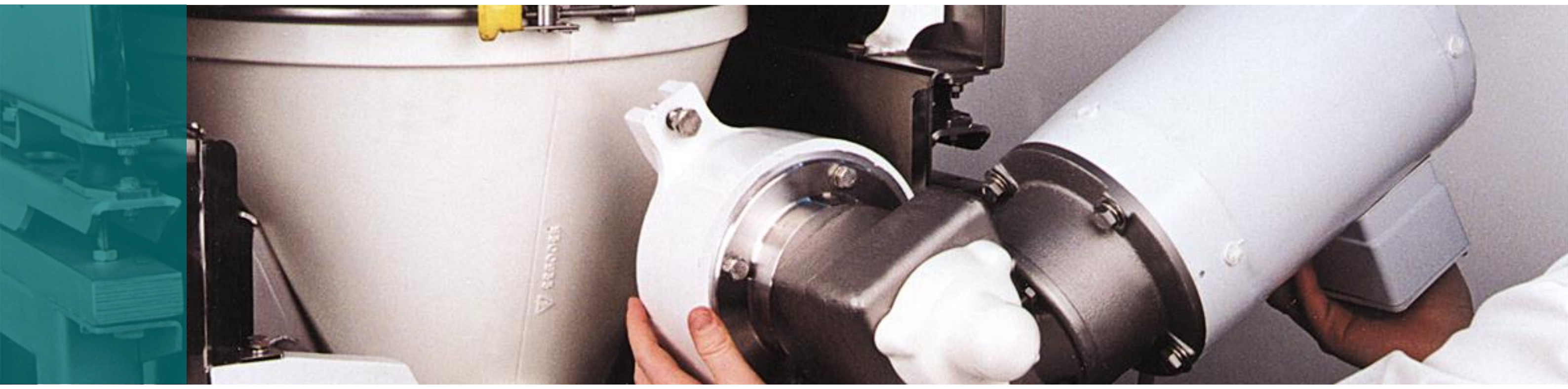
TECHNICAL ARTICLE FLEXIBLE-HOPPERS



Written by Todd Messmer, Schenck Process LLC

Using a flexible-hopper screw feeder to overcome common feeding problems

This article looks at how an externally agitated flexible-hopper screw feeder can gently condition material to a uniform bulk density, preventing feeding headaches common to traditional screw feeders. Sections cover the feeder's operation and components and explain how testing can help you select the feeder's components and adjust feeder settings for your application. The information here applies to both volumetric and gravimetric screw feeders.

As anyone in the dry bulk solids business knows, most fine powders, flakes, granules, chips, and pellets don't flow by themselves. This makes it a challenge to accurately feed these materials into a process. Screw feeders, one of the most common feeders for dry bulk materials, can use various flow-promotion mechanisms to keep material flowing into the screw flights, but some of them have undesirable side effects: material degradation, material compaction or segregation, uneven feedrates, and premature feeder wear and tear.

One way to overcome these problems is to use a screw feeder equipped with an externally agitated flexible hopper. Before we discuss how this feeder works, let's take a closer look at how material flow problems can affect a screw federate accuracy.

Flow problems with traditional screw feeders

A traditional screw feeder typically consists of a hopper, a feed screw with a drive motor that's lined to electronic controls (which can be volumetric or gravimetric), and a discharge tube (also called a *nozzle, discharge spout*, or *metering tube*). The screw's infeed end is in the hopper bottom, and the rest of the screw is enclosed in the discharge tube, with the screw's discharge end located at the discharge tube's outlet, above the downstream process. In operation, material flows downward through the hopper toward the feed screw, and as the screw rotates, material falls into the screw flights and is carried in the flights through the discharge tube to the process. The controls signal the motor to speed up or slow down to match the screw's rotation speed to the feedrate setpoint.

A common challenge with screw feeders is keeping the screw flights completely filled with material for accurate feeding. Equipping the feeder with a vibrating hopper or an internal agitation device are traditional methods for promoting material flow into the flights. However, they have some disadvantages.

