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More Questions and Answers

Q: How can I improve the accuracy of my loss-in-weight feeder for pharmaceutical operations?

A: Sharon Nowak, Coperion K-Tron USA, says:

Loss-in-weight (LIW) or gravimetric feeders are devices that directly measure a material's weight to achieve and maintain a target feed rate, which is measured in units of weight per time, such as pounds per hour. This article outlines several key areas where you can optimize the performance of a feeder for your batch or continuous process.

An LIW feeder for the pharmaceutical industry comprises 1) a hopper; 2) a refill device; 3) a weight-sensing device, which typically is either a digital or an analog load cell; 4) a feeder, which typically is a volumetric screw feeder powered by a variable-speed motor; and 5) a controller. An operator sets the controller to discharge material at the desired feed rate or *setpoint*.

Pharmaceutical manufacturers use LIW feeders for a number of unit operations, including continuous extrusion (photo), milling and micronization, batching into mixers or reactors, and continuous operations, such as blending, coating, and granulation. They use the feeders to batch either preblends or individual components of a formulation into a process, including APIs and excipients, many of which don't flow freely. The accuracy of the LIW feeder greatly affects the outcome of the process, as discussed below.

A pharmaceutical feeder mounted on an extruder

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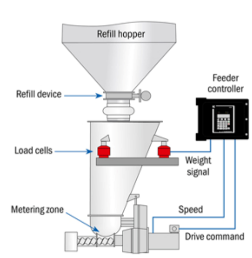
For example, in the case of continuous direct compression, the second-to-second accuracy of each component of the feeder can be critical to the uniformity of the final blend.

LIW feeding

As shown in Figure 1, an LIW feeder discharges bulk material from its hopper at a constant weight loss per unit of time. By weighing the hopper with the material, you can determine the actual weight loss, and by regulating the speed of the feeding device, you can control the flow to make the rate conform to the desired one. A control system compensates for nonuniform material flow characteristics and variations in bulk density, thereby providing a high degree of feeding accuracy. LIW feeding is most accurate when you use a high-resolution, fast responding, weighing system that is immune to vibrations and temperature changes.

Figure 1
LIW feeding principle



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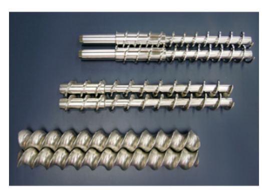
Optimizing performance
You must also consider a number of additional influences on feeder performance to design an optimal system. For screw feeders, accuracy is highly dependent on screw fill. To optimize screw fill, you must analyze your process requirements, your material's characteristics, and the required feed rates. To determine whether a feeder meets those requirements, you should consider: 1) the type of feeder to use—single or twin screw, 2) the type of screw to use, 3) the use of coatings on the screws, tubes, and/or hoppers, 4) the use of flow-aid devices, 5) weight balancing and isolating the feeder from vibrations, and 6) pressure compensation.

Single- or twin-screw feeder. Many pharmaceutical powders are cohesive, and to address that issue, select the feeder's components and design options properly. Using a single-screw feeder with a cohesive material, for example, could fling the material from the screw flights onto the screw's outlet tube, where it can stick. As the material accumulates, that buildup can cause fluctuations in output, decreasing the material's consistency. In that case, a co-rotating twin-screw design is the better choice. Twin screws have a self-wiping effect that not only helps to transport the material but also minimizes or eliminates the buildup in the outlet tube.

Type of screw. Screws are available in several designs, varying in flight pitch and depth (photo), and which you select depends on the type of material you're feeding.

For example, if the powder is cohesive, twin screws with a finer pitch could create an extrusion or squeezing effect, thus releasing moisture and causing additional material buildup. In that case, a screw configuration with a larger spacing on screw flights, such as an auger type, might be the better choice.

Examples of twin screw designs, including two spiral designs and coarse concave design



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Coatings. In some cases, adding nonstick coatings to the feeder's components in contact with the material will improve flow. These FDA-approved coatings are often extremely efficient when dealing with material that doesn't flow freely. The coatings can also minimize the effects of electrostatics, which are often a problem with micronized materials.

Flow-aid devices. Flow-aid devices in or on a feeder's hopper ensure that the material flows into the feeding device as uniformly as possible. The more stable or uniform the material flow, the easier it is for the weighing and control systems to optimize performance.

