Troubleshoot Your Feeder for Optimal Performance

Understand key factors affecting volumetric and loss-in-weight units

By John Winski, Coperion K-Tron

With the uncertainty of today's unprecedented times and tough global economy, the pressures for proper maintenance, increased longevity of process equipment and optimal performance are higher than ever before. Feeders that are not feeding accurately typically produce off-spec finished products and require extended periods of downtime to recalibrate or fix, resulting in decreased production rates and lost profits. In all industries, the improvement in accuracy performance by even 0.25% of ingredient feeding can result in significant overall profit yields.

Proper installation, ideal weighing configurations and appropriate choice of weighing controls can eliminate a variety of future feeder problems. For complex feeder systems (e.g., multiple loss-in-weight (LIW) feeders feeding powder and pellets into mixers or extruders), external influences such as vibration, platform stability and upstream/downstream equipment connections all can affect a feeder's performance. Knowing the significance of these influences is key to optimizing its performance. By training your operating and maintenance workers thoroughly and familiarizing them with effective troubleshooting and maintenance practices, a variety of these problems can be mitigated.

Feeders typically are engineered to address a specific material at a specific discharge rate. Changes in your material, operating conditions such as ambient or material temperatures, plant vibration levels and material characteristics all can affect feeder performance. Choosing a feeder that can be reconfigured easily in your plant to handle new conditions can help you solve these problems.

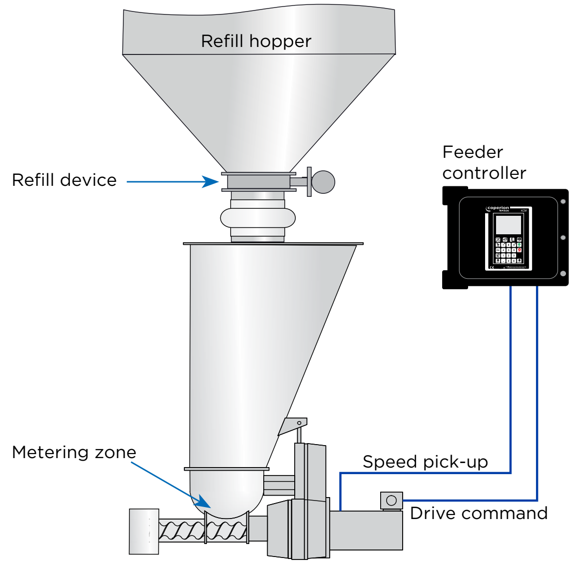
By definition, most feeders can be categorized as volumetric and gravimetric. This article will investigate both principles and review the significance of a number of parameters and their direct significance on feeder performance. The following sections discuss the operation of common feeder technologies and then explain how to optimize a feeder based on its operating principles.

VOLUMETRIC SCREW FEEDER PRINCIPLE OF OPERATION

A volumetric screw feeder (Figure 1) feeds a certain material volume per unit time (such as cubic feet per hour) to a process. The volumetric screw feeder consists of a hopper, material discharge device and controller. This is the most common volumetric feeder, and its material discharge device is a screw that rotates at a constant speed to meter material at a predetermined volume-per-revolution discharge rate from the hopper to the process. The controller monitors and controls the feeder's screw speed, which determines the material's discharge rate.

An optional agitation system located between the hopper and the screw can facilitate material discharge from the hopper. Various agitation systems and screw designs, sizes and geometries are available to suit your application.

Because the volumetric screw feeder cannot detect or adjust to variations in a material's bulk density, the feeder is most effective with relatively free-flowing, uniform-density materials, such as pellets, and in applications in which high feeding accuracy is not crucial.



Volumetric Feeder Principle

Figure 1 A volumetric screw feeder feeds a certain material volume per unit time to a process.

DIAGNOSING A VOLUMETRIC FEEDER

Volumetric screw feeder problems are relatively easy to diagnose. Most problems relating to the feeder's discharge rate stem from a faulty screw-speed control sensor (Figure 1) or motor drive, a change in the discharge rate's volume-per-revolution ratio or material flow problems from the hopper. Precise discharge rate control will be impossible if the feeder's screw-speed control sensor doesn't register the screw speed accurately (or at all). If the feeder's discharge rate is a problem, first check for loose sensor wiring and electrical connections. If the connections are sound, you may need to clean or replace the sensor. You easily can evaluate the sensor if the motor speed is stable.

