In this column, we’ll continue our discussion from the November 2009 column on ways to reduce your pneumatic conveying system’s power cost. This time, we’ll look at how the system’s feeding device, conveying line configuration, and air-material separation equipment affect the system’s horsepower requirements. Information is provided on how to select, design, or operate this equipment, where possible, to reduce your conveying system’s power usage.

Feeding devices
Many of us assume that it’s impossible to save energy with some conveying system feeding devices, such as a rotary valve or screw feeder, because we think that the device’s total required horsepower is for driving its rotor or screw. We may also assume that some other devices, such as a venturi or pressure tank, require no horsepower. Yet these assumptions are far from true. In fact, many of these devices contribute horsepower losses to the conveying system that we can control to reduce energy usage.

The following sections describe some common feeding devices for vacuum and pressure pneumatic conveying systems and their horsepower requirements. For each device, the information explains how to select and operate it to reduce its required horsepower, if possible, and cut your conveying system’s power usage.

Feeding devices for vacuum conveying systems. In a vacuum conveying system, even when the system has no feeding device, there’s some horsepower loss that the system’s air mover must overcome, increasing the system’s required horsepower. This is because the system requires a higher pickup velocity than a pressure system does, and the additional air mover horsepower required to create this higher velocity is considered a horsepower loss. In fact, a study of recommended pickup velocities for vacuum conveying systems reveals that the suggested pickup velocity for a vacuum system is between 10 and 20 percent higher than the recommended pickup velocity for a pressure system.

There are two reasons for the increase in suggested pickup velocity for a vacuum system: 1) The higher velocity can dislodge material from a pile, drum, or other source, enabling a vacuum wand to pick up the material for feeding to the system. 2) The vacuum system responds slowly to feedrate variations, so using a higher pickup velocity minimizes system startup problems. (Find more detailed information in the March 1996 and November 2005 columns.)

However, the vacuum system requires an increased pickup velocity only in the material acceleration zone, usually considered to be about the first 20 feet of the conveying line after the material feedpoint. So, after this point, you can increase the line diameter to reduce the conveying velocity about 10 to 20 percent to the standard velocity for pressure conveying. This will reduce the system’s operating vacuum and thus, the required horsepower.

Feeding devices for pressure conveying systems. Common feeding devices for pressure conveying systems include fluidized feeders, venturis, combination rotary feeder-airlocks, pressure tanks, and screw feeders. (For detailed information on these feeding devices and how they operate, see these previous columns: March 1994, July 1994, November 1996, March 1999, and July 2001.)

Fluidized feeder: A fluidized feeder can be used only with a fluidizable material. In this feeder, as shown in Figure 1a, fluidizing air enters the feeder vessel’s side and fluidizes the incoming material as lift air flows up through the vessel bottom toward the material-and-air outlet (that is, the pressure conveying system). Since this feeder has no moving parts, and the fluidized material’s depth in the feed vessel provides the airtight seal and pressure required for feeding, the feeder’s horsepower loss is small. The feeder’s only wasted horsepower is the energy required to provide the fluidizing air to the feed vessel. Because this feeder is usually designed to operate in a system with a 6-inch-diameter or larger conveying line and low pressure, the horsepower the feeder requires for fluidizing the air is minimal compared to the system’s required conveying horsepower. (However, in a system with a 2-inch-diameter line, the energy required to fluidize the air can approach the sys-
tem’s conveying horsepower.) While the fluidized feeder does increase the feed vessel’s required headroom, the feeder requires the least horsepower and least maintenance of any pressure conveying feeder.

