Flow problems are common when a dry powder is discharged from a storage vessel into a pneumatic conveying system. This article describes three common methods of promoting efficient flow in this operation: aeration, vibration, and agitation.

No matter what industry you’re in, you’ve probably run into powders that cause real problems when you try to discharge them from a storage vessel into your pneumatic conveying system. Very fine powders such as cocoa and pharmaceutical additives, crystalline powders such as sugar, powders that hold a static charge such as plastic resins, fine granular powders such as detergents, and many others have a tendency to form an arch or rathole when discharging from a silo, bin, filter-receiver, or bulk bag.

Powder arches and ratholes that cause erratic flow or stop flow from the storage vessel to the pneumatic conveying line can cause your entire production line to come to a halt. In addition, erratic flow can allow blow-by air to get into the powder in the pneumatic conveying line, causing pressure swings in the system and affecting the system’s stability. A stable system won’t plug and could allow you to run at higher pressures, resulting in more efficient conveying.

Getting the powder out of storage and into the conveying line can be the biggest challenge in designing and operating a pneumatic conveying system. So what can you do to ensure smooth discharge from your storage vessel into the system?

You’re in luck if you have a well-designed storage vessel that promotes efficient first-in first-out powder flow. The design of the vessel that discharges into your pneumatic conveying system can play a huge part in your system’s success by determining whether your powder discharges smoothly, erratically, or not at all.

The biggest design factor in promoting smooth powder discharge is the storage vessel’s hopper configuration. A vessel with a steep-angled hopper or a rectangular chisel...
hopper with 70-degree angles on opposite walls will ensure smooth discharge of most powders. These steep hoppers put less stress on the powder and reduce arching. However, they add more height to the storage vessel, increasing its headroom requirement. (Editor’s note: For more information on storage vessel design, see “For further reading” at the end of this article.)

If you don’t have the headroom for a tall vessel, and if you don’t have the resources to purchase a new vessel or redesign your current one, another solution is to use a mechanical flow aid. If you’re discharging a powder from a hard-sided vessel, such as a silo, bin, or filter-receiver, you can use a flow aid that applies aeration or vibration. If you’re discharging your powder from a bulk bag, an agitating flow aid can improve your powder discharge.

Aeration
Aeration is accomplished by injecting air into the storage vessel. There are several devices that can accomplish this. One common aeration device is an aeration disc (also called an aerator or fluidizer), as shown in Figure 1. The aeration disc consists of an air nozzle or jet that extends from the vessel exterior, through the vessel wall, and into a rubber or silicone disc mounted on the interior wall. The nozzle or jet is connected to a compressed-air source, and bursts of compressed air (typically 20 psi or less) pass through the nozzle and out from under the disc, radiating from the entire disc circumference along the vessel wall. The air fluidizes the powder, preventing it from sticking to the wall and keeping it in a flowable state.

A higher-power (typically 80 psi and above) aeration device is the air cannon, which is mounted on the vessel’s cylinder section or hopper. The air cannon consists of an air reservoir or tank, a quick-exhaust valve-piston assembly that’s connected to a compressed-air supply, and a nozzle that extends into the vessel. The cannon discharges a quick blast of air from the reservoir directly through the nozzle into the powder. The air forms an expanding “bubble” that keeps the powder moving.

Typically, both of these aeration devices are used in multiples, arranged around the vessel in a pattern designed to keep the powder moving throughout the entire vessel. Both devices can be set to automatically discharge once or in a strategic pattern at predetermined intervals. Which device you use depends on your powder characteristics, amount of stored powder, and process rate.

Vibration
Rather than using air, vibration applies indirect impact to keep the powder moving. A vast array of vibration devices is available, but two of the most common devices are impactors and high-frequency electric vibrators.

Most likely, someone in your plant has resorted at one time or another to striking a bin with a broom, hammer, or other object to dislodge stubborn powder. An impactor acts similarly, but in a more systematic and less damaging way. Typically, an impactor consists of a metal impact plate and a metal mounting device containing a pneumatically operated piston connected to a compressed-air source. The impact plate is welded to the vessel’s exterior wall and the mounting device is attached to the impact plate. The compressed air activates the piston, causing it to strike the impact plate a predetermined number of times per minute. The impact plate prevents the piston from damaging the vessel wall and also spreads the impact force over a large area, imparting a vibration effect to the powder, keeping it active. The impactor can operate continuously during discharge or at set intervals.

High-frequency electric vibrators are available in many configurations, including single vibrators that are mounted on the vessel, vibrating systems that include one or more vibrators and often a baffle system inside the vessel, and vibrators that are built into the vessel, making it a live-bottom vessel.

A typical single vibrator consists of a housing containing a motor and a metal rod with a weight on each end. The motor activates the rod, which moves the weights (usually
placed so they will move eccentrically) to create the vibration. The vibrator is mounted directly on the vessel’s exterior wall, usually on the hopper, and the vibration transfers to the powder in the vessel, keeping it active.

A vibrating system, also called a bin-activating system or bin activator, replaces the vessel’s hopper and consists of a conical housing (or cone), an adaptor ring for mounting the system to the vessel, and one or more vibrators attached to the cone. Often, the cone contains a baffle system (which may consist of simple cross-beams or an inverted cone shape) that promotes powder flow. The vibrator (or vibrators) usually operates eccentrically, keeping the powder in the cone active; the baffle system prevents the powder from clogging or arching as it passes through the cone and its outlet.

A live-bottom vessel is constructed with a built-in bin-activating system, often including a vibrating cone baffle or other vibrating mechanism integral to the vessel.

Agitation

Agitation applies mechanical force to the sides of a flexible-sided storage container, such as a bulk bag, to promote discharge. Getting powders to flow completely, not to mention smoothly, from a bulk bag can be a challenge. One way to ensure efficient discharge is to use an agitating device, such as dual-pivot paddles mounted on the bag discharge station (Figure 2). The paddles push against the bag bottom, breaking up powder clumps that might form an arch over the bag outlet or discharge spout. The paddles massage or agitate the bag bottom, stimulating powder movement. As the bag empties, air cylinders push the paddles farther toward the bag center, until a proximity sensor on one of the cylinders determines that the bag is nearly empty.

Working with your pneumatic conveying equipment supplier

As anyone who has ever built or managed a pneumatic conveying project knows, the variables involved can be staggering. They include, among other things, determining whether you’ll need a flow aid to ensure smooth delivery of your powder from the storage vessel into your pneumatic conveying system. Working with an experienced pneumatic conveying equipment supplier can be a huge help. To ensure your project’s success, the supplier must have an in-depth understanding of your process and your powder’s characteristics. This may require testing your powder at the supplier’s test center in a pneumatic conveying system that simulates your plant conditions.

For further reading

Find more information on this topic in articles listed under “Storage,” “Solids flow,” and “Pneumatic conveying” in Powder and Bulk Engineering’s Article Index (in the December 2011 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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