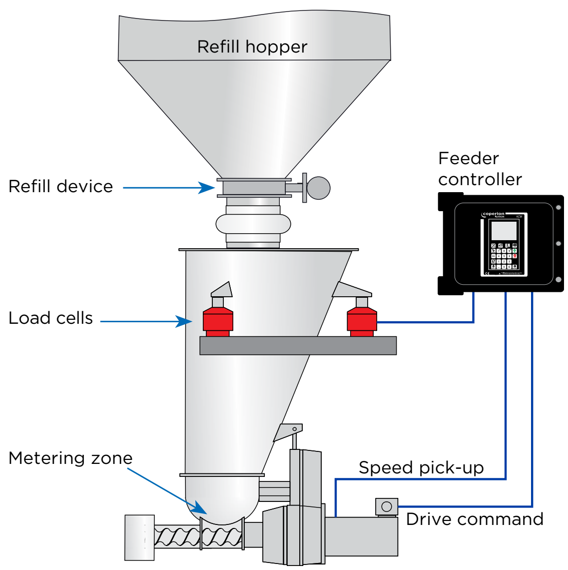
If the screw-speed sensor is not causing the problem, then the cause probably is a change in the discharge rate's volume-per-revolution ratio. Such a change typically is caused by material buildup on the screw or in the discharge tube or by a blockage in the hopper that prevents a consistent material supply to the screw. The buildup or blockage reduces the material volume that the screw discharges in each revolution at the constant screw speed.

An immediate, but temporary, remedy is to clean the screw, discharge tube or hopper — or all three. To permanently solve the problem, you may have to change the screw or hopper design or add an agitation system to help move material from the hopper to the feed screw. Coating or polishing the internal metal surfaces also may alleviate the problem, but consult your manufacturer for guidance.

THE BASICS OF LOSS-IN-WEIGHT FEEDING

Unlike the volumetric screw feeder, a loss-in-weight (LIW) feeder is a gravimetric feeder that measures the material's weight directly to achieve and maintain a predetermined feed rate that's measured in units of weight per time. The LIW feeder (Figure 2) consists of a hopper, refill device, weight-sensing device (typically either a digital or analog scale or load cells), material discharge device (typically a volumetric screw feeder powered by a variable-speed motor) and controller. Before operation, an operator programs the controller to discharge material at a predetermined feed rate (or setpoint) measured in units of weight per time (such as pounds per hour).

The bulk material or liquid is discharged from a hopper with a constant weight per unit of time by weighing the hopper and regulating the speed of the feeding device depending on the rate of weight loss.



Gravimetric Loss-in-Weight Feeder Principle

Figure 2. A loss-in-weight (LIW) feeder is a gravimetric feeder that measures the material's weight directly to achieve and maintain a predetermined feed rate that's measured in units of weight per time.

The weighing control system compensates for non-uniform material flow characteristics and variations in bulk density, therefore providing a high degree of feeding accuracy. When the hopper reaches a predetermined minimum weight level, the LIW control is interrupted briefly and the hopper is refilled.

With some manufacturers, during the refill period, the controller regulates the feeding device's speed based on the historic weight and speed information that was accumulated during the previous weight loss cycle. This prevents overfeeding of material during the refill cycle because of changes in headload of material and filling of material into the screws. This also is critical for maintaining feed rate performance within specification on a second to second basis. The LIW feeding principle is most accurate when using a high-resolution, fast-responding and vibration- and temperature-immune weighing system.

LIW feeder performance is dependent on three areas that are linked closely:

1. The feeding device's mechanical configuration and any material flow-aid used in the feeder hopper.
2. The weight measurement's accuracy and speed and the weighing system's immunity to in-plant vibration and temperature fluctuations.
3. The control algorithm's response and its available features.

