The highs and lows of non-contact level sensors: Comparing laser, 3D scanners and radar

by Jenny Nielson Christensen, MBA, VP of Marketing, BinMaster, USA

Grain storage facilities and millers find non-contact level sensors attractive for a number of reasons. Of course, since nothing comes into contact with the material, there's no risk of equipment interfering with the process or rogue parts breaking off and getting stuck in equipment or contaminating grain. Plus, they provide continuous level measurement for optimising inventory and preventing bins from running empty. With commodity prices where they are, inventory accuracy is important to the bottom line of every grain and milling operation.

Today's most popular non-contact technologies in the grain industry are 3D scanners, radar, and lasers. The sensor that might be best for your application is determined by a number of factors including the material being measured, the amount of dust in the environment, the size of the bin, and the desired inventory accuracy. Communications options for getting your needed data can also vary, as well as the price of the sensor, its mounting, wiring, and installation costs.

See through Bin Walls with 3D Scanners

Using a 3D scanner level sensor is like having Superman's x-ray vision. With its dust-penetrating technology, you can actually see the topography of what's inside the bin using the graphical option. The 3D scanner is mounted on top of the bin at an optimal location recommended for superior surface coverage, so the scanner can "see" the utmost material surface. It sends acoustic pulses that sound like chirping crickets to the material surface in a 15°, 30°, or 70° beam angle depending on the model. It then measures and maps the material surface at multiple points to detect uneven topography.

Distance is calculated using advanced algorithms that convert the difference between the timing the echo was sent and received to a distance. Data is sent via 4-20 mA or RS-485 output to software, or if you prefer an HMI/PLC. The included software records the data and calculates level, volume, and mass, whilst creating an optional 3D visual of bin contents. 3D scanners come in a variety of models, which are generally chosen based upon the vessel size, the desired accuracy, the need for 3D visual, and the operation's budget.

The 3D scanner is the only level sensor that measures multiple points on the material surface to account for irregular topography. To your operation, that can convert to precise volume measurement within 1-3 percent of total stored volume. For the grain industry, it offers the added benefit of detecting cone up, cone down, or sidewall buildup. When the MV or MVL models are used, 3D scanners are the only sensors that offer a 3D visual of bin contents. The visual can also be used to indicate where buildup is occurring and alert for the need for bin cleaning or excessive buildup that could lead to structural damage or collapse of the bin.

A key advantage of 3D scanners to operational efficiency is

volume accuracy in very large bins or domes. When bins are over 45 feet in diameter, more than one 3D scanner can be used on a single vessel. For example, three to four 3D scanners will provide very good volume accuracy on a 105-foot diameter bin depending on the bin height. The software takes into account measurements taken by multiple sensors and aggregates it to a single volume and single 3D visual. This can also be very useful in domes or any very large vessel. Multiple 3D scanners can also be used in flat storage warehouses for more accuracy than a single point measurement device, as it scans the material surface to detect irregularities caused by conveying grain into the structure or removing it using loaders.

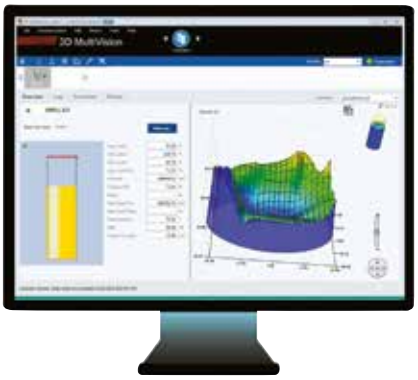
Redundancy is also an insurance of reliability. 3D scanners use three independent frequencies to transmit and receive to ensure accuracy. With self-cleaning transducers, they require minimal maintenance. An optional Teflon-coated sensor can be used if materials such as flours are excessively clingy or sticky. MultiVision software for managing multiple bins is also available for grain operations that have multiple bins or multiple locations where they want to monitor inventory throughout the entire operation.

Precise accuracy comes with a few considerations. The 3D scanner must be installed in the recommended location on the bin roof to obtain the best accuracy results. This may require a new eight-inch opening on the roof for installation. Although sensor installation is fairly routine, it's recommended that a trained technician do the startup and system configuration. This requires a site visit or temporary remote access to your company's network. A 3D scanner will have a slower update rate and tracking speed versus a laser or radar; scanners taking a few minutes versus the others less than a minute.

Avoid installing 3D scanners where there is excessive noise that may interfere with the acoustic technology. They also are not recommended for very narrow bins that have corrugation. If there's excessive internal structure that may interfere with operation, a neck extension or alternative sensor technology will need to be used. Due to its robustness, there is no loop power option.

