CONSIDERATIONS WHEN ADDING A CONVEYING SYSTEM TO BATCHING OPERATIONS

This article will look at some of the challenges faced when incorporating a conveying system into a batching process.

Larry Eagan, Magnum Systems

Many bulk solids manufacturers need to weigh material batches for processing. For a smaller company’s initial processing venture, this might begin as simply as hand dumping preweighed bags of material, by gravity, into a mixer. As batch size and frequency begin to increase, however, this can make raw material delivery more cumbersome, especially while trying to maintain quality control standards for the accuracy of various ingredients. One of the ways to address bulk solids delivery for larger and more frequent batches — and to make the process easier — is to incorporate conveying systems into the process. In this article, we’ll look at some of the factors to consider when doing so.

Let’s start with some general definitions:

**Gain-in-weight feeding.** This is a method of batching materials by placing a receiving vessel on load cells or a scale and feeding materials one at a time into the vessel. The feeding devices are usually volumetric in nature. Advantages of this type of system typically are lower costs since only one scale or set of load cells is required. Disadvantages include longer batch completion times since ingredients are fed one at a time. Also, volumetrically fed materials can become segregated or stratified into layers when going into the mixer.

**Loss-in-weight feeding.** This is the opposite of gain-in-weight feeding. In this method, materials are reverse-weighed out of individual ingredient-receiving vessels. The vessels are charged with more material than required and discharged down to the batch weight needed. Advantages of this system type typically are faster batching rates for multiple ingredients because several ingredients can be discharged at once. Materials also can be comingled during filling, which helps reduce mixing times. Disadvantages can be the added costs of purchasing and maintaining multiple sets of load cells or scales.

**Pressure conveying systems.** These are pneumatic conveying systems in which positive pressure is used to convey material from point A to point B. As a general rule, positive pressure systems are more efficient than vacuum conveying systems because pressure systems can operate at higher absolute differential pressure in a given line size. Pressure systems also tend to work better when conveying from a single pickup point to multiple destinations. (Example: Material from a single silo being conveyed to hoppers above three different mixers.) Pressure conveying systems, while often requiring more vertical space at the material inlet or pickup point, usually require less vertical space than vacuum systems at the material destination points.

**Vacuum conveying systems.** These are pneumatic conveying systems in which negative pressure is used to convey material from point A to point B. As a general rule, negative pressure systems are better at dust containment in the event of a hole or leak than positive pressure systems as fugitive gas leaks into the system but not out of it. Negative pressure systems also lend themselves better when conveying from a single pickup point to a single destination. (Example: A single mixer pulling three different ingredients from different bulk bag unloaders.) Vacuum conveying systems, while requiring less height at the material inlet or pickup point, usually require more vertical space at the destination than pressure systems.

**Ask questions to design the best system**

To combine these elements into the most cost-efficient and effective system requires a detailed examination and thorough understanding of your process. The following questions can help reveal potential challenges and difficulties you might face along the way.
How are my ingredients classified? Ingredients going into a batch mix often need to be added in disproportionate or unequal amounts. One given batch might require thousands of pounds of one or two ingredients, but only 200 pounds of another and maybe only 10 pounds of another. For classification purposes, ingredients are usually segmented into major, minor, and micro-ingredient categories. There are no hard and fast rules for what makes up these classifications, and they’re usually relative to each other based on the customer’s process. Raw ingredient delivery, however, will differ and the classification can help better determine how the ingredients are or should be handled and conveyed with major ingredients usually arriving in rail cars or trucks, minor ingredients in bulk bags, and micro ingredients in small (nominal 50-pound) bags.

How much time is available? The most common application for weighing and batching is filling a mixer. When starting the process, it’s important to understand what is meant by mixing time. Mixers typically are quoted based on a volumetric capacity to be completed in a certain amount of time. This time is usually divided into three parts — fill time, mix time, and discharge time.

For example, a mixer may be designed to produce four 100-cubic-foot batches per hour, processing material that weighs 50 pounds per cubic foot, for a total of 20,000 pounds per hour. The batch time for the process in our example could include 5 minutes for filling, 5 minutes for mixing, and 5 minutes for discharge. The material handling capabilities for this mixer and the conveyor filling it would look markedly different from the same system designed for 1.5 minutes of filling, 12 minutes of mixing, and 1.5 minutes of discharge time. The amount of time available for batch delivery will factor into whether material can be fed directly into the mixer or whether the material must be conveyed and batched into another vessel and pre-weighed, then rapidly introduced into the mixer.

What rate of accuracy is required? It’s important to consider the required accuracy expectations for a batch. This information is often given as a percentage but also is important to understand in relation to the size of the weighment. For instance, if you have a ±5 percent accuracy requirement for a 1-pound weighment, that’s 0.05 pounds. Another application could require a 1 percent target accuracy on a 10,000-pound batch. That amounts to ±100 pounds. The required level of accuracy combined with the rate at which it must be delivered will affect the type and size of metering device that can be used.

How much headroom and footprint space is available? It’s important to know how much room is available above the device to be filled with the conveyed material. In our previously mentioned examples, the customer needing to fill 5,000 pounds of material in 5 minutes would need to fill 1,000 pounds per minute. That same size batch to be filled in 1.5 minutes would need to be filled at 3,333 pounds per minute. These scenarios may not be practical. However, if a 100-cubic-foot batching tank could be located directly above the mixer and refilled while the mixer is mixing and discharging, the batching hopper refill rates could be reduced to 500 pounds per minute or even 370 pounds per minute. This would make the conveying system much smaller but would only work if there’s enough room above the mixer to place a surge hopper.

