PROCESS INSTRUMENTATION

Meeting the Challenges in the Pet Food Industry with Instrumentation

SIEMENS

Introduction

Maintaining regulatory requirements in a rapidly expanding market is challenging for many industries – and few are feeling this more than the pet food industry. Pets are increasingly being treated as family members and emotional support animals are becoming more common. Both factors have contributed to the recent trend of humanizing pets, leading owners to pay more attention to pets' needs and driving pet food customers to be much more demanding. These increased expectations and the implementation of the Food Safety Modernization Act (FSMA) make maintaining product quality and traceability more important than ever for the pet food industry. On top of this, the industry is growing at a pace that has not been seen in many years. With more discerning customers, increased regulations and rapid expansion, precise measurement and control is critical to maintaining traceability and minimizing the risk of product loss in the production of pet food.

Inventory Management

Levels and weights of raw materials and finished products are measured often throughout the manufacturing process. Accuracy is vital for everything from measuring the inventory of silos and controlling the material feed/rate in batching to filling/dispensing of finished products for packaging. Maintaining accuracy can reduce operating cost, boost yield, minimize downtime and increase the percentage of manufacturing time that is truly productive.

Stage one in the production of pet food is to make sure there is an accurate inventory of raw materials that are fed through to the manufacturing supply chain. Reliable accuracy is key to ensuring the process runs smoothly, productively, profitably and safely, with the result being premium product quality and the ability to quickly respond to customer and market demands.

Inconsistent and unreliable measurements at this early stage can lead to delays in delivering materials to the downstream processes, contribute to production shutdowns and lead to material losses, which is critical as the cost of raw materials like soybean, corn and feed grains continue to increase.

Leveraging proven technologies can secure dependable and trustworthy measurements, but equally important is aligning with instrument companies that have a demonstrative pedigree and holistic understanding of the behavior of these materials inside a silo, bin or hopper. This will ensure that the best-fit solution for non-contact level or static weighing is applied.

Operators, plant engineers, production managers, maintenance personnel and plant managers all must trust the reliability of the technologies employed. Instruments are often too easily blamed for discrepancies, erratic measurements and inconsistencies in critical loops, but many times the root cause of the problem is not the equipment but rather the lack of understanding of material properties, their behavior inside a vessel and the vessel type itself. These include the feeder mechanism, aeration system, material flowability issues, silo wall friction, moisture content that can lead to clumping, fluidization, funnel flow conditions and even seasonal impacts, among others.

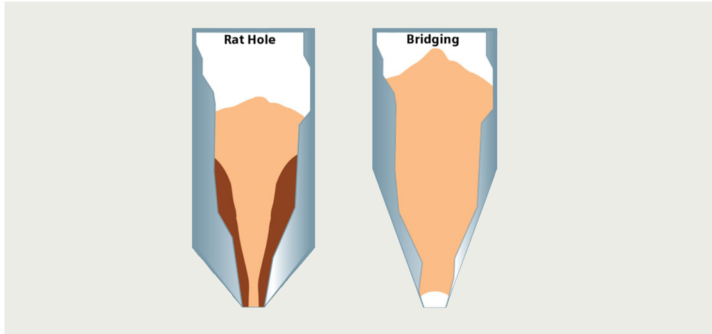

Figure 1- Rat holing and bridging are two material behaviors that can occur in a silo which can adversely affect the performance of a level measurement device.

Recognizing the nuances of how bulk materials behave in silos is a complex subject impacted by influences that can affect a facility in one area of the country but not another. Figure 1 shows some of the conditions that occur in a silo that could affect the performance of a level measurement device. It is imperative that the collective experiences of the end user and instrument supplier are combined when settling on the ideal measurement technology.

Over a decade ago, high-frequency radar was pioneered and developed to open up opportunities for a non-contact measurement of bulk solids in very tall silos (> 100') and in very dusty environments, eliminating the need for reliance on contact type technologies (i.e., mechanical plumb bobs, guided wave radar, capacitance). Such devices always came with the burdens of maintenance headaches, exposure to pull-down forces that might detach the probe, knotting of cables and inherent safety risks associated with maintenance having to climb the silos on a regular basis.

