

Choosing a feeder: It's all about your material

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To select a feeder that reliably dispenses your bulk solid material at the rate your process requires, you need to understand your material and how it flows. After giving some background on material flow properties, this article describes common feeders, their major pros and cons, and how to match a feeder to your material's flow behavior.

Are your customers demanding higher-quality products? Are you trying to eliminate repetitive-motion injuries to workers and reduce your raw material costs? Then it's time to consider replacing your manual feeding method with a dry bulk solids feeder that can provide more accurate feeding, eliminate manual handling and feeding tasks, and allow you to receive your raw materials in bulk, reducing their cost.

With the variety of bulk solids feeders available today, choosing the one best suited to your application will take some serious research. You need to begin by identifying your material's flow characteristics. Why? Not all feeders are suited to handling all materials. Whether you conduct your own material tests or have an independent lab or your feeder supplier's lab do them, the more you know about your material and how it flows, the easier it will be to narrow your feeder choices.

Your material will probably fit into one of these common categories based on the material's flow properties and other characteristics:

Free-flowing: A free-flowing material, like plastic pellets, flows easily by gravity without help from flow aids or specially designed equipment.

Friable: A friable material, such as wax beads, pasta products, or flake adhesives, has particles that are easily broken, so it requires gentle handling to avoid reducing the particle size, changing the particle shape, or causing the material to flow at an inconsistent rate.

Adhesive: An adhesive material sticks to everything, making it one of the most challenging materials to feed; a good example is color pigments, which are notorious for adhering to all types of surfaces.

Cohesive: A cohesive material typically has a high angle of repose and tends to pack or clump like a snowball rather than flow easily. Examples include very fine powders and powders containing fat (like a cake mix) or moisture.

Fibrous: A fibrous material, such as wood flour or biomass fibers, contains long particles that tend to interlock and form masses that slow or stop flow.

Aeratable: An aeratable (or floodable) material, such as glass microspheres, flour, or phenolic resin, typically has a low angle of repose and behaves like a fluid when aerated. This can cause it to flood in an uncontrolled flow from an equipment discharge.

Hygroscopic: A hygroscopic material, such as sugar, salt, or cellulose fibers, readily wicks up moisture that can cause it to clump. Leaving this material in equipment overnight can cause it to harden into a rock-hard lump by morning.

Pressure sensitive: A pressure-sensitive material, such as wax beads, is prone to packing, especially under a large head load.

Meltable at low temperatures: A material with a low melting temperature tends to break down, melt, or caramelize when subjected to excess friction or energy.

Once you know which of these categories your material fits into, you're ready to look at what feeders are available and how your material's flow behavior will affect your feeder choice.

Common bulk solids feeders

The following information describes the operation and major advantages and disadvantages of several common feeders. Note that all but the last feeder are volumetric feeders — that is, they dispense a volume of material at a given rate over a certain time period. By taking the desired feedrate (typically in pounds per hour) and dividing it by the material's bulk density (typically in pounds per cubic foot), you can calculate what volumetric throughput — that is, what volume of material per unit time (in cubic feet per hour) — the feeder must dispense. Once you've selected a feeder type, this information will help you determine the feeder's size.

The volumetric feeders described here can also be controlled gravimetrically so they feed material at the desired rate by weight rather than volume. Gravimetric feeder control is well-suited for a material with a variable bulk density or an application requiring very high feeding accuracy. [*Editor's note:* Contact the author for detailed information on selecting volumetric or gravimetric feeder control for your application.]

Vibratory feeder. A vibratory feeder is equipped with a vibrating discharge tube (or tray), as shown in Figure 1. Material flows into the tube and is carried gently forward by the tube's vibratory action. Adjusting the tube's vibration amplitude and frequency controls the volumetric throughput, which is calculated by multiplying the particle flow velocity by the cross-sectional area of the material bed in the tube.

Main advantages:

- The vibratory feeder can handle very low and very high feedrates.
- It produces a uniform material flow that provides gentle handling.
- The feeder has a relatively low installation cost because the feeder's low voltage requirements involve less wiring and electrical work at installation.
- The feeder has virtually no moving parts, minimizing its maintenance requirements.
- It has low power consumption.

Main disadvantages:

- The feeder's vibrating action can generate dust with some materials.

- The vibrating action can segregate material blends.
- The feeder doesn't provide positive material extraction (that is, a means for pulling the material out of the feeder's hopper).
- Adhesive materials and fines can build up on the feeder tube (or tray), restricting material flow and requiring cleanout to remove the buildup.
- The feeder doesn't provide a linear feedrate (that is, it doesn't achieve the same repeatability throughout its feed-rate range), unlike the other feeders described in this article.

Single-screw feeder. In a single-screw feeder, a feed screw (or helix) mounted below a rigid carbon steel or stainless steel hopper and rotating inside a discharge tube (or nozzle) provides continuous material flow. The feeder's volumetric throughput is calculated by multiplying the volume of material held in one feed screw flight (at a 100 percent fill level) by the screw's rotation speed (in revolutions per minute). [*Editor's note:* Volumetric throughput is calculated in the same way for all screw feeders discussed in this article.]

