Better Drying with Infrared

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Want to reduce energy costs, increase productivity and improve product quality? Here are four things you can do with infrared to improve your drying process.

Figure 1. Precise product drying can happen only with precise temperature control. In this control and user interface for an electric infrared predryer, thermocouple feedback control loops use SCR controls for precision.

Drying coatings or saturants on substrates is a common process heating application. The simple process of evaporating water or other solvent from a coating can consume large amounts of energy. Moreover, the rate at which a coating is dried on a product while it is being manufactured often is the critical factor in determining how fast the manufacturing line can run; likewise, product quality often is determined by how smoothly or thoroughly a coating is dried. Therefore, any improvement in drying can reduce energy costs, increase productivity and improve product quality. One way to improve drying operations is to add or use infrared energy.

For process heating, infrared energy can be generated by electric or gas infrared heaters or emitters. Each energy source has advantages and disadvantages. Typically, gas infrared systems are more expensive to buy because they require safety controls and gas-handling equipment, but they often are less expensive to run because gas usually is cheaper than electricity. Gas infrared is often a good choice for applications that require a lot of energy. Of course, the product being heated has to be able to withstand the intense heat. Products such as nonwoven and textile webs are examples where gas often is a good choice. By contrast, electric infrared is likely better for sensitive substrates such as film and certain fabrics and where "quiet heat" is needed.

So, the first thing that you can do to improve the efficiency of a drying application with infrared is to be sure that you select the energy source that works best for your application given the utilities and capital investment money available to you. There are many types of electric and gas infrared heaters from which to choose that are likely to meet your needs. Your decision process must consider not just equipment specifications and heat load calculations but also how these process heaters perform on your particular product. That is why it is important to do some feasibility testing on a supplier's pilot lines before making a purchasing decision. There is nothing like getting some samples of your actual product to help you decide among many possibilities.

Temperature Control

Figure 2. For efficient drying with infrared, it is best to mount the infrared heaters in an insulated oven enclosure as in this 8.25' long dryer. The reflective interior redirects energy to the product where it is needed, and the integral support legs permit the dryer to straddle a tenter frame. Controlled air input and exhaust accelerate drying of waterborne adhesives on a web.

The second thing you can do to improve the efficiency of a drying application with infrared is to have good control of the heat. There are several factors in good control. Whether you are using electric or gas infrared, it is important that the temperature profile across the web or conveyor be precise enough to meet your quality standards. For example, for wide products that require even heat across the entire width of the product, electric infrared heaters can be divided into multiple, separately controlled temperature zones with tolerances as tight as +/-1°F. Preheating vinyl before embossing is a good example of this: To ensure a uniform emboss across the vinyl, the temperature needs to be uniform. Gas infrared also can be zoned across product widths, but the costs may be high because you will need individual ignition and heater mixer assemblies for each zone.

Additionally, it is important to decide whether to zone in the machine direction or in the direction of product travel. In some drying applications, when the product first enters the dryer, it can withstand high temperatures because of the amount of water in it. As the product moves through the oven or dryer and contains less moisture, it may be necessary to reduce the temperature in subsequent zones to allow further drying without overheating and damaging the product. In other applications, after a product is dried, it needs to be further heated at a higher temperature. For example, if a coating needs to be cured, a quick blast of high temperature infrared sometimes is all that is needed to initiate the cross-linking process. Sintering fluoropolymer coatings on glass fabric is another example of a higher temperature zone after the drying zone.

Temperature feedback is another factor that is important in heat control of an infrared dryer. Both electric and gas infrared typically are controlled by thermocouple feedback control loops that regulate the electrical power or fuel mixture going to the infrared heaters (figure 1). For more precise -- although costly -- control, consider getting temperature feedback from the product using an optical pyrometer. Importantly, if you have a demanding process, it is wise to consider infrared heaters that respond quickly to control signals for good feedback-loop control. There are both electric and gas infrared heaters that get hotter or cooler almost instantly in response to control changes, ensuring that the product is heated consistently. These heaters also heat up almost instantly on startup, enabling you to start work quickly rather than waiting for a dryer to come up to temperature. More importantly, these rapid-response infrared heaters cool down so rapidly when turned off that, when they are interlocked with control systems to turn off on line stops, they will not emit residual heat that could damage products.

Electric infrared usually offers more flexibility of control than gas infrared because it operates over a wider temperature range. Gas infrared burners have a limited turndown, so when lower emitter temperatures are required, gas is less suitable.

Control systems for infrared dryers can include PLCs and touch-screen interfaces. The important thing for an efficient drying application is to get the appropriate type of zoning, feedback and control flexibility for your application.