Disadvantages with vibration. A screw feeder equipped with a vibrating hopper can produce compacted material in the hopper bottom and around the feed screw, preventing steady flow into the screw flights. This compaction can also degrade particles and overwork the feeder as the motor strains to turn the screw in the packed material. The vibration can also segregate blended material; this results in heavier particles settling out of the hopper and being fed first while lighter particles are fed last, rather than producing a first-in, first-out flow pattern.

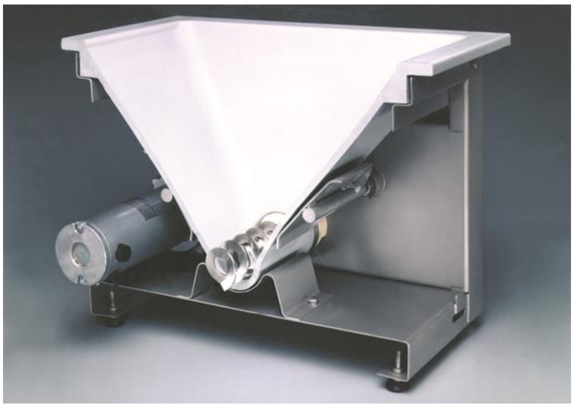
Disadvantages with internal agitation. A screw feeder with an internal agitating mechanism --- a stirring device located in the hopper over the feed screw to prevent bridging --- can degrade friable materials such as flakes or chips. Adhesive materials can build up on the internal agitating mechanism, resulting in an erratic feedrate. Heavier materials can prematurely wear the internal agitation device's drive motor and gear reducer.

The advantages of a screw feeder with external agitation

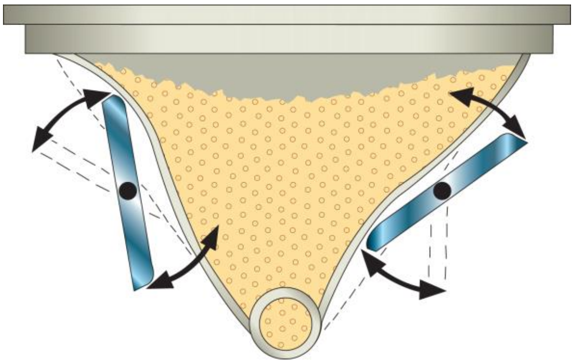
A screw feeder equipped with an externally agitated flexible hopper can overcome the disadvantages of vibrated and internally agitated screw feeders. As shown in Figure 1a, the externally agitated feeder has a flexible hopper, typically made of plasticized polyvinyl chloride (vinyl), and agitating devices that are mounted to rest against the hopper's exterior. The agitating devices are usually steel paddles, but other types are available. The paddle movement's amplitude and frequency are adjusted to match the material's flow characteristics.

Figure 1
Externally agitated screw feeder with flexible hopper

a. Cutaway view



b. Paddle agitation during feeding



In operation, the paddles undulate against the hopper walls, as shown in Figure 1b, gently massaging them. This action brings the material downward through the hopper toward the feed screw, preventing any ratholing or bridging over it while conditioning the material to a uniform bulk density so it can completely fill the screw flights. The gentle external agitation keeps the material moving in mass flow --- first- in, first-out --- from the hopper into the screw flights for discharge into the process. In addition to conditioning the material to a uniform bulk density, the external agitation is less prone to segregating blended materials and degrading friable materials.

Turndown ratio and feeding accuracy. Turndown ratio is the range of feedrates at which a feeder can operate within specified performance limits. The externally agitated screw feeder typically has a turndown ratio of 50:1 (with a DC motor and controls) rather than the standard 10:1 of a traditional screw feeder's gentle, adjustable agitation, this high turndown control allows the feeder to achieve the desired feedrate without erratic flow. Be aware that in a given application, the turndown ratio will be influenced by the material's flow characteristics, the feeder controls, and the feed screw diameter and design. The externally agitated screw feeder can achieve volumetric feeding accuracies between ±0.5 and ±3 percent, depending on the material's characteristics.

