Feeder or conveyor: what's the difference and why does it matter?

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Feeders and conveyors are extremely important elements in a bulk material handling system, but their function and design requirements are very different.

A feeder is the means by which the rate of material from a bin or hopper is controlled. When a feeder stops, material flow should cease. When a feeder is turned on, there should be a close correlation between its speed of operation and the rate of discharge of the bulk material. Examples of feeders include a belt feeder for coal, a vibratory pan feeder for applying seasoning to chips, and an apron feeder for ore under a stockpile.

Mechanical conveyors are used to transport bulk materials but, unlike feeders, they are incapable of modulating the rate of material flow. Examples of conveyors include a drag-chain conveyor for hot clinker, a screw conveyor for limestone, and a belt conveyor to take ore from a primary to a secondary crusher.

The main difference between a feeder and a conveyor is that feeders are flood-loaded while conveyors are not. Also, while conveyors typically operate at a constant speed, feeders are always capable of varying the speed of operation. As a result, feeders are capable of modulating the discharge rate from the vessel that is flood loading it. These differences are summarized in Table 1.

Dischargers are sometimes used to encourage material to flow out of a bin and, like feeders, they are flood-loaded. However, a discharger is neither a feeder nor a conveyor since it cannot modulate the discharge rate from the vessel that is flood loading it. An example of a discharger is a vibratory bin activator used for powdered soap.

Gates placed directly below bin outlets are flood loaded and sometimes used to modulate discharge rate. In so doing they act like feeders. However, they do not provide the same degree of discharge rate control as, for example, a belt or screw feeder. In addition, different design requirements apply.

Neither dischargers nor gates will be covered in this paper.

In order to ensure that a feeder accomplishes its purpose, namely the modulation of discharge rate, several design criteria have to be considered. A key one is the flow pattern in the bin above the feeder. There are two primary flow patterns that can develop in a bin during discharge: funnel flow and mass flow. Both patterns are shown in Figure A.

In funnel flow, an active flow channel forms above the hopper outlet, with stagnant material at the periphery. As the level of material in the bin decreases, material from stagnant regions may or may not slide into the flowing channel, depending on the bulk material's cohesive strength. When the bulk material has sufficient cohesive strength, the stagnant material does not slide into the flow channel, which results in the formation of a stable rathole. In addition to flow stoppages that occur as a consequence of ratholing, funnel flow can cause material degradation, results in a first-in-last-out flow sequence, and increases the extent to which sifting segregation impacts the uniformity of the discharging material.

In mass flow, all of the material is in motion whenever any is withdrawn from the hopper. Material from the centre as well as the periphery moves toward the outlet. Mass flow hoppers provide a first-in-first-out flow sequence, eliminate stagnant material, reduce sifting segregation, and provide a steady discharge with a consistent bulk density and a flow that is uniform and well controlled. Requirements for achieving mass flow include sizing the outlet large enough to prevent arching and ensuring the hopper walls have sufficiently low wall (material/surface boundary) friction and are steep enough to achieve flow at the walls.

A bin's flow pattern is strongly influenced by the feeder below the hopper. Ultimately, a feeder, regardless of the type (volumetric or gravimetric) should accomplish the following [1]:

- Provide reliable and uninterrupted flow of material from the bin above.

Table 1: Summary of differences between feeders and conveyors

Attribute	Feeder	Conveyor
Mode of operation	100% full	Partially full
Speed of operation	Variable, relatively low speeds	Fixed, relatively high speeds
Capable of rate control	Yes	No

