How to Use Humidity Control in Heat Processing

By Michael Grande, Wisconsin Oven

Some materials can be processed more effectively in a humidity controlled environment. If your process could benefit, don't hesitate. Specifying a humidity controlled oven isn't as hard as you think.

Many heat processing applications require more than simply applying heat to a product to obtain the desired result. In some applications, it is beneficial to increase and control the relative humidity in the heating chamber. Examples include curing certain coatings on glass, drying sealants on aircraft parts, processing lead battery plates, paper processing, drying aluminum printing plates and curing special gasket material. The goal is to apply heat without subjecting the product to the full drying effect of convection heating.

When should you use humidity control? The answer depends on your process.

For instance, certain gasket materials are applied as a bead, similar to a caulk, and cure into a durable, foam-like state in an elevated humidity environment. For optimum cure, these materials may need to be heated to 120°F (49°C) at a 90% relative humidity, for example. Your gasket material or coating supplier will be able to help you determine the best heating/humidity profile.

Another potential application is quality assurance testing. Some electronics manufacturers, for example, subject their products to elevated temperature and relative humidity to simulate worst-case environmental conditions.

Enhanced humidity oven systems can be either batch-type or continuous, depending on your process requirements. The important thing is to not be apprehensive about utilizing an enhanced relative humidity oven system if you feel it will benefit your process.

What is Humidity Control?

First, we must define what is meant by relative humidity (RH). Simply put, the relative humidity at a given temperature is the ratio of moisture (water) in the air to the maximum amount of moisture the air can hold at that temperature. Hot air can hold more moisture than cool air; therefore, as the temperature of air increases, relative humidity decreases. This means that if you want to maintain a constant relative humidity while heating the air, moisture must be added. And, to increase the relative humidity of air already at an elevated temperature, you must add substantially more moisture.

Second, it is important to understand that the two key variables, temperature and relative humidity, are interrelated, and relative humidity is the dependent variable. Therefore, it is meaningless to specify a certain relative humidity without also specifying a corresponding temperature.

In a process application, the humidity is controlled by adding the desired amount of moisture to the air while maintaining the desired temperature. It sounds simple - and it is, provided the system is designed properly. Your system can be designed several ways, depending on the method of relative humidity enhancement.

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How is Humidity Added?

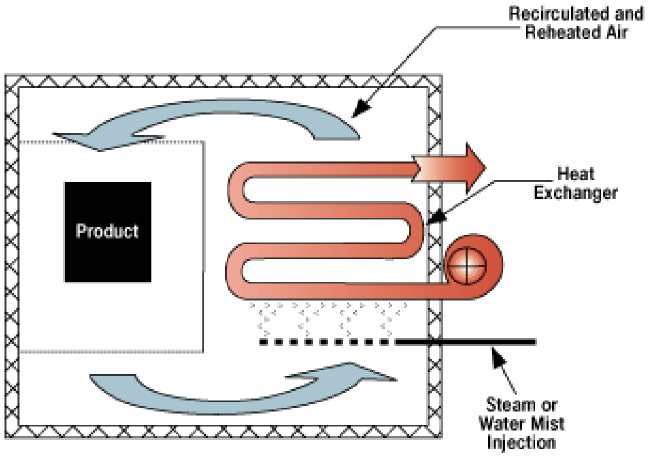

Figure 1. Gas-fired ovens must employ an indirect heating method where the burner is fired through a heat exchanger. Products of combustion from the burner can disturb the moisture-to-air ratio in humidity controlled ovens.

There are several ways to enhance the humidity in an oven. One technique is air atomizing nozzles. These nozzles mix air and water to generate a mist that is injected into the airstream circulating within the oven. Two separate piping assemblies are used: one for air and one for water. Each has its own valves, filters and pressure regulator. During system setup, both pressure and flow of the air and water are adjusted to achieve proper nozzle misting. The desired relative humidity is maintained by a sensor that measures the relative humidity and opens and closes the water solenoid valve as required.

This technique is simple and inexpensive, but it only is suitable for lower temperatures and lower relative humidity. It will comfortably provide 20 to 30% relative humidity at 120°F, for example. It is important to note that not all of the mist generated by the nozzles successfully evaporates into the air immediately upon being discharged. Some of the moisture is carried in droplet form and collects on internal surfaces. Care must be taken during oven design to prevent water from dripping or spraying onto the product being processed. A drip pan usually is necessary to collect the moisture that does not evaporate immediately.

