constant the guided wave radar sensor's direct measuring mode was extremely successful in providing real-time continuous updates of the material level during filling and drawdown. In fact, the cement producer claims the unit is "excellent" and they couldn't be happier. In fact, they are in the process of replacing the sonar unit in the old silo with the same guided wave radar unit.

Conclusion

Whether you manufacture cement or produce concrete the use of flyash is likely an important part of your production process and an integral part to producing quality in your end product. However, flyash presents challenges when it comes to monitoring the amount of it that you have. Measuring the level of flyash in your storage bins and silos can prove impossible or be severely hampered when using virtually all other technologies available. Guided wave radar, using TDR (time domain reflectometry) technology is a proven problem solver and is proven reliable for measuring virtually any powder and especially the previously-difficult-to-measure flyash.