Figure 2 - Modern high frequency radar with Process Intelligence, narrow beam angle, and aiming capability that to provide reliable level measurement in dusty bins with steep angles of repose, obstructions in the silo, and deep bottom cones.

Modern high-frequency radars (such as the one shown in Figure 2) use Process Intelligence, tight beam angle, aiming capability, sensor purging and diagnostics, all of which are key to measuring difficult applications – even with tremendous amounts of dust, steep angles of repose, obstructions in the silo and deep bottom cones.

Free-space, non-contacting radar transmitters provide a measurement from what they see at the top of the surface and are designed to perform well with many types of bulk solids, but if the surface develops too many peaks/valleys, rat holes or channel flows, the signal quality may be challenged and the transmitter may detect a new and sudden level change, which will pose production problems.

When these challenges present themselves – or the desire is to have a mass-based measurement – then a weighing system consisting of load cells, mounting hardware, a digital junction box and electronics module for seamless control system integration should be employed.

Silos can often range to where several hundred tons of material are stored and typically entail the use of compression-type load cells in a three- or four-point weight-bearing configuration. Selection of the requisite load cells requires a calculation of the rated, working and ultimate loads. The environment, silo geometry, overload protection, liftoff protection to limit horizontal movement and EMC protection to help guard against potential damage caused by welding in and around the vessel should all be considered in selecting the appropriate mounting hardware. The price point of analog load cells can still be leveraged for asset management when packaged with a digital junction box and electronics module for integration into any control system environment and asset information for each individual load cell.

Proper calibration of a weight measurement system is paramount to secure an accurate and repeatable measurement. The expectation is for a properly calibrated load cell system on a firm foundation to offer a 0.1% accuracy. Calibration defines the relationship between the load cell output and weight. A calibration is done by establishing two or more points on a line representative of this relationship. Because load cell outputs are linear, the weight for a given load cell output can be determined at any point on that line.

There are three main types of errors that cause inaccurate weighing: calibration errors, linearity errors and repeatability errors.

When there is a calibration error the load cell output to load ratio remains in a straight line as if properly calibrated, but that line is not representative of the actual load cell output to load ratio and the weighing system requires a recalibration.

Linearity is all about the load cell's ability to maintain consistency as the load is applied. When there is a linearity error, a load cell will measure correctly at no load and full load capacity but there will be an error in between (either higher or lower than the actual weight).

Repeatability is a load cell's ability to repeat the same reading when the same weight is applied. It reflects the maximum difference between readings and is expressed as a percentage of the applied load.

It is imperative to understand the characteristics of the material while stored in a silo in order to determine whether a non-contact radar level transmitter or load cell package is the ideal choice. It is equally important to align with an instrument manufacturer who has a complete portfolio of solids measurement packages – including inventory, weighing, conveyance and feeding – when addressing critical raw material inventories.

Blending Measurement Methods

Blending different components in the pet food process is usually done using weight. This may be done either in a batch or in continuous process. In batch blending process the flow of material is stopped when the desired amount of material is added to the mix. A continuous blending process, material is blended without interruption to the material flow. The type of blending used will often depend on the process. For example, in the blending of the ingredients to make kibble, the ingredients are stored in the ingredient bins, from there they are moved to a mixing bin where the material flow will be stopped so the ingredients can be mixed. Because the process stops for mixing this is most often done in a batch blending process. On the other hand, after the kibble has been cooked and extruded, nutrients will be sprayed on. Because this part of the process is fed by the extruders and the extrusion is a continuous process, the spraying of additives will often be done in a continuous blending process.

Batch Blending

Batch blending processes can be set up two ways. In some cases, the mixing bin will be installed on load cells, similar to the load cell shown in Figure 3, so the amount of material in the mixing bin is weighed as material is added to it. The weight of the mixing bin is monitored as each component is added, and when the material weight approaches the desired setpoint, the fill rate will be reduced by switching to a slower nozzle or fill stream. This type of batching system is sometimes referred to as a "gain in weight" system. Another batch blending process operates in a similar fashion, but instead of using load cells on the mixing bin, they are used on each ingredient bin. Liquid ingredients can be measured in the same way as the solid components or by using a liquid Coriolis mass flow meter as shown in Figure 4. The amount of material drawn from each ingredient bin is monitored and the transfer of material is stopped when the setpoint is reached. This type of batching system is sometimes referred to as a "loss in weight" system.

