Pneumatic points to ponder...

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Preventing material buildup in pneumatic conveying lines

Material buildup on the inner wall of the conveying line is one of the more common pneumatic conveying system problems and one that I'm continually asked about in the field. In this month's column, I'll discuss why material buildup occurs and ways you can prevent material from building up in your pneumatic conveying line.[1] The problem is usually caused by too much moisture in your system's conveying airstream or very fine conveyed material.

Conveying-air moisture

Moisture in your pneumatic conveying system's airstream can change your material's characteristics and make it sticky, causing the material to build up on the conveying-line wall. This problem, which is most common in pressure conveying systems, can result when the conveying-air dew point is higher than the conveyed material's temperature. This causes moisture to form on the particle surfaces, making the particles sticky. If the material contains fines with a particle size less than 300 mesh (35 microns) and moisture mixes with the fines, the material's moisture content can increase to between 0.2 and 1.0 percent, giving the material a paste-like consistency. When this material impacts the conveying-line wall, particularly where the line has a change in direction, the particles adhere to the wall and build up.

Even when the air supply entering your system's blower or compressor seems clean and dry, you may have a conveying-air moisture problem. In a vacuum or pressure pneumatic conveying system, the air pressure changes as the air flows through the system. As the air pressure changes, so does the air's volume and capacity to hold moisture. Air temperature changes have a similar effect. The air entering the blower or compressor may appear to be dry, with a relative humidity of, say, 70 percent, but when the air passes through the blower or compressor, its temperature and pressure increase. The temperature rise increases the air's volume, reducing the air's relative humidity, while the pressure rise decreases the air's volume, raising the air's relative humidity. Usually, the temperature rise reduces the air's humidity more than the pressure rise increases it. *However,* as the air moves from the blower or compressor to the conveying line, the air cools, and its relative humidity increases again. If the material being fed to the conveying system is cooler than the conveying air's dew point, moisture can form on the particle surfaces as the material contacts the air.

Let's consider two different examples of conveying-air moisture problems and how to solve them:

Example 1: A bulk bag unloading system discharges material to a pressure conveying system for transfer to a process. Both the unloading system and conveying system — including the air mover and conveying line — are inside a plant. During the winter, the material builds up inside the conveying line and plugs it. This may seem odd, since the lower humidity typical in winter makes moisture in the conveying system an unlikely problem. However, the bulk bags are stored in an unheated room for long periods before they're discharged. When a bulk bag is about to be unloaded, it's moved to the unloading area and immediately discharged. Although the conveying system was well-designed, when the conveying air contacts the very cold material, moisture forms on the material and causes the particles to build up inside the conveying line.

To solve the problem, workers should move the bulk bags into a warm room several days before unloading the material into the process. This will raise the material's temperature above the conveying air's dew point, eliminating moisture formation and preventing material buildup.

Example 2: A plant is pneumatically conveying sugar, which is both moisture- and temperature-sensitive. Because of sugar's temperature limitations, the plant installs an air cooler at the blower discharge in a pressure conveying system to cool the blower's discharge air. However, the reduced air temperature at the conveying system's elevated pressure frequently raises the air's moisture content above 100 percent humidity, causing water to form in the conveying line.

In this case, the solution is to install an air dryer after the air cooler to remove the conveying-air moisture before the material enters the system.

Fine material

Material buildup inside conveying lines has always been a problem with fine materials. Buildup is typically a problem with materials that don't fluidize well and have a particle size distribution of 100 percent smaller than 10 microns. These are materials that are classified as type C materials on the Geldart classification model discussed in previous "Pneumatic points to ponder…" columns.[2] Some common examples of Geldart type C materials are pigments such as titanium dioxide, zinc oxide, and iron oxide.

To better understand this problem and potential solutions, let's get a little technical. The normal airflow pattern in an empty conveying line is shown in Figure 1a. Along the outer walls, the airflow is *laminar* — that is, it forms a thin, smoothly flowing layer. But at the center of the conveying line, the airflow is *turbulent.* Most material is conveyed in this turbulent airflow area. As the velocity profile in Figure 1a shows, the airflow is fastest at the turbulent airflow's center and slowest in the laminar airflow along the conveying-line wall.

The laminar airflow's thickness is a function of the air velocity through the conveying line: The higher the air velocity, the thinner the laminar airflow. If all the conveyed particles are finer than the laminar airflow's thickness, particles can coat the inside wall of the conveying line, as shown in Figure 1b. The buildup is protected by the laminar airflow layer and isn't broken up by the effects of the turbulent airflow.