VALIDATING THE MECHANICAL CONFIGURATION FOR LIW FEEDER PERFORMANCE

The mechanical feed device and its configuration are the starting point in any LIW feeding system and include feeders and vibratory trays:

Single screw feeders can be applied when feeding granular free-flowing materials. When running

at lower setpoints, single screw feeders may produce a pulsating discharge that will affect second-to-second performance. Some manufacturers have developed software to compensate for this pulsation and achieve consistent accuracy.

Twin screw feeders can be applied when feeding difficult-to-flow and sticky materials and reduces the pulsating discharge even at lower setpoint rates.

Vibratory trays are used for granular free-flowing materials providing a uniform discharge.

Single and twin screw feeders have different screw profiles and configurations that also can be tailored to the material being fed as well as the setpoint turndown requirements. The key is to select the proper feeder and configuration to give the most uniform and reliable volumetric feeding of the material. By doing this, the weighing and control system does not have to work as hard to provide optimal performance.

The same holds true for any flow-aid device that may be required in the feeder's hopper. This will assure that the process material flows into the feeding device as uniformly as possible. Stability of the feeding system allows for the weighing and control system to provide optimal second-to-second performance.

Several types of material flow aids are available:

1. Flexible side walled feeders gently agitate materials. However, they don't have stainless steel surfaces and may wear or create contamination concerns.
2. Mechanical hopper agitators stir the material and break down any bridging or rat-holing of the material. However, these devices require additional headroom for the feeder and may become a cleaning concern.
3. A smart control vibration device such as ActiFlow applies vibration to the hopper using an external drive at a variable frequency and amplitude based upon the weighing and control system detecting nonuniform material flow by weight (Figure 3). This technique eliminates headroom and cleaning concerns and avoids process material compaction because only the necessary amount of vibration is applied to the material to assure uniform material flow.

Smart Control Vibration Device

Figure 3. Coperion K-Tron ActiFlow Bulk Solids Activator gently promotes material flow in feeder hoppers.

SIGNIFICANCE OF THE WEIGHING SYSTEM ON LIW FEEDER PERFORMANCE

Any LIW process controller requires accurate high-speed measurement of material weight changes to provide optimal feeder control and performance, especially on a second-to-second basis. The weighing system also must be able to filter out erroneous measurements that plant vibrations or disturbances may cause and be stable over changes in process room or process material temperatures.

Two types of weighing technology typically are used in LIW feeders: analog strain gauge technology and

digital vibrating wire technology. The key is that the higher the resolution of weight measurement and the faster those weight measurements are taken, the better the information that will be provided to the control algorithm to work and the better any vibration-filtering algorithm will work. Almost all weighing systems provide temperature compensation. However it should be verified over your application's temperature range, as this can affect the long-term stability of the feeder performance.

TROUBLESHOOTING AND IMPROVING YOUR LIW FEEDER PERFORMANCE

Because the LIW feeder typically uses a volumetric screw feeder to meter material, many of the volumetric feeder problems and solutions in the previous section also apply to the LIW feeder. But as the LIW feeder's operation is based on the weight loss rate per unit time rather than the screw speed, the controller automatically compensates for material buildup on the screw or in the discharge tube or a blockage in the hopper by increasing the screw speed to maintain the setpoint.

The controller continues to increase the screw speed until the feeder reaches an alarm condition, such as when the screw speed exceeds the recommended operating speed. If an alarm condition occurs in your LIW feeder, check first for material buildup on the screw or in the discharge tube or a blockage in the hopper. Understanding and configuring your controller's alarm settings properly will allow users to perform preventive maintenance before to a catastrophic failure.

If you find no material buildup or blockage, check the hopper to ensure that it has material in it. If the hopper is empty, you then need to check the upstream material delivery system for a blockage or other malfunction. The LIW feeder's operation depends on accurate weight measurements of the material in the hopper, and vibration can impose artificial forces on the feeder that cause weighing errors.

To avoid this, isolate the feeder and weight-sensing device from any external vibration created by other equipment in your process. This requires installing the feeder so that the weight-sensing device is shielded from vibration effects. Do this by ensuring that the feeder has a stable mounting, using flexible connections and shock mounts and eliminating strong air currents near the feeder.

