Automating Your Weigh Batching System

Reductions in dust, lower costs and improved measurement accuracy for your ingredients are just some of the advantages

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In many plants that batch-blend bulk products, weigh batching is a manual, time-consuming operation in which ingredients are weighed individually before being discharged to a blender or some other process vessel. A significant number of such plants could benefit from the installation of an automated weigh-batching system.

For small as well as large operations, an automated weigh-batching system can pay for itself fairly rapidly through increased productivity, increased accuracy for the measurement of ingredients (resulting in better product quality and lower feedstock costs), minimization of product losses and dust, and reductions in the cost of materials now purchasable in larger containers or volumes.

One of the strongest cases for an automated weigh-batching system is that it improves product quality by providing a more accurate and consistent mixture. In many plants that use manual methods, a common practice is to work with pre-weighed bags — for example, dumping ten 50-lb (22.7 kg) bags of 300 lb (227 kg) of an ingredient. Problems associated with this method are that each bag may not contain exactly 50 lb of material, and that the worker may not empty the bag completely. Inaccuracies are compounded as more bags are used. Additionally, if an operator is required to manually count bags in order to achieve the proper weight, yet another chance for human error is present.

**Gain-in-weight vs. loss-of-weight**

There are two automated weigh-batching methods: Gain-in-weight and loss-of-weight. In the first arrangement, batch ingredients are generally conveyed in sequence into a hopper located above a process vessel, typically a blender or storage vessel. The hopper is set on load cells that transmit weight-gain data to a programmable logic controller (PLC) that starts the conveyor for each ingredient and then stops it when the preset weight for that ingredient is reached. Finally, the controller automatically charges the batch to the process vessel. In a loss-of-weight system, the source of each ingredient (such as, a bulk bag unloader or preloaded hopper) is mounted on load cells that transmit weight-loss data to a controller that starts and stops each conveyor (or rotary airlock valve) to weigh each ingredient.

Determining the most suitable weigh-batching method can depend on how and where bulk material is received and stored. If, for example, the material is delivered in rail cars or bulk trucks for storage in silos — which are impractical to mount on the load cells required of loss-of-weight systems — a gain-in-weight system would be more appropriate. Conversely, if the material is received in bulk bags, a loss-of-weight system integrating bulk bag unloaders mounted on load cells may offer the simplest solution.

**Accounting for material-in-flight.**

When operating in a gain-in-weight mode, an additional variable that must be accounted for in the design of the system is the "material-in-flight,"
which is defined as the amount of material still on its way to the scale after the batch controller has deactivated the material-feed device. Although the material-in-flight variable can be minimized by proper control sequencing, it is important to be aware of this source of potential inaccuracy. In general, greater volumes of material-in-flight and greater variations in material flow to the batch scale will result in higher potential for inaccuracies.

For example, if a mechanical conveyor (Figure 1) is discharging by gravity directly into a gain-in-weight hopper, the amount of material-in-flight will be proportional to the vertical distance from the conveyor discharge to the gain-in-weight hopper. If the discharge of the mechanical conveyor is immediately above the top of the gain-in-weight hopper, there will be little material-in-flight. Hence, even if there is a good deal of variation in the flow rate, which can be caused by a poorly flowing material being inconsistently introduced to the mechanical conveyor, the material-in-flight will be relatively constant from batch to batch. Since a constant amount of material-in-flight is predictable, it is easily compensated for by the weigh-batch controller by stopping the feed device at a point prior to actually achieving the desired batch weight.

An example of a gain-in-weight system with a significant amount of material-in-flight would be a relatively long pneumatic conveyor with a rotary valve functioning as the material feed device. In this case, when the rotary valve at the material-in-feed point is stopped by the batch controller, the pneumatic conveying line will be full of material that is already in the process of being conveyed to the scale. Although trial-and-error tests can approximate how much sooner the conveyors should be stopped to compensate, the increased volume of material-in-flight can result in a higher degree of variability from batch to batch. In this situation, it may be prudent to utilize alternate modes of operation, or a different equipment configuration, such as using a scale valve.

A scale valve is a type of diverter valve mounted in a pneumatic conveying line that passes above a gain-in-weight hopper. It allows material to either pass through the valve body or, directs material downward into the gain-in-weight hopper below. When the target weight is reached, the valve redirects any remaining material in the conveying line past the scale, eliminating or minimizing the aforementioned problem of excessive material-in-flight.

Because the material continuing downstream ("carry-over") must be accumulated, and air vented from the system, the pneumatic line downstream of the scale valve is normally routed back toward the material source (such as a bulk bag unloader) into a filter receiver with a rotary airlock valve that reintroduces the material into the pneumatic line immediately downstream of the material source.

If the material-in-flight is to be reused in the process, a separate filter receiver is needed for each batch ingredient. Accordingly, scale valves are generally suited for the weigh batching of only one or two ingredients having single or multiple destinations, particularly if headroom above the gain-in-weight hopper(s) or process equipment is limited.