Types of flow aids include:

- **Flexible sidewalls that gently agitate materials.** Because they don't have stainless steel surfaces, they may wear and lead to contamination.
- **Mechanical hopper agitators that stir the material.** These break down bridges and ratholes in the material. Note: These devices require additional headroom for the feeder and may be difficult to clean.
- **LIW integral vibration technologies that apply vibration to the hopper, such as my company's Actiflow system (photo).** The Actiflow is unique because it ties a vibration

A pharmaceutical LIW feeder equipped with integral vibration technology (Actiflow)

device directly into the mass flow signal. It uses an external drive with variable frequency and amplitude that is based on the weighing and control systems' detection of nonuniform material flow by weight. The vibration device works with the feeder's controller to respond to changes in how the material is feeding. For example, a rise in ambient humidity could affect the material flow and lead to arching or ratholing in the hopper, which could starve the dosing unit. With integrated vibration technologies, the weighing system senses the starving, and the controller applies more vibration to the hopper to resolve the problem. When consistent feeding resumes, the system provides less or no vibration. The system invokes a smart vibration, which is active only when required, and therefore eliminates the subsequent packing that can often occur with normal vibrators on hoppers.

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Weight balancing and countering vibrations. You must install and isolate the feeder so that no external forces or friction can influence the weighing. Flexible connections are mandatory to upstream and downstream process equipment, such as at the product or refill inlet and product discharge, and will isolate the feeder. Any feeder vent tubing or CIP piping must also be flexible so they don't add stress to the weighing device or load cell.

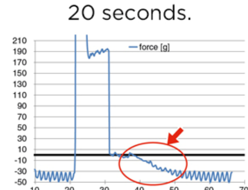
In-plant shock and vibration can also corrupt the weight measurement, interfering with feed rate control. Because an LIW feeder's operation depends on accurately measuring the weight of the material in the hopper, you must isolate the feeder and weight-sensing device from any external vibration. Ensure that the feeder is stably mounted, uses flexible connections and shock mounts, and is not subjected to strong air currents.

Modern load cells and control algorithms can discriminate between the load to be measured and the transient forces of vibration. To distinguish between them, you can apply a sophisticated control algorithm and cells that use a digital filter to identify and extract the characteristic frequency of in-plant vibration.

Pressure compensation. If an LIW feeder is discharging material into a variable-pressure environment, such as a pressurized or vacuum conveying line, a pressure or vacuum pulse can cause a feed rate error (Figure 2). The pressure pulse affects the hopper's instantaneous weight measurement by exerting a vertical force on the hopper opposite to the downward force, slightly lifting it so that it registers less weight. The controller interprets that weight as an indication that the feeder delivered too much material and slows the screw feeder. The actual feed rate will be less than desired.

Figure 2

Display of pressure in LIW feeder at 100 kilograms per hour. The pressure differential caused a seven percent error in mass flow for 20 seconds.



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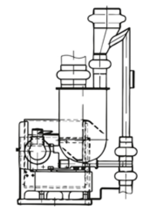
A consistent positive pressure at the feeder's discharge can also restrict the weight loss it senses; thus, the control interprets the reading as an indication that insufficient material is being fed and speeds up the screw feeder, resulting in too much actual material being fed. This scenario often occurs when feeding into continuous pharmaceutical processes that might exert a back pressure on the feeder, such as blending and extruding.

Other causes of hopper pressure problems include a clogged vent filter, a dust collection system connected to the hopper vent, and/or a nitrogen blanket applied to the hopper.

Traditionally, mechanical means, which are usually costly, have compensated for troublesome pressure fluctuations, as shown in Figure 3. However, factors such as mechanical tolerances or the alignment and age of a flexible bellows can affect the mechanical pressure compensation and prevent it from fully offsetting the forces generated by changing pressures. The equipment is also difficult to clean.

Figure 3
Traditional mechanical means for pressure equalization in an LIW feeder



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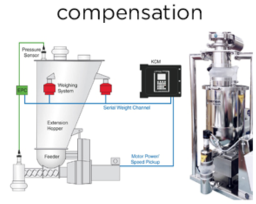
An alternative is to use instrumentation and control algorithms that monitor and compensate for pressure influences. One example is the Electronic Pressure Compensation (EPC) system that my company offers. You can use it to detect changes in pressure automatically within a feeder and adjust the weight signal accordingly. When you must handle air-pressure issues in LIW feeders, these systems allow the feeder to compensate for pressure changes in the process. The principle of operation of the EPC is shown in Figure 4.

Summary

Accuracy in feeding is critical to a number of pharmaceutical operations, particularly when dealing with continuous processes. Proper installation, ideal weighing configurations, and the proper choice of feeder controls and instrumentation can prevent a variety of process problems.

Figure 4
Example of pressure compensation



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Understanding the significance of those factors is critical to achieving optimal performance. The strategies outlined above can improve the performance of LIW feeding. Too often the savings and process improvements that an efficient feeding system can produce over time are not considered at the time of purchase because the focus is on the up front capital cost. But it's worth analyzing the return on investment of a higher-accuracy feeding technology. Its superior performance will increase process profitability and quality.

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