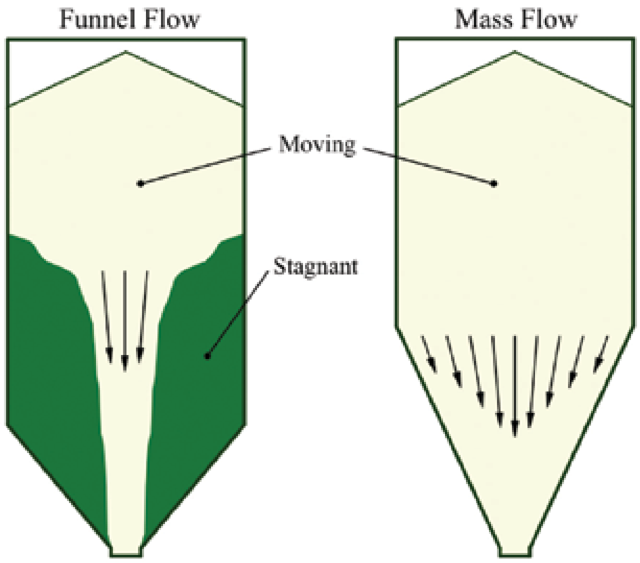

Figure A: Funnel and mass flow patterns.

- Control discharge rate from the bin, achieving the required rate while preventing flooding.
- Remove material from the entire cross section of the hopper outlet. This is particularly important if a mass flow pattern is desired [2].
- Interface with the hopper above such that loads acting on the feeder are minimized. This minimizes the power required to operate the feeder, particle attrition, and abrasive wear of the feeder components.

The major considerations in deciding which type of feeder to use are the properties of the bulk material being handled (e.g. cohesiveness, maximum particle size, particle friability, propensity for dust generation) and the application (e.g. geometry of hopper outlet, need for volumetric or gravimetric control, necessary throughput) [3].

When starting to design a bin or hopper, one of the first things that should be decided is what shape the outlet will be – square, round or elongated. This decision should be based on the flow properties of the material and facility constraints.

Square and round outlets provide more flexibility in the choice of feeder and have fewer design constraints when compared to elongated outlets. It is possible, for example, to place a belt or screw conveyor under a square or round outlet and turn it into a feeder without much in the way of negative consequences to either the bin's flow pattern or conveyor's horsepower.

In the case of an elongated outlet, this situation changes drastically. For example, if a belt is placed under a hopper with an elongated outlet and the hopper/belt interface is not properly designed, the material will channel at one end of the hopper and disrupt mass flow, as shown in Figure B.

In the case of elongated outlets, the key to a properly designed screw or apron/belt feeder is to provide increasing capacity along the length of the outlet. Another alternative for elongated outlets is a vibratory pan feeder oriented to feed across the shorter dimension.

As a general rule, conveyors should not be used as feeders, and feeders should not be used as conveyors. If modulation of flow rate is necessary and mass flow in the bin above is required, then a feeder should be used. If the horizontal distance between the hopper outlet and the discharge point is greater than two to three times the length of the outlet, then a combination of feeder and conveyor should be used, i.e. the feeder discharges onto the conveyor, and the conveyor transports the material to the discharge point.

In mass flow, proper sizing of the bin outlet is required to prevent stable arches from forming, to prohibit ratholing in the bin above, and to provide the required discharge rate. Even though square and round outlets offer larger versatility

Figure B: Belt conveyor under hopper with an elongated outlet. Belt feeds from the back (left) or front (right).

in terms of feeder choice, there are significant benefits of an elongated outlet with regards to flow. An elongated outlet reduces the minimum opening size required by a factor of approximately two when compared to a round outlet. For example, if a certain bulk material requires a minimum 60 cm outlet diameter to prevent arching in a conical hopper, the same material will only require a 30 cm wide (by at least 90 cm long) elongated outlet to prevent arching. In addition, an elongated outlet allows for mass flow to occur in a hopper with less steep hopper walls. The side walls of a conical hopper must be at least 10° to 12° steeper than the side walls of a wedge- or chisel-shaped hopper to allow mass flow with the same wall surface [4].