Venturi: The venturi is a tube-like device with a material inlet and air inlet and a constricted nozzle section, as shown in Figure 1b. The venturi creates a vacuum at the material inlet, allowing the material to feed easily to the system, but as the air velocity slows in the venturi, the device converts the kinetic velocity pressure into static pressure, producing pressure conveying. This feeder requires no extra headroom, and as with the fluidized feeder, the venturi has no moving parts, so there’s no apparent required horsepower at the venturi’s feedpoint. However, because the venturi’s operation depends on air passing through the nozzle to create a low-pressure zone (actually, a vacuum zone) to

![Figure 1](image_url)

**Figure 1**

Feeding devices for pressure conveying systems

- a. Fluidized feeder
- b. Venturi
- c. Combination rotary feeder-airlock
- d. Pressure tank
feed the material, the venturi really has a high pressure requirement. For example, if the conveying line pressure downstream from the venturi is 3 psig, the air supply pressure to the venturi will be about 3.2 times the conveying line pressure, or 9.6 psig. So, knowing that the power requirement is proportional to the required pressure (November 2009 column), we know that this feeder has one of the highest horsepower requirements of any feeding device for pressure conveying systems.

Combination rotary feeder-airlock: The typical combination rotary feeder-airlock (rotary valve), as shown in Figure 1c, is the most common feeding device for pressure conveying systems. It consists of a rotor typically equipped with 6 to 10 blades and mounted on a rotating shaft inside a housing. The rotary feeder-airlock is usually driven by a 2-horsepower or smaller motor. But this feeding device has horsepower loss from air leakage through the rotor-tip-to-housing clearances and from the air displaced from each rotor pocket as the rotor turns, adding to the conveying system’s required horsepower. This leaked air volume, originally supplied at the conveying pressure by the air mover, ranges from about 50 to 200 scfm depending on the combination rotary feeder-airlock’s size and the conveying line pressure. In a conveying system with small-diameter line (2 inches or less) that operates at high pressure (above 10 psig), the horsepower lost to this air leakage can equal the horsepower required for conveying.

Ways you can reduce this horsepower loss and cut the system’s energy cost include using a rotary feeder-airlock with more blades (to ensure that more blades contact the feeder housing at any given time, preventing air leaks), inspecting the device frequently to ensure that close rotor-tip-to-housing clearances (typically less than 0.006 inch) are maintained, and decreasing the conveying pressure by increasing the system’s line diameter.

Pressure tank: For each operating cycle in a typical pressure tank (also called a pressure vessel or blow pot), as shown in Figure 1d, a material inlet valve opens so material can fill the tank, while the air displaced by the material exits the tank through a vent. Next, the material inlet valve and vent are closed and compressed air enters the tank, pressurizing it. The tank’s discharge valve is opened and the increasing air pressure inside the tank moves the material from the tank into the conveying line.

The pressure tank has two horsepower losses. The first one, of course, results when a given volume of compressed air is exhausted through the vent or down the conveying line for each operating cycle. For example, to determine how much air will vent from a pressure tank with a volume of 50 cubic feet cycling 12 times per hour and operating at 20 psig, we calculate $50 \times (34.7/14.7) = 115.6 - 50 = 65.6$ cubic feet per cycle. With a 5-minute cycle, this would average out to $65.6/5 = 13.1$ scfm at 20 psig. (See the November 2009 column for information about this calculation.)

Keeping the pressure tank’s filling, venting, and valve-operating time as short as possible (usually 20 percent or less of the tank’s overall cycle time) will reduce this feeding device’s horsepower losses.

Calculating the second horsepower loss is a little more complicated. For example, if we want to convey material at 4,000 lb/h and the pressure tank is cycling 12 times per hour, each cycle must deliver $4,000/12 = 333$ pounds of material. But the conveying time won’t be 5 minutes because some time is required for filling the pressure tank, venting the displaced air from it, and operating the inlet and discharge valves.

Let’s assume that the conveying system requires 1.5 minutes for tank cycling and actually conveys for 3.5 minutes. This means that this conveying system must convey 333 pounds in 3.5 minutes, which is a conveying rate of 95 lb/min or 5,714 lb/h. Since we’re conveying at a higher rate, the system operating pressure will be higher, and the corresponding horsepower requirement will be higher.

Keeping the pressure tank’s filling, venting, and valve-operating time as short as possible (usually 20 percent or less of the tank’s overall cycle time) will reduce this feeding device’s horsepower losses.