Another way to generate humidity is by injecting steam into the oven, typically (but not always) into the air recirculation ductwork. With this approach, a steam generator is required. One advantage of steam humidification is that higher relative humidity can be obtained - up to 100% at certain temperatures. Also, steam humidification is a constant dry-bulb process - because the water already has been evaporated before it is injected into the oven as steam, it has little effect on the oven temperature. By contrast, the nozzle method uses the oven heat to evaporate the water, so it requires an increased oven heat input to overcome the cooling effect of evaporation. The primary drawback of the steam injection approach is greater complexity and capital cost - the steam generator is a separate unit that must be purchased and installed with the oven. Depending on the system design, water softeners also may be required, adding to the cost, and as with nozzle humidification, a drip pan typically is required. It may even be necessary to locate the oven directly over a drain at higher relative humidity levels. The same types of sensors used in nozzle systems typically are suitable for steam.

Oven manufacturers also use other methods that can best be described as hybrid systems, where steam is generated by heaters inside the oven. These systems often can provide a satisfactory solution that balances cost and performance.

Required Equipment

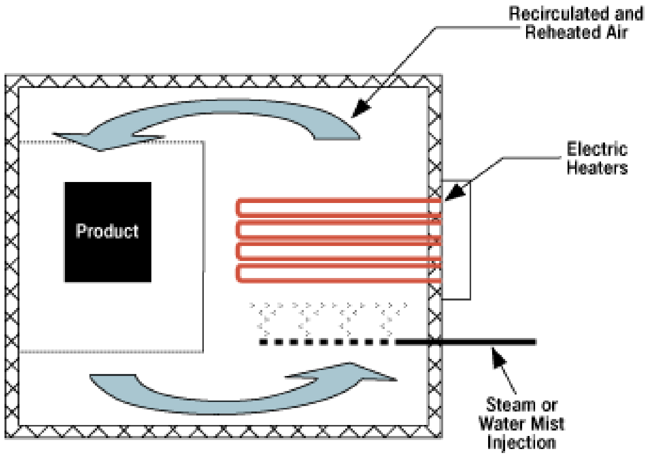

Figure 2. In electrically heated, humidity controlled ovens, electric resistance heating elements are used.

All systems that provide enhanced relative humidity require a means of sensing the humidity to provide closed-loop control of the steam or atomizing nozzles. Relatively low cost electronic relative humidity sensors are available for most applications. A thin film polymer type, for example, is suitable for temperatures up to 662°F (350°C). Another common sensor is the wet/dry bulb type. While this design has certain advantages, it is limited to lower temperatures. Some special applications for relative humidity measurement and control require more exotic sensors. Variable capacitive measurement devices are available that measure relative humidity at temperatures up to 1,220°F (650°C) or even 1,832°F (1,000°C). Finally, portable instruments that can accompany the product on a conveyor and record the relative humidity data for downloading later also are available.

Oven Design. Ovens designed for enhanced relative humidity incorporate features that are different than those selected for nonhumidity applications. Many relative humdity-specific features are costly, but necessary. It is important that the system you purchase be designed with your application in mind.

If your process is rigorous - where the system will be used frequently with high relative humidity levels - a stainless steel interior may be desired for longevity. In conveyorized applications, a stainless steel or acetal (plastic) conveyor belt may be necessary. In most applications, it is important that the oven interior shell be sealed; otherwise, condensation can infiltrate the insulation and eventually saturate it. Sealing the oven can be accomplished in several ways depending on the temperature and relative humidity.

Enhanced relative humidity ovens are most often gas or electric heated. On gas-fired systems, if the products of combustion and moisture generated by the burner are allowed to mix with the oven process air, the humidity control will be disturbed. Therefore, the burner must be fired through a heat exchanger, which then is used to heat the oven recirculating air indirectly. Such precautions are not necessary for electric heat.

An enhanced relative humidity oven system may offer certain advantages for your process. If you are considering such a system, contact an oven manufacturer with experience in this area. They will be able to guide you to a successful solution.