Using heat exchangers to solve temperature and humidity problems in pneumatic conveying systems

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Pneumatic conveying systems are used in many different applications with a diverse range of products. However, with some products the temperature or moisture content of the conveying gas causes problems. Heat exchangers designed specifically for use in pneumatic conveying systems can effectively and efficiently change the conveying gas's temperature, moisture level, or both to prevent degradation of the conveyed product. This article discusses the advantages and disadvantages of heat exchangers commonly used in pneumatic conveying systems. Problems solved by heat exchangers are also discussed.

Increased temperatures and high humidity can cause problems in pneumatic conveying systems, especially for materials such as plastics and food products. Many plastics melt at 250°F. Products such as cake mix and sugar are degraded by high temperatures and high humidity.

When a gas is compressed, its temperature increases. Positive-displacement and centrifugal blowers used in pressure pneumatic conveying systems typically raise the conveying gas temperature 13° to 15°F for every 1 psi of pressure produced. If the inlet temperature of a 15 psig blower is 100°F, the outlet temperature ranges from 195° to 225°F.

Air and other gases are also able to support less moisture when they're compressed, resulting in a higher relative humidity and dew point. For example, if ambient air at 98°F with a relative humidity of 68 percent is compressed to 15 psig, the dew point rises to 111°F. In other words, dew forms if the air contacts a surface cooler than 111°F.

These temperature and humidity problems can be avoided or solved by using a heat exchanger to change the temperature of the conveying gas. Heat exchangers use a service media such as water, refrigerant, or steam to either heat or cool the conveying air.

Types of heat exchangers

Three types of heat exchangers are commonly used in pneumatic conveying systems: shell and tube, extended surface, and double extended surface.

Shell-and-tube heat exchangers consist of a metal shell with metal tubes running through it. The conveying gas passes through the tubes, which are surrounded by service media circulating in the shell. For many years, the US pneumatic conveying industry relied on shell-and-tube heat exchangers as they were the only type available. However, because the inside and outside surface areas of the tubes are nearly the same, shell-and-tube heat exchangers
don't transfer heat well between good heat conductors, such as water, and poor heat conductors, such as air. They are also bulky and produce a relatively high pressure drop in the conveying air. As such, they've been replaced by more efficient extended-surface and double-extended-surface heat exchangers that are designed specifically for pneumatic conveying applications.

*Extended-surface heat exchangers* have fins on the outside of the service media tubes (Photo 1). The fins increase the ratio of outside to inside surface area — usually to around 20:1. Because of this, extended-surface heat exchangers are very good at transferring heat between a poor heat conductor (such as air) on the extended, or finned, side and a good heat conductor (such as water, refrigerant, or steam) on the tube side.

A typical unit consists of finned tubes (much like those in an air conditioner) encased in a pressure housing. The service media circulates inside the tubes; the conveying gas passes through the pressure housing and blows past the fins. The fins transfer heat from the conveying gas to the service media or vice-versa.

The temperature of the conveying gas can closely approach the temperature of the cooling or heating media; within 10°F is usually practical. In addition, the pressure loss on the conveying gas is typically less than 5 inches water column.

However, this type of heat exchanger can be difficult to install. You have to run plumbing for the service media. The service media can also be expensive, especially if a refrigerant or chilled water is used. In addition, the unit can be damaged by freezing temperatures if water is used as a service media. However, this problem can be avoided by installing a drain petcock on the tube assembly.

The finned tubes can be constructed of copper, aluminum, cupro-nickel, stainless steel alloys, or carbon steel. The most economical units use copper tubes and aluminum fins, as these materials are excellent conductors of heat and inexpensive to fabricate. Pressure housings can be constructed of plain or galvanized mild steel, aluminum, or stainless steel alloys.

Standard extended-surface heat exchangers can handle conveying gas pressures to 14 psig and gasflows from 200 to 5,000 cfm. Custom units can be built to handle greater pressures and gasflows.