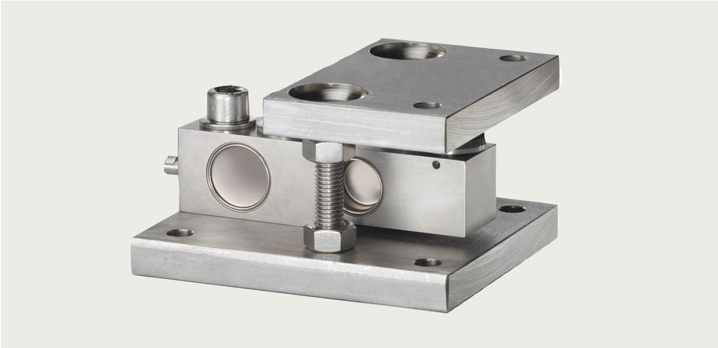

Figure 3 – A load cell that could be used in a batching system to determine how much material has been added to a mixing bin.

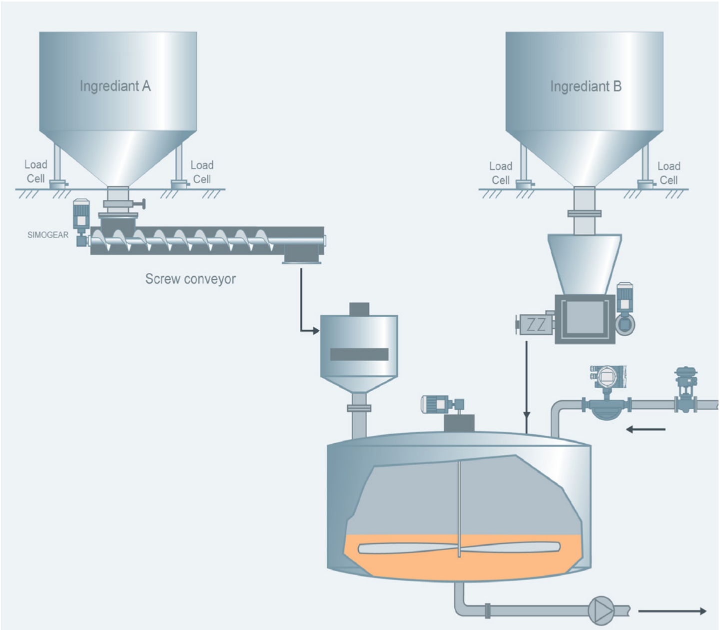

Figure 4 – A typical batch blending systems with 2 solids components and 1 liquid component. The solids components are measured using load cells and the liquid component is measured using a Coriolis mass flow meter.

Modern weighing electronics can monitor the weight in the bin and provide outputs to reduce the rate of material transfer as the setpoint is approached. The weighing electronics will then send a signal to stop the transfer of material when the setpoint is reached. In addition to being able to signal a switch in fill streams, they also have the ability to monitor the accuracy of each component of the blend and adjust the next batch to compensate for any errors caused by material in the stream between the mixing bin and the ingredient bins. For example, if the proper amount of material required for the blend is 2000 pounds, when the weighing system determines 2000 pounds has been transferred, the material flow is stopped. Because there will still be material between the point the material is stopped and the mixing bin, the weight will go up slightly after the material flow is stopped. If there were 2 pounds of material left in the fill stream, the final amount would stabilize at 2002 pounds so on the next batch the material flow would be turned off at 1998 pounds to compensate for the material in the fill stream.

Because this process is critical for quality control and to maintain FSMA standards, the health of each load cell should be monitored to be certain the weighing system is operating properly. Most modern weighing electronics can monitor the health of the load cells in a weighing system; however, on multiple load cell systems the load cell signals are summed in the field and brought back to the weighing electronics as a single signal, so determining which load cell in the system requires attention may not be possible from the weighing electronics. To allow full diagnostics to each individual load cell in the system, the load cell signal is digitized in the field and the information from each cell is sent to the scale electronics. Traditionally this has been achieved using digital load cells, but because digital load cells can be costly, load cell manufacturers have recently developed field-mounted digital junction boxes to convert the analog signal from the load cell to a digital signal – allowing full diagnostics of each individual load cell without the need for a digital load cell.