A system’s available footprint also is important. In our example, a mixer that needs a fill rate of 1,000 pounds per minute would require a relatively large feeder when being fed by only one device at a time. Four loss-in-weight feeders feeding simultaneously, however, could be sized for 250 pounds-per-minute each to achieve the combined weight requirement. Then again, if the mix has 10 ingredients, trying to fit 10 loss-in-weight feeders above a mixer may not even be possible — even if the extra capital investment is possible. As the number of ingredients increases, managing and fitting all system components into an existing space becomes more expensive and complex.

A few more considerations

Once there’s a full understanding of the parameters — number of ingredients, density, feedrate, batch size, required time and accuracy, floor space availability — you can consider other equipment that will help meet processing expectations.

The pneumatic conveying of batches, which typically involves relatively large batches, can incorporate one of four different device types as the feed control to start and stop material flow. Each of these devices has advantages and disadvantages for given applications. See Figure 1, which outlines the four main feeder types, their primary use, and their advantages.

Other items to understand and recognize include: Inherent load cell or scale inaccuracies. Load cells and scales all come with a certain degree of percent variance. These usually are relatively minor (usually less than 0.01 percent) when compared to the other factors listed here, but these variances shouldn’t be ignored when determining total accuracy, especially in situations requiring a high level of accuracy. These factors can be explained in more detail by the device.
manufacturers but can include considerations such as nonlinearity, hysteresis, nonrepeatability, and creep.

**Weather conditions on load cells and electronics.** Environmental factors can play tricks with weighing and batching in pneumatic conveying systems. This is especially true in outdoor installations and in cold weather locations without conditioned environments. Silos are especially problematic with load cells for a variety of reasons. These can include wind loadings on the vessel, snow loadings on the vessel, and heat and/or sunlight on a metal silo or bin, which can cause expansion over time. In addition, just as with computers and cell phones, cold weather often can affect a scale’s electronics. Similar to your cell phone or laptop, which may not work after being exposed to freezing temperatures for long time periods, circuit boards inside of scales may react the same way.

**Installation of equipment.** It’s also important to remember when installing equipment to be sure that storage bins, hoppers, receivers, pressure vessels, and other vessels to be weighed all are kept isolated from outside forces. A common mistake in our industry is to have a pneumatic conveying line piped directly to a work bin or filter-receiver on load cells. Without flexible connections, such as small pieces of hose near the inlet and flex sleeves on the discharge valve, the vessel can receive unwanted outside support, which can distort the weighment. This is akin to standing on a scale with one foot while the other remains on the ground. Flex is also important in isolating vibration. If a bin or feeder is installed on a lose mezzanine or structure that’s exposed to vibration from other rotational equipment or ancillary flow aids, that vibration could impact the weighments. Finally, if a bin that’s being filled is under pressure (or vacuum) from a conveying system, and the vessel becomes pressurized versus remaining at ambient pressure, returning that vessel’s pressure as close as possible to ambient — or accounting for the difference — is important when determining the impact of the system’s pressure down or lift.

In summary, a multitude of factors can determine the best orientation and equipment layout to use in conjunction with a pneumatic conveying system when trying to weigh and batch materials. Understanding expectations such as fit within the plant, layout, speed, and accuracy will help to determine the most cost-effective and efficient design. Working with an experienced application engineer to plan a layout for fit and function can provide assistance in optimizing your process. PBE

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**FIGURE 1**

Conveying system batch feeding devices

<table>
<thead>
<tr>
<th></th>
<th>Slide or knife gate</th>
<th>Rotary valve</th>
<th>Vibratory or belt feeder</th>
<th>Screw feeder</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bulk/dribble</strong></td>
<td>Multi-position actuator</td>
<td>Variable-frequency drive</td>
<td>Variable-frequency drive</td>
<td>Variable-frequency drive</td>
</tr>
<tr>
<td><strong>Advantage</strong></td>
<td>Low profile, low cost</td>
<td>Low cost, can be pressurized</td>
<td>Relatively high control &amp; accuracy at relatively low cost</td>
<td>High accuracy, built-in agitation</td>
</tr>
<tr>
<td><strong>Disadvantage</strong></td>
<td>Lower accuracy, can’t be pressurized when open</td>
<td>Lower accuracy, no built-in agitation</td>
<td>Secondary device with limited built-in agitation available</td>
<td>Secondary device with higher relative cost</td>
</tr>
<tr>
<td><strong>Primary use</strong></td>
<td>Low-profile situations in gravity service with lower degrees of accuracy or large batch sizes</td>
<td>Differential pressure applications with lower degrees of accuracy or large batch sizes</td>
<td>Smaller batch sizes with high degrees of accuracy feeding granular or irregularly shaped larger particles. Vibratory for free flow; belt-fed for sticky materials</td>
<td>Smaller batch sizes with high degrees of accuracy; powders and/or difficult-to-flow materials</td>
</tr>
</tbody>
</table>
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Magnum Systems
Parsons, KS
800-748-7000
www.magnumsystems.com