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Infrared Equipment Division of IHEA

This column is provided to you by members of the Infrared Equipment Division (IRED) of the Industrial Heating Equipment Association (IHEA). The group includes infrared (IR) curing equipment suppliers from throughout North America. We publish the column three times a year to give you the latest information about IR curing techniques and equipment. Contact information is at the end of the column. Most IR manufacturers offer testing for free or for a fee. Any IRED member can assist you in finding solutions to curing problems and best practices for finishing of coatings. This issue's column was submitted by IRED member Tom Rozek, Red-Ray Manufacturing, Branchburg, N.J.; telephone 908/722-0040; Web site [www.red-ray.com].

Adding gas-fired infrared energy to a powder coating process: A decision-tree analysis

Regardless of the application, interest in adding infrared (IR) energy into commercial ovens is gaining momentum. This is true in many application areas that have typically relied on convection heat, such as the food industry as well as the industrial process industries. In fact, several equipment manufacturers are beginning to produce all IR ovens. The reasons are many. Less square footage is required to produce the same output, so ovens can be made smaller. A reduced footprint means lower acquisition costs and lower operating costs (less wasted heat). Ovens can be made more efficient. Higher efficiency means lower carbon dioxide (CO_2) emissions and lower ventilation losses. Infrared energy delivers the BTUs to the substrate where they are needed (line of sight), not to the surrounding air, which is then exhausted.

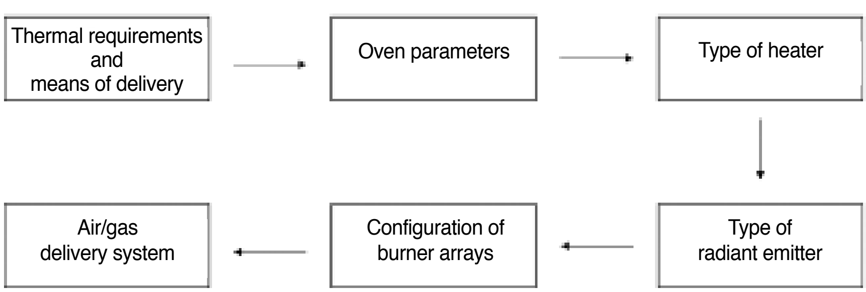
There are many factors to consider when making decisions about adding IR energy into a powder coating or an electrodeposition-coating (e-coating) process. Even though there is no standard approach, there is a certain logic sequence that needs to be followed. This is shown in Figure 1.

Determine thermal requirements and means of delivery (IR versus convection)

Thermal energy is needed to dry the parts after they're washed, to advance the powder coating to the gel stage, and to cure the powder coating.

FIGURE 1

Decision flowchart



Infrared heating can be used in all three areas in the design phase of the production line or in a retrofit situation. The thermal requirements can be defined by using the BTU calculator in Figure 2. This calculator is available in an Excel format that enables quick calculation of the thermal requirements for various-sized parts of different materials, with different spacing and line speeds. Area dimensions, thicknesses, and heat capacities are all factored in.

In the drying process, heat is needed to bring the water and the part to the change-of-state (vapor) temperature, which for water is 212°F. The specific heat (heat capacity) of both water and the material are needed to make this calculation. To further increase the temperature to the desired operating range, the heat of vaporization (latent heat) of water and the specific heat of the material are needed. It requires 965 BTUs to change one pound of water to one pound of steam. The water content of the part can be approximated by the weight differential of the dry part and the wet part. The drying process is particularly critical with certain metals, such as zinc castings, which can outgas, compromising a finished coating.

In the gelling process, heat is needed to advance the powder coating to the gel stage. The gel temperature depends on the powder type used and is specified by the manufacturer. It's important to advance the powder coating to the gel stage as soon as possible in an oven to reduce the risk of contamination, allow for an even flow, and optimize the surface luster. The curing temperature and dwell time are also specified by the manufacturer.

Whether they're used in the drying, gelling, or curing phase, IR heaters are often chosen over convection heaters because they're more efficient in delivering the BTUs where they're needed. This reduces overall energy consumption and CO2 emissions.