Continuous Blending

In a continuous blending system, the flow of two or more streams of material will be brought together in the correct proportions. Each component is measured, and the measurement of the primary component will be used to control the flow of the other components. In solids blending applications, the material is measured using continuous weighing instruments, for example a belt scale, shown in Figure 5, or a solids flow meter. If the flow rate needs to be measured and controlled, a machine such as a weigh belt feeder can be used; a belt scale or solids flow meter could also be utilized in conjunction with a separate feeding device like a rotary feeder or screw feeder. For liquid materials, a mass liquid flow meter such as a Coriolis meter is used to measure the flow rate.

Figure 5 – Belt scales measure solid bulk material as it is transported by conveyor belt. Belt scales that use parallelogram load cells remove horizontal forces without the need for pivots allowing easier installation.

For example, in a pet food factory, where additives are added to the kibble after being cooked, the kibble will go into a mixing drum where the liquid additives are sprayed in. To determine the proper rate the additive should be sprayed into the mixing drum, the amount of kibble is measured as it is transferred using a continuous scale. The speed of the additive pump will increase as the transfer rate of the kibble increases and decrease as the rate decreases. The rate the additive is being added is measured by a liquid mass flow meter to provide feedback to the control loop.

In a continuous blending process, conveyor belt scales and weigh belt feeders will typically provide the highest accuracy for solids measurement. However, if the material is not easily contained on a conveyor, such as fine powders, a solids flow meter may be the better option.

Belt scales can achieve accuracies of 0.25% and better. To achieve high accuracy, the conveyor belt scale must be designed to remove the horizontal forces on the scale created as the conveyor belt is pulled across the scale. Some belt scale manufacturers assume these forces will average out over time. While this is true to some extent, to achieve the highest possible accuracy, these forces must be mechanically removed in the scale design. Some manufacturers will use a system of pivots and levers to remove these horizontal forces, while others will use parallelogram load cells, such as the one shown in Figure 6. Both methods are very effective at removing these unwanted forces. Conveyor belt scale designs that use the parallelogram load cell eliminate the need for the pivot and lever system, allowing for easier installation with less maintenance.

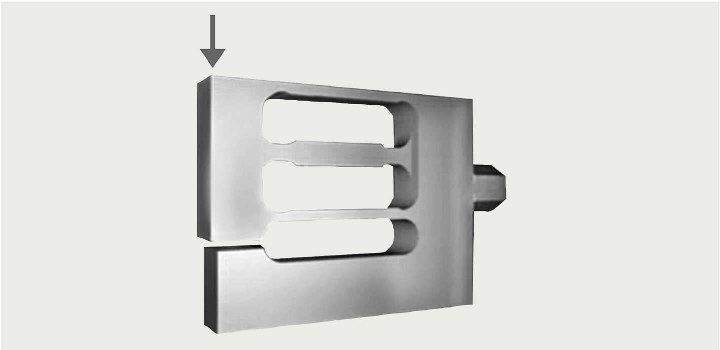

Figure 6 - Parallelogram-style load cell for use in a conveyor belt scale converts the downward force of the load acting on it into an electrical signal. The weight on the load cell is measured by the voltage changes caused by the strain gauges when it undergoes deformation of less than a millimeter.

Conclusion

Whether for inventory or blending control, there are multiple technologies available for process measurements. In most cases, weight measurement will provide the highest accuracy, but other technologies can, in some instances, meet the accuracy requirements with lower installation costs. Be sure to consider the material being measured, the required accuracy and the type of blending process to ensure you select the measurement device best suited for your application.

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Chuck DiLullo is currently a Technical Instrumentation Consultant for Siemens Industry. In his current role he is responsible for working with end users, design firms, OEM's and our Channel Partners on application support, process vetting and industry analysis to secure the proper instrumentation is employed. He has been involved in process instrumentation for over 30 years in technical and application support.

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