Scale valves are unsuitable and unnecessary for loss-of-weight systems because the rotary valve feeding material into a conveyor line stops immediately upon losing the predetermined batch weight, after which all of the material residing in the conveying line is transported to the process vessel, eliminating material-in-flight variables.

**Accounting for load cell position.**

An added advantage of a loss-of-weight system involving two or more ingredients is increased batching speed, since all ingredients can be weighed simultaneously, as opposed to sequentially as required by gain-in-weight systems that employ a single load cell holding a receiving hopper or process vessel.

A potential downside of loss-of-weight systems is that load cells will often be located at floor level, making them more susceptible to damage or more likely to require frequent calibration due to potential impact from mobile plant equipment, such as pallet jacks or forklifts. A gain-in-weight system employing a weigh hopper suspended above the floor can virtually eliminate this possibility.

Since gain-in-weight systems employing weigh hoppers accumulate the ingredients above the use point, it is possible to check weigh the batch before it enters the process vessel. This allows an operator to adjust a batch that is outside of allowable tolerances prior to discharging material downstream — not so with loss-of-weight systems that generally discharge each ingredient directly into the process vessel, or gain-in-weight systems that weigh their batches with a process vessel on a load cell. An out-of-specification ingredient in the latter situations can poten-
tially ruin the entire batch without the possibility of correction.

In cases where space is limited, however, a weigh hopper in a gain-in-weight system may not be feasible.

**Summary considerations.** As a general rule, loss-of-weight systems are more suitable for weighing a smaller number of large-volume ingredients being sourced from nearby or distant process vessels. This is because mounting separate pieces of equipment on load cells for every source ingredient increases cost, and the heavy-duty load cells capable of supporting equipment and large volumes of source material cannot weigh small volumes of batch ingredients with a high degree of accuracy. In addition, source distance from the process vessel is of no consequence as weighing an amount of material at its source will not be affected by material-in-flight.

Gain-in-weight systems are preferable for weighing a larger number of smaller-volume ingredients using mechanical conveyors or pneumatic conveying systems with relatively short runs from the material source to the batching destination for various reasons. For all cases, costs are minimized since only one set of load cells is required for an entire gain-in-weight system. In instances where gain-in-weight systems use receiving hoppers on load cells as the central weigh point, accuracy is higher than loss-of-weight systems using heavy equipment to weigh source material.

Lastly, utilizing a weigh hopper above the mixer in a blending operation can save time by allowing a batch to be weighed while the mixer runs so that a batch is staged and immediately ready to be blended at the completion of the blending cycle.

With either system, pre-weighed minor ingredients can be added by hand to the process vessel receiving the weighed batch, and in the case of a gain-in-weight system, into the weigh hopper. As noted earlier, it is safer for “hand adds” to weigh the material before it is added than to rely on the stated weight of material received in sacks or other containers.

**Loss-of-weight operation.** A typical loss-of-weight batching system conveys bulk materials mechanically or pneumatically from any location to a central receiving vessel that is mounted on load cells (Figure 2). The receiving vessel can be a hopper positioned above a blender, reactor or other process equipment, or it can be the equipment itself as noted earlier.

When the batch sequence is initiated by a manual start button or automatic signal, a programmable controller activates the first mechanical conveyor or rotary airlock valve to begin loading the first ingredient into the receiving vessel at maximum feedrate.

Load cells transmit weight-gain information to the controller, which steps the feedrate to a dribble prior to reaching the target weight, for greater accuracy. The controller stops the mechanical conveyor or rotary airlock valve at a pre-set amount before the target weight is reached to compensate for material-in-flight.

**Loss-of-weight operation.** A typical loss-of-weight batching system consists of at least one bulk bag unloader mounted on load cells, which measure weight loss during the batching cycle and transmit the information to a system controller (Figure 3).

The batch sequence is initiated by a manual start button or automated signal. As the conveyor unloads material at the maximum feedrate, load cells transmit loss-of-weight information to the controller, which reduces the feedrate to a dribble immediately prior to stopping the flexible screw conveyor or rotary airlock valve once the target batch weight has been discharged. System software should be configured to permit mid-batch bag changes.

Multiple weigh-batch dischargers can each convey a different ingredient to a central discharge point such as a hopper, blender, reactor or other process equipment.

**Material flow and accuracy.** Non-free-flowing bulk materials that pack, cake or bridge can cause weigh batching inaccuracies unless material flow can be induced by the equipment unloading, transporting and weighing the material.

When gain-in-weight hoppers are employed, for example, they must be designed so that 100% of the weighed batch can be discharged with no residual. To this end, proper hopper wall angles, along with vibration or air fluidization, are often employed to promote flow and evacuation of non-free-flowing batch materials.

Maintaining flow of materials received in bulk bags can present the greatest challenge because shipping and storing of the bags often causes the material to pack, or worse, completely solidify — a common problem with certain fine powders, hygroscopic...
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chemicals and food products. To promote flow, bulk bag unloading equipment can be fitted with pneumatically actuated plates that massage opposite bottom edges of the bag and push material into the bag spout. Additionally, devices that maintain constant downward tension on the spout as it empties and elongates, serve to promote complete discharge from the bag with no manual intervention.