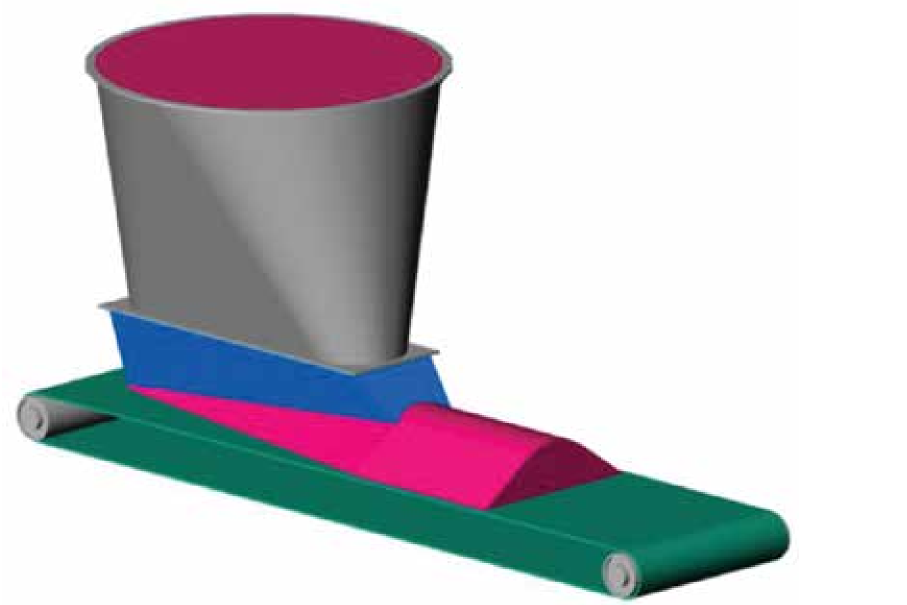

Figure C: Properly designed belt feeder interface.

Selecting and designing an appropriate feeder for a particular application with a specific bulk material is not a trivial matter. Unlike conveyors, where design rules are well developed, the same is not true for feeders – especially those used under elongated outlets.

The following general design guidelines apply to belt feeders used under elongated outlets. Similar guidelines apply for screw and apron feeders:

- Ensure that the interface between the belt and the hopper is large enough to prevent arching in the hopper and to ensure discharge of material over the entire cross section of the outlet.
- Make sure the hopper outlet is large enough to provide the required discharge rate. With fine materials, such as gypsum, fly ash, magnetite concentrate, and titanium dioxide, the discharge rate may be limited if the belt feeder is operating at a speed greater than the bulk material's critical steady-state rate of discharge.
- Beware of the possibility of flooding with fine powders. This is a common problem if the interface is not designed for uniform withdrawal and the bin is not designed for mass flow.
- Provide sufficient power to operate the feeder. Sometimes the power required to shear material and operate a belt feeder is greater than the available power. This is usually a result of a poorly designed interface.
- Structurally design and reinforce the interface to withstand the pressures exerted by the bulk material against it. Otherwise, it will deform in such a way that significantly higher forces are needed to shear the material.
- All of these issues can be avoided with a properly designed interface such as the one shown in Figure C. Some of the requirements for a properly designed belt feeder interface are [5]:
- The minimum outlet width at the rear of the interface must be greater than or equal to the value required to prevent arching in the hopper above.
- The sloping side walls must be at least as steep as the hopper wall slope required for mass flow, and a slanted "nose" with an arch-shaped cutout should be included at the front to provide stress relief and prevent stagnation at the discharge end.
- A flexible rubber or plastic buffer should be placed at the back end to allow a typical 12mm gap for uniform material withdrawal without belt or interface damage.

Summary

When designing a bulk material handling system, a decision must be made as to whether to use a conveyor or a feeder. If modulation of flow rate is required, a feeder should be used.

Misusing a conveyor for a feeder, especially without a proper interface, can result in increased power requirements and stagnant regions within the bin. If bulk materials need to be transported over long distances, then a conveyor should be used.

Several types of feeders are available, and more than one feeder may be appropriate for a particular application. Care must be taken to ensure that the feeder is designed in order to provide reliable, uninterrupted flow from the bin above, remove material from the entire cross section of the outlet (particularly important if a mass flow pattern is required), and interface with the hopper above such that loads on the feeder are minimized.

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