Vibration problems can result later from installing new equipment near the feeder or refitting the feeder's flexible connections improperly during maintenance. For example, if your LIW feeder has feed rate problems that appear to correlate with the operation of newly installed machinery or that occur after feeder maintenance, external vibration probably is affecting the weight-sensing device.

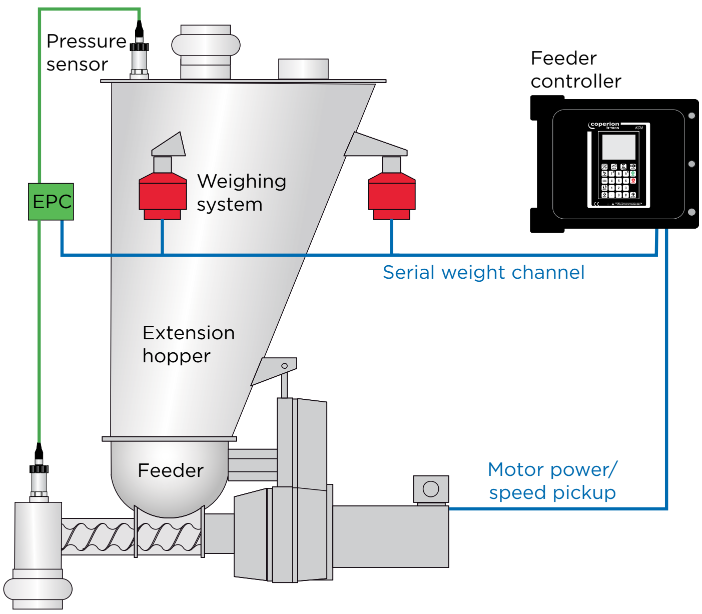
To solve these problems, make sure that the feeder and weight-sensing device are isolated from any vibration the newly installed equipment is creating. If the problems occur after maintenance, recheck the flexible connections to ensure that they're connected to the feeder properly.

The weight-sensing device itself can cause performance problems if you don't select it properly for your application. Carefully evaluate the weight-sensing device's capabilities — resolution, stability, responsiveness, weight signal integrity, vibration sensitivity, reliability, and data communications — before purchasing the LIW feeder. After installing your feeder, maintain its performance and find any problems such as drift (a gradual deviation from a set adjustment) as

early as possible by calibrating the weight-sensing device regularly.

Other performance problems can result from a defective refill device or a leaky seal at the feeder's discharge. If an automatic refill device loads material into the hopper, any leakage in the refill device at the hopper's inlet will produce a feed rate error because material will continue leaking into the hopper after the refilling process has stopped. This creates a weight loss rate change; the controller senses that not enough material is being discharged from the hopper. To compensate for this, the controller increases the screw speed to meet the setpoint, discharging more material per unit time.

Also, if the LIW feeder discharges material to a nonambient pressure environment such as a pressurized or vacuum conveying line, a pressure pulse (air leaking from the downstream system through the feeder's discharge tube to the weight-sensing device) can cause a feed rate error. A pressure pulse affects the hopper's instantaneous weight measurement by exerting a vertical force on the weight-sensing device opposite the hopper's downward force, in effect, slightly lifting it so that its weight reads less.



Electronic Pressure Compensation System

Figure 4.: Coperion K-Tron's solution monitors and compensates for pressure influences.

Traditionally the solution is a complex arrangement of pipes and flexible connections to compensate for known pressure differentials within the system. As an alternative to traditional mechanical compensation systems, instrumentation and control algorithms to monitor and compensate for pressure influences electronically can be supplied. An electronic pressure compensation system can be used to detect changes in pressure automatically within the feeder hopper or outlet tube and adjust the weight signal accordingly to compensate for any errors caused by pressure fluctuations (Figure 4).

AN OUNCE OF PREVENTION

You can do several things to prevent feeding problems and keep your feeders performing at peak levels. First, consult the feeder supplier to ensure that the feeder you choose can handle your material and process and then install the feeder correctly in your process. Finally, train your operators and maintenance workers thoroughly to provide effective feeder troubleshooting and maintenance.

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