Screw feeder: In a screw feeder, which is located below a material storage vessel, a compressing screw with a reducing pitch (rather than a constant pitch) is mounted inside a tubular chamber with a material inlet at one end. The screw motor ranges from 25 horsepower, for a low-capacity unit delivering 25 tph of material, to 600 horsepower, for delivering 500 tph or more. Entering material is conveyed through the feeder by the flights at the screw’s larger end, and as the screw turns, it advances the material, compressing it into the screw’s smaller end and forcing air out of it.

The screw feeder’s obvious horsepower requirement is for turning the screw, which in many cases can approach the horsepower required for conveying the material through the system. As a result, the screw feeder usually has one of the highest horsepower requirements for a pressure conveying feeding device. However, the feeding provided by the screw feeder is continuous, so the conveying system doesn’t have to be designed for a higher instantaneous conveying rate as is the case when using a pressure tank. The horsepower this saves offsets the horsepower required to turn the screw.

One way to reduce the screw feeder’s high horsepower requirement is to reduce the system’s conveying line pressure by using larger-diameter line. However, depending on the system’s line length and capacity, the larger conveying line may be in the
12- to 18-inch-diameter range. Increasing to line of this diameter can be cost-prohibitive.

Despite the screw feeder’s high horsepower requirement, the continuous feeding it provides makes this feeder desirable for pressure systems that must run 24/7.

Conveying line configuration
In general, each bend in a pneumatic conveying system’s conveying line adds the equivalent of 20 feet of additional line to the conveying distance, increasing the required conveying line pressure and, thus, the air mover’s required horsepower. Multiple back-to-back bends in a line will greatly increase the conveying line pressure, wasting horsepower. Sloped line sections may require as much as 3 times the horsepower required by horizontal and vertical line sections of equivalent length. A conveying system designed with all parallel and perpendicular line sections can considerably lengthen the system and increase the conveying distance, also increasing the air mover’s horsepower requirement. (Find more detailed information in the July 1993 column.) Consider diagonal lines to reduce the line length and required pressure.

To minimize your conveying system’s horsepower requirements, route the conveying system to eliminate or minimize bends, avoid back-to-back bends, eliminate sloped line sections, and shorten the overall conveying system.

Air-material separation equipment
A pneumatic conveying system can have a filter-receiver (with fabric filters) or a cyclone to separate the material from the conveying air, and both devices produce a pressure drop that the system’s air mover must overcome, thus costing horsepower.

With a filter-receiver, it’s common to try to reduce the pressure drop across the filters by cleaning the filters more frequently. But cleaning the filters requires using high-pressure air, which may cost more than the energy saved in reducing the pressure drop. Another problem caused by more frequent cleaning is that with a fine material, the dust cake formed on the filter surface does most of the fines collection. If the filters are over-cleaned to reduce the conveying system’s required horsepower, particles may bleed through the filters.

A cyclone also contributes a pressure drop that the air mover must overcome. But designing a cyclone with a lower pressure drop also reduces the unit’s separation efficiency, especially when it handles smaller, lightweight particles.

Rather than try to reduce the pressure drop across your filter-receiver or cyclone, remember that the pressure drop is necessary for satisfactory air-material separation. —P.E. Solt

Endnote
1. Find topics, issue dates, and page numbers for previous “Pneumatic points to ponder...” columns in Powder and Bulk Engineering’s comprehensive article index in the December 2009 issue and at www.powderbulk.com. For more information, see “For further reading.”

For further reading
Find more information on improving pneumatic conveying system operating efficiency in articles listed under “Pneumatic conveying” in Powder and Bulk Engineering’s comprehensive article index (in the December 2009 issue and at PBE’s Web site, www.powderbulk.com) and in books available on the Web site at the PBE Bookstore. You may also purchase a CD containing all previous “Pneumatic points to ponder...” columns through 2008, or individual copies of past columns, at www.powderbulk.com.

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