Applications. The externally agitated screw feeder can handle most dry bulk materials and is especially well suited to easily aerated materials that must be conditioned to achieve uniform bulk density and to materials that end to bridge over the feed screw at the hopper bottom. The feeder isn't a good candidate for feeding fibrous materials; the material's interlocking strands must be pulled apart, which may be better achieved by a screw feeder with internal agitation. Some cohesive materials also tend to pack in the externally agitated screw feeder and may be better handled by another feeder.

More about the feeder components

The following information describes common construction materials, designs, and sizes for the externally agitated screw feeder's major components. Note: A well-designed screw feeder allows quick and easy removal and replacement of the flexible hopper, feed screw, and other components to handle material changeovers or cleaning between batches without taking the feeder off the production line. If your application requires frequent changeovers or washdowns, make sure the feeder you select is designed for fast, simple component removal and replacement.

Flexible Hopper. While the screw feeder's flexible hopper is typically vinyl, hoppers made of polyurethane and other flexible materials are available from most suppliers for handling bulk solids that are incompatible with vinyl. For instance, high-temperature materials can melt vinyl, and some chlorine or chlorine-based materials can leach plasticizers out of the vinyl and make it brittle. The vinyl hopper can also be incompatible with some cleaning solutions and vinyl's porosity can make a hopper of a less porous material more suitable for some sanitary applications.

The flexible hopper is available in sizes from a fraction of a cubic foot to several cubic feet, depending on the supplier. For maximum flexibility, the hopper should be easy to remove and replace for cleaning and for switching hoppers for material changeovers, such as when dedicated hoppers are used for different color pigments or toners. To allow the feeder to handle additional material, a steel or stainless steel extension hopper can be added to the feeder. Extension hopper sizes commonly range from less than a cubic foot to 100 cubic feet.

Feed screw. The standard feed screw is made of Type 301 stainless steel, but the screw can be constructed of many other types of steel to suit your application. For instance, for feeding salt, a Type 316L stainless steel screw would be a better choice than a screw made of Type 304 stainless steel, which will rust in contact with salt. The feed screw can also be manually polished, electropolished, or coated with various materials to prevent material buildup on the screw and promote flow through the feeder.

Typically feed screw diameters (measured as the outside diameter of the screw flights) range from fractions of an inch up to 6 inches, with larger diameters producing higher feedrates. For instance, a 0.75-inch-diameter screw can provide a maximum feedrate of about 0.5 ft^3/h, while a 4-inch-diameter screw can provide a feedrate up to about 280 ft^3/h.

The feed screw's design --- which can have variations such as closely or widely spaced flights (known as screw pitch and measured from tip to tip of adjacent screw flights), an opening at the screw center, or a rod at the center --- should be matched to your material's characteristics. For instance, a non-free-flowing material tends to flow better into a screw with widely spaced flights, while a free-flowing material will flow easily into more closely spaced flights. A very free-flowing (floodable) material may require a screw with a center rod to prevent the material from passing down through the screw's center opening, while a sticky material could build up in this type of screw, in the corners between the rod and the screw flights or between the rod and the discharge tube.

Discharge tube. The discharge tube is selected in combination with the feed screw. Like the feed screw, the tube is available in various materials, with several polishes and coatings, and in multiple diameters to match the feed screw size. For instance, to handle an extremely sticky material, the discharge tube can be made of a nonstick material, such as ultrahigh- molecular-weight polyethylene (UHMW-PE), or coated with polytetrafluoroethylene (PTFE [Teflon]). An important part of sizing the discharge tube is ensuring that the gap between the screw flight tips and the tube's inside wall is appropriate for your material's characteristics. The gap for a sticky material, for instance, should be narrow enough to prevent the material from building up inside the tube and constricting the screw's rotation. For pellets, the gap should be wide enough to allow pellets to pass through without being pinched.

This externally agitated screw feeder has a flexible hopper that's easy to remove and replace for frequent material changeovers.