More Than Just Heaters

For a product to be heated by infrared, the product must absorb the infrared energy. Substrates and coatings do not absorb all of the infrared energy that is emitted. Some of the energy is transmitted through the product and some is reflected. To improve the efficiency of a drying process, care must be taken to use as much of the transmitted and reflected energy as possible. So, the third thing that you can do to improve the efficiency of a drying application with infrared is to be sure that the entire mechanical design of the system is efficient, not just the infrared source. The infrared heaters are an important part, but not the only part, of a drying system.

Figure 3. This vertical dual-radiation electric infrared tower preheats a paper web to reduce residual moisture before a urethane coating is applied. Electric infrared heaters on both sides of the product deliver massive amounts of energy while an optical pyrometer control maintains exact temperature in the system.

Typically, infrared heaters are mounted in some type of an enclosure. Therefore, designing a dryer with metal reflectors above, below and on the sides of the product path can redirect energy back to the product so more of the energy is used to heat the product. Well-insulated oven enclosures, insulated, gasketed access doors and insulation on the backs of the infrared heaters also help to reduce heat losses and direct the infrared energy towards the product (figure 2). Although these basic mechanical design elements may seem mundane, they cannot be taken for granted. They have a great effect on improving drying efficiency.

Furthermore, the basic configuration of the infrared dryer needs to be considered. Dryers can be mounted horizontally, vertically or in an arched configuration. For example, in applications that require a lot of energy but have limited floor space, vertical systems with small footprints may be a way to have an efficient drying application. Multipass dryers can allow you to pack even more energy in a limited space. The product can enter a two-pass, tower-type infrared dryer from the bottom, travel up the first tower and be steered by idler or driven rolls down into the second tower. This configuration means the moving fabric or web has been exposed to several feet of heat in only a few feet of floor space. To make things even hotter and drying faster, infrared heaters can be mounted on both sides of the towers to deliver heat to both sides of the product at once (figure 3). This is especially effective for saturated nonwovens and fabrics or for removing residual moisture from paper webs as opposed to products that are coated on one side only.

Combining Infrared with Air

The fourth thing you can do to improve the efficiency of a drying application with infrared is to experiment with combining infrared with either hot air or ambient air, especially if you are dealing with waterborne coatings that require more energy to dry than solvent-based chemistries. Controlled airflow is not only necessary for proper ventilation and exhaust, it also can enhance drying of coatings. In an infrared/air dryer, infrared provides the energy for heating and air removes the water vapor. Hybrid dryers are especially effective for drying coatings, finishes, inks and adhesives on sensitive substrates like polycoated release paper and film, where excessive heat could damage the web or fabric.

Figure 4. This vertical gas infrared fabric predryer blasts the product with high intensity infrared energy from both sides, which helps to kick off the drying process and allows faster line speeds.

Infrared/air dryers come in many configurations. For one, infrared heaters can be used as predryers before hot air dryers. The infrared predryer quickly raises the product temperature, starting the evaporative process before the product enters the hot air dryer, resulting in faster line speeds. This drying method is effective on textile fabric finishing ranges and paper coating lines (figure 4).

Infrared also can be introduced between the nozzles of a hot air dryer. Often times, manufacturers have had to slow down coating lines when using waterborne coatings to give the product more dwell time in the hot air dryer. Alternatively, they go to longer dryers. One solution decreases productivity; the other uses more plant floor space. By mounting infrared heaters between hot-air nozzles, added energy is delivered to the product to facilitate drying at fast line speeds in the existing dryer footprint.

Ambient or heated air also can be directed toward the product from between infrared heater modules in a dryer and then exhausted. In this configuration, as a coating or saturant absorbs infrared energy and the water evaporates, air scrubs the surface of the coating, carrying away the water vapor and enhancing drying without blistering the coating or damaging the substrate (figure 5).

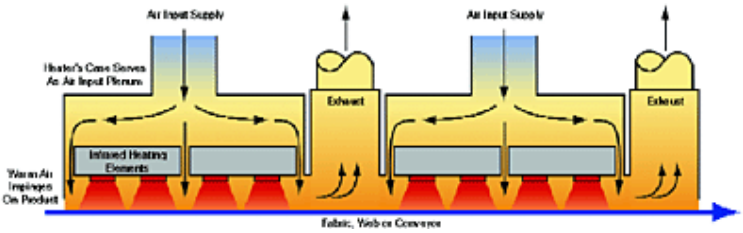

Figure 5. Air input and exhaust between infrared heaters accelerates drying and prevents visual defects such as blisters on coatings. Air scrubs the surface of the coating, carrying away the water vapor and enhancing drying.

So, what can you do with infrared to improve drying processes? One, select the appropriate energy source for your application. Two, get good heat control. Three, be sure that your infrared heaters are designed properly into an infrared dryer. Four, use air with infrared. Finally, remember, infrared is a great way to dry many products, but the infrared heat you use should be delivered by an efficiently designed system that is engineered to meet the particular drying requirements of your product.