Main advantages:

- Changing the feed screw and discharge tube configuration allows the feeder to handle a wide range of materials and feedrates.

Figure 1

Vibratory feeder with discharge tube



- The feeder provides positive material extraction, pulling material out of the feeder hopper and into the screw.
- The feeder's infeed-to-discharge distance (that is, the feed screw length) can be customized for the installation by using an appropriately sized feed screw and discharge tube.
- Depending on the model, the feeder can be quickly cleaned or serviced by disassembling it from the non-process side, without having to take the feeder off the production line.

Main disadvantages:

- Adhesive materials and fines can build up inside the feeder, restricting flow.
- The screw feeder's moving parts can wear, especially when handling abrasive materials, increasing required maintenance.
- The feeder typically consumes more power than a vibratory feeder, giving it a higher operating cost.

Externally agitated screw feeder with flexible hopper.

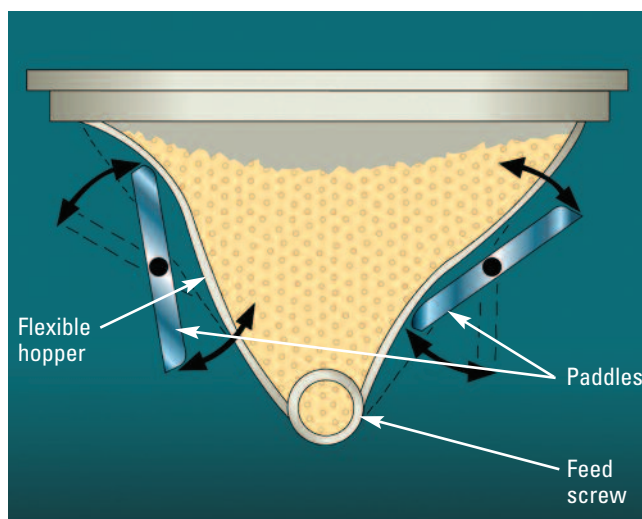
This feeder is a specialized version of a single-screw feeder, with a hopper made from a flexible material (typically plasticized polyvinyl chloride). Agitating steel paddles (or other devices) are mounted to rest against the hopper's exterior, as shown in Figure 2. As the feeder operates, the paddles gently massage the hopper sides to facilitate flow from the hopper and complete filling of the screw flights.

Main advantages:

- The feeder provides positive material extraction.
- The agitation promotes first-in first-out flow to minimize blend segregation or degradation of friable materials.

Figure 2

Externally agitated screw feeder



- The agitation can condition an aeratable material to a uniform bulk density so it can completely fill the screw flights.
- The agitation promotes smooth flow by breaking material bridges over the feed screw and preventing ratholes.
- The external paddles don't contact the material in the hopper, preventing buildup and contamination problems.
- The feeder can be equipped with a dual drive (with one motor for the feed screw and another for the agitating paddles) that allows the operation of each to be adjusted for handling various materials.

Main disadvantages:

- The feeder can't be used with materials that can leach the plasticizers from the vinyl hopper walls.
- It can't be used with high-temperature (212°F or higher) materials, which can melt the hopper walls.
- The feeder can't be used with fibrous materials or some cohesive materials that tend to pack.
- If the feeder is equipped with a single motor, increasing the feed screw rotation speed also increases the paddles' agitation frequency, reducing the feeder's ability to handle some materials.
- When equipped with a dual drive, the two motors will increase the feeder's initial and operating costs. (However, the dual drive's flexibility for handling various applications can make this feeder less costly to operate than other feeders in the same applications.)

Internally agitated screw feeder. Another type of single-screw feeder has a hopper equipped with an internal agitator that rotates vertically, as shown in Figure 3, or horizontally, to promote material flow into the screw flights.

Figure 3

Internally agitated screw feeder



Main advantages:

- The feeder's rotating agitator eliminates bridging and ratholing of cohesive materials.
- The feeder promotes the flow of fibrous materials.
- The feeder hopper can be carbon steel or stainless steel, allowing the feeder to handle materials incompatible with the vinyl hopper wall of an externally agitated screw feeder.

Main disadvantages:

- The internal agitator directly contacts the material, potentially leading to buildup and contamination problems.
- The feeder isn't recommended for handling adhesive materials because they can build up on the internal agitator.
- The feeder may not prevent blend segregation or degradation of friable materials.
- It requires installation in a location with enough headroom to allow the internal agitator to be removed for cleaning and service.

Twin-screw feeder. This feeder has a pair of feed screws rotating side-by-side inside a discharge tube. A gear-reduction doubler splits the drive motor's rotational energy between the screws.

Main advantages:

- The feeder provides positive material extraction.
- The feed screws intermesh as they rotate, which typically makes the feeder self-cleaning and reduces material buildup.
- The two screws tend to produce smaller flow pulses than a single screw does, leading to better second-to-second feeding accuracy.