The discharge tube is also available with multiple options to meet your application requirements. For instance, the tube can have a side discharge, which can be used with a free-flowing material to provide positive flow cutoff in a batching application or for reducing flowrate variations in a continuous application. Or the tube can have an end screen, which can provide back pressure to promote better filling of the screw flights and prevent pulsating flow.

Controls. The screw feeder can be equipped with various volumetric or gravimetric controls that allow it to adapt to your process and material. For instance, the controls can accept various external automatic input signals, such as signals from fast- and dribble-rate potentiometers, totalizers, batching timers, tachometers, and many other devices.

Adjusting the agitation for your material

Both the amount (amplitude) and speed (frequency) of the paddles' agitation against the flexible hopper walls must be adjusted for your material's flow characteristics. This will condition the material to a uniform bulk density so that it can fill the screw flights as completely as possible. The ideal combination of amplitude and frequency varies for each material and can be determined by testing in the supplier's test lab (covered in more detail in the next section). Proper agitation amplitude and frequency will contribute to the feeder's linearity---that is, its ability to achieve the same feeding accuracy and performance throughout the feedrate range of the feed screw and discharge tube.

Matching the paddles' amplitude to your material tube and bulk density allows the paddles to move and condition the material just enough without damaging or overworking it. For instance, for a heavy material that segregates easily, the paddles should be set at a low amplitude to keep the material barely moving toward the screw. For a light material, the paddle amplitude typically should be set at the highest level to transfer the movement through the entire hopper.

Adjusting the paddles' agitation frequency will achieve better feeding accuracy. Adhesive, low-bulk-density powders tend to require the highest agitation frequency to keep them flowing toward the screw, while free-flowing powders with medium to high bulk density require the lowest frequency. If the feed screw's rotation speed is varied during feeding to maintain the feedrate setpoint, the paddle movement speed typically must also be varied.

Note: Most externally agitated screw feeders have a single motor that drives both the feed screw and the paddles, so that as the feedrate increases, both the screw rotation speed and the paddle agitation frequency increase. Dual-drive models with a dedicated motor for the screw and another for the paddles improve conditioning for some cohesive materials that tend to pack rather than flow into the screw flights.

The Importance of testing

The feeder supplier may want to test your material in the screw feeder you've selected to verify that the feeder can achieve the accuracy you need. Using your material in the tests, rather than a material by the same name is critical: While two materials can be called the same thing --- such as "titanium dioxide" --- they can be from different suppliers and have different characteristics that make them behave very differently during feeding.

Testing will help you choose the feeder components, such as the feed screw and discharge tube that can best handle your material's characteristics. Determining how to adjust the combination of agitation amplitude and frequency is a key part of the testing and will ensure that the paddles condition your material to a uniform bulk density for better feeding accuracy. The more accuracy your feeding application requires, the more testing to adjust the agitation may be required.

Before the tests, you'll typically need to complete an application survey form that asks for detailed information about your material, desired feedrate, and other application requirements. This will help the lab staff determine what feeder model and components your application requires, what you expect the feeder tests to accomplish, and how much material you need to ship to the lab for the test. The amount of material typically required depends on your desired feedrate; the higher the feedrate, the more material you'll need to ship to the lab. Some labs use automated refill systems that allow them to test equipment at higher feedrates without requiring as much material. You'll need to ship your material with an MSDS that indicates whether the material is hazardous. Also be aware that most feeder suppliers won't be able to dispose of the material after testing and so must ship it back to you, usually at your expense.

Typically, the supplier lab will pretest your material in the feeder you've selected; this will help narrow down the feeder component and setting options before detailed testing begins. Once the pretests are completed, you can visit the lab in person to witness the detailed tests, or you may be able to watch the test live over the Internet or receive a video of the tests. If your material is hazardous, the lab staff may be able to test the material in a screw feeder they bring to your plant. This is also a good option when you prefer to test the feeder in your process rather than under lab conditions, because the on-site tests will give you a better idea of the feeder's performance in the climate and process conditions (such as vibrations) at your site.

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7901 NW 107th Terrace
Kansas City, MO 64153
816-891-9300
sales-fcp@schenckprocess.com
www.schenckprocess.com/us