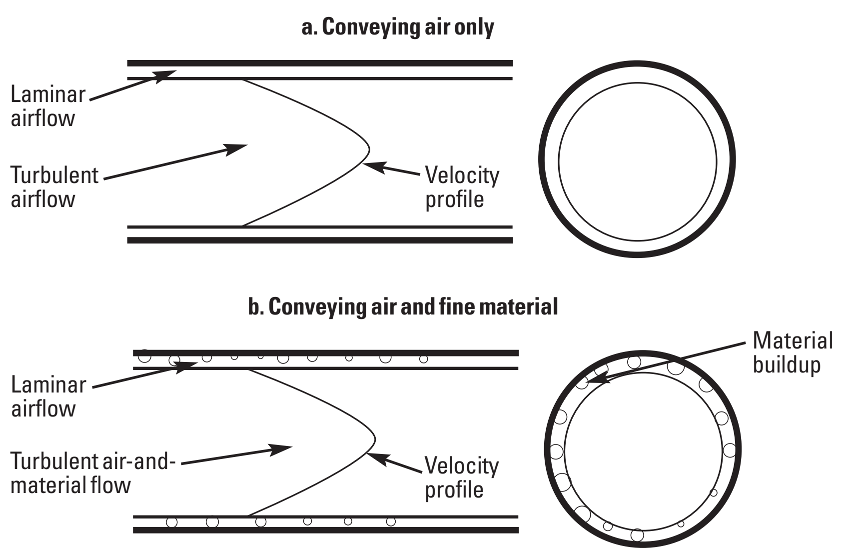
One obvious solution to this buildup problem is to convey material coarser than the thickness of the laminar airflow, but this isn't practical in most applications as you probably won't be able to increase your fine material's particle size. Another solution, which may also be impractical, is to add a small quantity of a coarser material that will act like a scouring tool to dislodge the fine material coating the conveying line.

More practical solutions to material buildup when conveying fine material are to increase the conveying velocity, change from dilute-phase to dense-phase flow, or use a flexible conveying line.

Increased conveying velocity. Increasing the conveying velocity reduces the laminar airflow thickness, which can minimize buildup but

Figure 1

Laminar and turbulent flow inside conveying line



usually won't eliminate it. The drawbacks to this solution are increased material degradation, conveying-line wear, and horsepower requirements.

Dense-phase flow. Changing the conveying phase from dilute-phase flow (or two-phase dense-phase flow) to piston dense-phase flow[3] can often eliminate material buildup while avoiding the drawbacks of increasing the conveying velocity. By conveying the fine material in pistons or slugs, the material moves by a pressure differential across the piston rather than by the conveying air's velocity. The moving pistons act like scouring tools to prevent the fine material from building up inside the conveying line. Dense-phase conveying is a condition created by the system's conveying-line diameter, air volume, and conveying capacity, not by the system's material-feeding method, so you don't need to have a pressure tank to feed the material to the piston-flow dense-phase conveying system and you don't need to operate the system at high pressure. This solution should be well thought out, however, because trying to force a material to operate in dense phase can create another set of problems, including increased force on the conveying line, which can potentially break pipe supports and connections.

Flexible conveying line. Another solution is to keep the conveying system's current air velocity and material load but change the conveying line's characteristics to make the line flexible. If you've ever tried to create a material coating on a flexible surface, you know that it's nearly impossible: Every time the surface flexes, the coating breaks off. Using this same principle, you can install a flexible rather than rigid conveying line that flexes by expansion (like a balloon) or by total line movement (by shaking, for example), so that when fine material starts to build up on the inside wall, the flexing breaks the coating off.

You can use flexible hose in conveying systems handling fine materials such as very fine calcium carbonate (100 percent less than 10 microns), pigments, and particles collected in dust collectors. To ensure that the flexible conveying line can flex properly, don't mount the line rigidly. Instead, rest the line on a support, such as a channel or angle iron, so that the line can move. The more rigid the hose, the less it can flex, potentially preventing it from flexing enough to prevent material buildup. If you're handling an abrasive material, the standard multi-ply rubber hose used for unloading bulk trailers works well. If you're handling a food or pharmaceutical product, you can use a food-grade plastic hose. In this case, be sure to ground the plastic hose properly to prevent electrostatic charge from building up along the hose and triggering an explosion or fire.

Using a flexible conveying line works especially well for a sticky material with a high fat or moisture content. A recipe premix plant, for example, was pneumatically conveying a bakery mix with a high fat content to a process, and material buildup in the system's rigid conveying line was causing frequent line plugs. Replacing the conveying line with translucent, flexible plastic hose almost completely eliminated the buildup. The company installed a pressure monitor in the plant's control room to indicate above-normal conveying system pressure. When the system pressure increases above normal, the operator walks over to the conveying line and looks through the hose to spot any buildup. After finding buildup, the operator taps the hose, dislodging the buildup and returning the system pressure to normal.

In my next "Pneumatic points to ponder…" column, I'll discuss using flexible conveying line for your pneumatic conveying system in greater detail. **PBE**

References

1. The information presented here is adapted from the November 2008 "Pneumatic points to ponder…" column. See "For further reading."
2. Find a detailed explanation of the Geldart model in the March 2011 "Pneumatic points to ponder…" column. See "For further reading."
3. For more information about pneumatic conveying phases, see "For further reading."

For further reading

Find more information on this topic in previous "Pneumatic points to ponder…" columns or in articles listed under "Pneumatic conveying" in *Powder and Bulk Engineering*'s article index in the December 2015 issue or the Article Archive at *PBE*'s website, www.powderbulk.com. (All articles and columns listed in the archive are available for free download to registered users.) You may also purchase a CD containing all "Pneumatic points to ponder..." columns from 1989 through 2008 from the Store at www.powderbulk.com.

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