Main disadvantages:

- The twin-screw feeder requires a higher initial investment and more maintenance than screw feeders with one screw, increasing its costs.
- The feeder isn't suitable for feeding pellets, which can become pinched between the screws.
- If the feed screws become caked with material, they're difficult to remove for cleaning.
- The screws and discharge tube are available in limited lengths, limiting the ability to customize the twin-screw feeder's infeed-to-discharge distance.

Weighbelt feeder. A weighbelt feeder provides a continuous flow of material on a moving conveyor belt with a weighed section, making it a gravimetric, rather than volumetric, feeder. The material passes under a shear gate, giving the material a consistent, uniform profile as it travels over the weighed section. While not a volumetric

feeder, its volumetric throughput can be calculated by multiplying the material bed's cross-sectional area by the belt speed.

Main advantages:

- The weighbelt feeder provides positive material extraction from the hopper.
- It provides gentle handling for friable materials.
- The feeder is available in a variety of belt widths to feed at higher rates and handle larger particle sizes than other feeders.
- The feeder fits more easily in low-headroom locations than other feeders.
- Like a belt conveyor, the feeder has relatively simple construction compared with vibratory or screw feeders, making it easier to clean and maintain.

Main disadvantages:

- If the feeder is misapplied, the belt can wear and require periodic replacement, especially when handling an abrasive material, and the belt's wear particles can contaminate the material.
- Cohesive and adhesive materials and fines tend to build up on the belt, creating problems that can affect the feed-rate and belt tracking.
- Depending on the belt's length, the feeder typically isn't suitable for an aeratable material, because the material can fail to form a stable bed on the belt.
- The feeder generates dust unless the feeder is enclosed and equipped with dust collection.
- The feeder requires more maintenance than other feeders; in addition to periodic belt replacement in some applications, the feeder requires regular maintenance to prevent belt slippage and tracking problems.

Choosing a feeder for your material

For each of the material types described previously, find information here about which feeders are best suited to it, along with some practical feeding tips.

Free-flowing material. A free-flowing material doesn't require the positive extraction provided by a screw feeder, making the energy-efficient vibratory feeder a good choice for handling it.

Friable material. The gentle handling provided by vibratory and weighbelt feeders makes either ideal for feeding a friable material.

Adhesive material. Any of the screw feeders discussed here, except for the internally agitated screw feeder, is well-suited for handling an adhesive material because of

the feeder's positive material extraction. (An internally agitated screw feeder isn't recommended for an adhesive material because the particles can quickly build up on the feeder's agitator.) Periodically clean the feed screw and discharge tube to prevent adhesive material from building up on these components. You can also select feeder components with Teflon coatings or more polished contact surfaces and use a self-cleaning system inside the discharge tube to prevent buildup.

Cohesive material. Feeding this material typically requires the positive extraction provided by a screw feeder, but the feeder must also be equipped with some type of flow aid to break up material clumps. Good choices include externally agitated and internally agitated screw feeders and other screw feeders that have hoppers equipped with air sweeps or air pads.

Fibrous material. An internally agitated screw feeder is well-suited to handling a fibrous material because the agitating action inside the feeder hopper pushes the material into the screw flights.

Aeratable material. A screw feeder, and in particular an externally agitated screw feeder, is a sound choice for preventing an aeratable material from flooding out of the feed screw during feeding. Selecting a feed screw with a center rod rather than a standard open-flight design can also prevent this problem. To avoid aerating the material during refill, refill the feed hopper frequently with a small amount of material rather than less often with a large amount.

Which feeder is best for a hygroscopic material depends on how hygroscopic it is and how well the application environment is controlled.

Hygroscopic material. Which feeder is best for a hygroscopic material depends on how hygroscopic it is and how well the application environment is controlled. Any of the feeders discussed in this article can handle a less hygroscopic material, such as phenolic resin, in a humidity-controlled environment. However, without a controlled environment, even mildly hygroscopic materials can wick up enough moisture to prevent them from feeding. In an enclosed feeder, a hygroscopic material can also be blanketed with clean, dry air or nitrogen to keep moisture out and promote uniform flow.

Pressure-sensitive material. Any of the feeders described in this article is suited to handling a pressure-sensitive material, as long as the feeder doesn't have a large-volume hopper extension, which can cause the material to pack. If

the feeder must have such a hopper extension, use frequent smaller refills to help prevent packing problems. When using a vibratory feeder or an externally agitated screw feeder with this material, avoid high-frequency vibration or agitation to prevent packing problems.

Material that melts at low temperatures. This material can be fed by any screw feeder, but a screw feeder with a large-diameter feed screw rotating at a low speed is better suited to it than one with a small-diameter screw at high speed. However, the larger the feed screw and the slower the screw speed, the less feedrate accuracy the feeder can achieve. **PBE**

For further reading

Find more information on selecting feeders in articles listed under "Feeders" in *Powder and Bulk Engineering's* article index (later in this issue and at *PBE's* website, www.powderbulk.com) and in books available on the website at the *PBE* Bookstore. You can also purchase copies of past *PBE* articles at www.powderbulk.com.

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