The new reality of radar

Non-contact radar has become increasingly popular in the grain industry since the recent introduction of 78GHz to 80GHz frequency radar level sensors to the market. Unlike the 26GHz radar, radars using these high frequencies are quite reliable in dust. Their principle of operation is the same, but they are less prone to erratic data or lost signals that were common in older models. They have a 4° versus 10° beam angle for better



precision and a substantial 393 foot measuring range.

Radar works by emitting an electromagnetic pulse through the antenna where the emitted signal is then reflected off the material and received by the antenna as an echo. The frequency of the received signal is different from the emitting frequency with the frequency difference being proportional to the distance and the height of the material being measured. The difference is calculated using special algorithms contained in the sensor's electronics, where the material height is converted and output as a measured value. Or to vastly simplify this explanation, these high frequency radars use the same basis of technology as self-driving cars.

Since high frequency radar works in high dust, it's quite reliable for measuring inventory of just about all types of grain at any stage of processing. It is suitable for corn, soybeans, wheat, rice, oats, barley, sorghum, and rye as well as milled flours that can be excessively dusty.

Since it is powerful across long ranges, it can be used in very tall, narrow bins for single point level measurement at distances of up to almost 400ft. With its 4° beam, it can be used in segmented bins with narrow compartments. It is also proven to work in bins with excessive noise created during filling, extreme dust, or high temperatures. Radar is ideal for bins where precise aiming is needed to avoid internal structure, the flow stream, or sidewall buildup.

It can be mounted over piled material, on dome roofs, or in storage bunkers. In large grain operations, radar is used over conveyors belts to prevent overloading or detect when belts are running empty.

One of the things that grain operators like best about the newest models of non-contact radar is their ability to work in dust. High frequency radar is able to track levels despite excessive dust generated during the filling process. The narrow beam can be targeted to avoid measuring internal structure such as ladders versus the material in the bottom of the bin. The signal is not affected by corrugation, if material is stored in such a vessel. Fast reaction and updating times allow for the tracking of filling or emptying activity. Radar is also versatile enough for use in solids or powders and it offers loop power capability to simplify installation.

The potential downside of non-contact radar is that it measures only a single point, as does laser. Therefore, it is not the recommended instrument when very precise volume accuracy is needed for inventory management. Since it can't detect topography of material such as uneven piling or cone up or down, inventory accuracy will be similar to dropping a tape measure at a single point on the material. In extreme conditions where there's both harsh dust and excessive humidity, an air purge may be required for optimal performance. In that case, between the cost of running compressed air lines and paying for compressed air, preventive maintenance costs can add up quickly.

The lowdown on laser

A laser sensor is mounted on top of the bin using an adjustable 10° mounting flange for aiming the laser to the desired location, generally toward the output of the cone. During configuration, the minimum and maximum distances are set using 4 and 20 inputs configured on the sensor. The sensor sends timed laser pulses to the material surface. The distance to the materials is calculated using complex algorithms that convert the laser pulses to a data output. A compensation for "slant range" is made based upon the angle of the beam to ensure accurate level measurement.

The laser is not always ideal for the grain industry because it is best suited for low or no dust environments. However, because of its very narrow beam, it is a good option for level control in narrow vessels containing solids, so long as it's not used on high dust materials. It can also be used for plugged chute detection or restrictive chutes and hoppers where precise targeting is needed. For materials that don't flow freely, it can be used for monitoring buildup when installed above the monitoring point or directed toward the sidewall.

Some of the advantages of laser are that its adjustable, swiveling mounting flange is flexible up to 10 degrees. This may allow for use of an existing mounting location and eliminate drilling another hole in the bin roof. The laser's extremely narrow beam can be directed to avoid obstructions that could interfere with sensor operation. It is easily configured in the field using a USB port, while configuration can be performed without filling or emptying the vessel. The laser has a fast update rate of eight times per second and also features integrated dust protection for minimal maintenance.

The laser's major disadvantage is that it is not recommended for use in dusty environments. This limits its application in the grain industry. Plus, it only measures a single point in the bin, which could be problematic for materials that don't flow freely or pile unevenly in the bin. It can be subject to interference from falling materials that can temporarily render the readings inaccurate. If used in a bin with any dust, it may need an air purge option to keep lenses free of buildup for reliable performance.

When it comes to non-contact level sensors, one size doesn't fit all. In fact, many grain operations use a combination of sensors – both continuous and point level – to keep their facilities running smoothly. Different size bins, different grains, and different material management objectives will all come into play when selecting the right sensor solution for your grain or milling operation.