For materials that have solidified in bulk bags, a more extreme flow promotion measure in the form of a "bulk bag conditioner" is required. These devices either stand alone or integrated with bulk bag unloading frames, use hydraulic rams with contoured end plates that press opposite sides of the bag with high pressure at various heights, loosening the material.

Integration considerations

An automated weigh-batching system is often integrated with the plant's bulk handling system, and generally incorporates pneumatic or mechanical conveyors or both. All upstream and downstream equipment, from receiving to processing and packaging, can be sealed to eliminate contamination of the product and plant environment.

The entire operation can also be automatically controlled, using various control systems. One option is to use a scale interface card to link up with an existing plant-wide PLC system; a second is to use a stand-alone PLC; and a third is to employ a sequential batch controller. The latter is a programmable device that will run the entire equipment associated with the weigh batching system and store the product recipes. It can operate in stand-alone mode or be integrated with the plant PLC to varying degrees.

Considerations for selecting a conveying system are many, and the subject of a different article, but the requirements presented by the weigh batching system can influence or dictate the selection of a conveying system. Conversely, a conveying system preference, or an existing bulk handling system, may govern the choice of a weigh batching system.

Generally, mechanical conveyors are suitable for transporting both free- and non-free-flowing materials over relatively short distances, and are suitable for both loss-of-weight and gain-in-weight batching systems.

Since most mechanical conveyors cannot fully evacuate their contents, however, a loss-of-weight unloader equipped with a mechanical conveyor must account for the weight of the conveyor and its residual material in order to weigh only the amount of material the conveyor has lost. This is generally accomplished by supporting the conveyor from the frame of the loss-of-weight unloader, but as the lengths of mechanical conveyors increase, so does the difficulty of weighing the unloader-conveyor as one.

No such constraint exists with mechanical conveyors that are integrated with gain-in-weight batching systems. In this case, the discharge end of conveyors can be suspended from a ceiling joist or other overhead structure, over a weigh hopper or a process vessel.

A pneumatic gain-in-weight system, on the other hand, requires a filter receiver above the process vessel and the overhead space to accommodate it. As conveying-line lengths increase, however, so does the amount of material-in-flight that must be dealt with in order to maximize system accuracy.

Installation examples

The following two examples of actual installations illustrate how an automated weigh-batching system can be configured and the benefits that can be realized.

Case 1. A food company boosted margarine production by 50% and improved product quality by switching from a manual operation to an automated materials-handling system that includes weigh batching. The system is used to check weigh salt and whey powder, which are then mixed with canola oil to make margarine.

Previously, the company received the ingredients in 33- and 44-lb (15- and 20-kg) bags, which were manually dumped into a pre-mixer on an open processing floor. The plant had to dispose of 100 bags per day, spoilage occurred, and there were occasional inaccuracies in the quantities of ingredients added to the mixer.

In the new arrangement, salt and whey powder are received in 2,206-lb (1,000-kg)/bulk bags, which are loaded into two bulk-bag dischargers. A loss-of-weight system unloads pre-selected-batch weights from each discharger into 8-ft³ (0.22 m³) stainless-steel hoppers, from which a flexible-screw conveyor moves the material to the mixer (Figure 4).

The entire operation is controlled from the plant's central computer, thus minimizing the chance of human error. Also, the salt and whey powder remain enclosed from bulk bag to mixing tank, thereby avoiding the possibility of contamination while also eliminating fugitive dust.

Case 2. A manufacturer of isotopic chemicals installed a gain-in-weight system for a process that involves mixing five fine powders in batch weights ranging from less than 20 lb (9 kg) to nearly 400 lb (181 kg). The system meets the company's strict accuracy
requirement of ±1.00% over this broad range of ingredient weights.

Two of the ingredients go directly to a wet blender. The other three are routed first to a dry blender for mixing, then on to the wet blender.

Four of the products are received in bulk bags, which are unloaded from bulk bag dischargers. The fifth, minor ingredient is received in 50-lb bags, which are manually unloaded into a bag dump station. All five ingredients are transferred sequentially into a single weigh hopper by five flexible screw conveyors, each of which is engineered according to the flow characteristics of the powder it handles.

Load cells under the hopper transmit weight-gain information to a controller that starts and stops each conveyor, slowing the feed rate to a dribble as the weight approaches the target in order to meet the high accuracy requirements.

Ingredients are discharged from the hopper through a slide gate valve into a wye diverter that directs them to either the wet or the dry blender.

Conclusion

A weigh-batching system should be engineered according to the number, volume, flowability and location of materials to be weighed, the respective strengths of loss-of-weight and gain-in-weight batching methods, and the new or existing conveyors, control systems and processes with which it will be integrated. The availability of numerous weigh-batching components and many ways in which they can be configured, enable the plant engineer to design a system that functions reliably, improves product quality and boosts output while cutting cost.

Edited by Matthew Phelan

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