*Double-extended-surface heat exchangers* (Photo 2) have large surface areas on both the conveying gas and service media sides, which allow them to work well for exchanging heat between two poor conductors, such as between air and air or nitrogen and air. These exchangers pass the conveying gas through an aluminum core that is finned on the inside and outside. The service media is ambient air, which is drawn over the core by an electric fan.

Since ambient air is used as the service media, the unit is limited to cooling within 10° to 15°F of the ambient temperature, which may vary. Typical pressure losses are less than 15 inches water column.

*Photo 1: Extended-surface heat exchangers use water, refrigerant, or steam as service media; conveying gas can be cooled or heated.*

*Photo 2: Double-extended-surface heat exchangers use ambient air as a service media.*
Double-extended-surface heat exchangers are very easy to install; the only hookups required are for the conveying gas and the fan's electricity. There's also little chance that the unit will be damaged by freezing temperatures.

Double-extended-surface heat exchangers are generally constructed entirely of aluminum because it conducts heat well. Standard units handle conveying gas pressures up to 30 psig and gasflows up to 1,000 cfm. Custom units can be built to handle greater pressures and gasflows.

**Problems solved by heat exchangers**

Heat exchangers can improve the operation of pneumatic conveying systems that have problems with excess heat, or humidity, or both. The following examples illustrate typical problems.

**Excess heat.** Assume you're conveying plastic pellets in a pressure system. The conveying line temperature is 325°F at a pressure of 15 psig. Because the melting point of the pellets is 135°F, the pellets are melting, degrading the product and plugging the conveying line.

To solve this problem, you can install an extended-surface (gas-to-water) or a double-extended-surface (gas-to-gas) heat exchanger on the discharge side of the blower. The heat exchanger cools the conveying gas from 325° to 110°F, preventing product degradation and line plugging.

**Excess humidity.** Your company is vacuum conveying fly ash from a coal furnace. Moisture is condensing in the conveying line, wetting the ash, and causing the system to plug.

To solve this problem, you can install an extended-surface heat exchanger at the vacuum inlet, using steam to heat the conveying gas. This raises the conveying gas's temperature above its dew point, lowering the relative humidity and preventing condensation.
**Excess humidity and a heat-sensitive product.** If you’re pressure conveying a product like powdered milk, you have to watch both moisture and temperature: Humidity in the conveying air will combine with the powder, causing it to plug the conveying lines; heat will damage the powder. Thus, cool, dry air is needed to successfully convey powdered milk.

In this case, cooling the air alone is not a viable solution, because cooling will raise the relative humidity and eventually bring the air to saturation. A steam heater alone would solve the humidity problem, but the heat would have a detrimental effect on the powder.

This problem can be solved by first cooling and dehumidifying the air, then warming it. First, the conveying air passes through a heat exchanger using water as a service media. This is an inexpensive way to remove the bulk of the heat load. Next, an extended-surface heat exchanger, using either chilled water or refrigerant, cools the air below its dew point. The humidity condenses from the conveying air and is collected and removed. This leaves cool, saturated air that you can then pass through a second extended-surface heat exchanger, this time using steam as the service media. This results in cool conveying air with a low relative humidity.

**Installation precautions**

When you install a heat exchanger in a pneumatic conveying system, you should take a few precautions to avoid damaging the exchanger. First, isolate the exchanger from the blower’s vibration and pressure pulses by installing a chambered silencer and a flexible connection between the blower and the heat exchanger (Fig. 1). Second, install a relief valve and a check valve at the heat exchanger’s outlet. Should the conveying line plug, the relief valve will prevent a pressure buildup in the exchanger that can damage the pressure housing. The check valve will prevent any conveyed product from backing up into the exchanger.

**Conclusion**

A heat exchanger designed specifically for use in a pneumatic conveying system is an efficient way to solve temperature and humidity problems. When choosing a heat exchanger for a pneumatic conveying application, consider the heat and humidity tolerances of the product being conveyed, the conveying system’s design, and the type of service media available.

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