Define oven parameters

The oven design is based on the thermal requirements of the parts, dwell (or soak) time needed at a desired temperature, and expected line speed. The part dimensions will determine the size of the oven opening. Using IR heating can reduce the overall size of the oven and the complexity of the conveyor's serpentine arrangement. Size and complexity reductions result in a smaller footprint, which reduces overall heat loss, oven capital costs, and plant floor space. Infrared heating often allows for increased line speeds, reducing the variable and fixed costs per part. This is particularly true in a retrofit situation.

Select type of heater needed

There are three basic types of IR heaters: gas, gas catalytic, and electric. Though they're not mutually exclusive, gas IR is most often used with substrates that are heat-tolerant. Because of its lower operating temperature, gas catalytic IR can be used with temperature-sensitive substrates. Because of the many construction variations with electric IR, it can be designed for a broad range of substrates. Testing by the end user or vendor is recommended to determine the optimal IR energy source.

Select optimal radiant emitter

Different emitter options are available with each basic type of IR heater. Selection somewhat depends on the wavelength desired for the coating and the material to which the coating is applied. Medium-wavelength emitters, which operate at temperatures of 1100°F-1900°F, are often selected for powder coating ovens because of their wide range of applicability.

With gas-fired IR, the emitters can be constructed of metal alloy fiber, coated ceramic fibers, metallic refractory foam, or gas impingement ceramic refractory. Metal alloy fiber emitters have very high surface areas and high IR flux density. These emitters are most often fixed to a stainless steel body. Ceramic fiber and metallic foam emitters have somewhat lower IR flux density and are fastened to cast iron bodies through the use of high-temperature gaskets and hold-down assemblies. All three of these emitter types produce about 65 percent IR and 35 percent convective energy at their rated input capacities. They quickly reach maximum temperature and cool to the touch within seconds. This allows them to be turned on and off, saving energy and preventing overheating of parts during line stops. The quick response also reduces labor and lost productivity costs because waiting time is diminished.

Gas impingement burners using ceramic refractory emitters are high-velocity burners. This high-heat flux causes a scraping action and improves diffusion of the surface layers surrounding a part. Their output is about 35 percent IR and 65 percent convective energy. They're most often used in the curing section of an oven. The refractory emitters have a lag time between full radiance and cool down. The burner bodies can be either cast iron or special cast alloy, and the construction is very durable.

Gas catalytic IR emitters operate at temperatures of 450°F-900°F and predominantly produce long-wavelength IR. They require a longer heat-up time to reach full radiance. Electric IR emitters have a faster response time, and because of the different metals and mounting methods used, can be tailored to the desired wavelength. However, most heaters require reflectors to direct the energy to the material being processed. These reflectors need to be cleaned regularly, creating downtime that can reduce overall process efficiency. Relatively high electricity costs also need to be factored into operating costs.

Figure 2

BTU requirement calculator

Part requirement

Length (inches)	Width (inches)	Area (sq in)	Weight for gauge (lbs/sq ft)	Part weight (lbs)

Oven loading

Part weight (lbs)	Spacing (ft apart)	Belt speed (ft/mn)	Belt speed conversion 1 (ft/hr)	input (lbs/hr)

Heat requirement

Oven loading	Beginning temp (F°)	Ending temp (F°)	Temp differenial	Heat capacity (BTU/lb °F)	BTU/hr required

Actual heat required

BTU/hr required	Efficiency loss factor	Actual BTU/hr required	Output/ burner	# of burners needed

Configure burner arrays

Burner arrays can be configured in many different patterns. Infrared heat is often used in the vestibule of an oven with any convective heat ducted back into the cure oven. The burners are often mounted vertically with the length approximating that of the opening. The burners are offset so that they're not firing directly at each other. A ceramic insulation board is typically placed between the burners. This insulation board is typically rigid calcium silicate or aluminum oxide ceramic foam. The surface of the board reflects the radiation back onto the parts, prevents the energy from escaping the vestibule chamber, and keeps the burner bodies cooler. Gelling can now occur several feet into the oven instead of 10-15 feet. The temperature in the subsequent convection cure zone can be reduced 20-30 degrees, saving energy cost.

Inside an oven, the burner arrays can be configured in a vertical, horizontal, or diagonal pattern along the sides. They can also be configured to surround the part if it's irregular in shape. Burners should be placed as close as possible to the part because IR energy received by the part is inversely proportional to the square of the distance from the emitter. Positioning of the burners based on the part shape and size should be carefully thought out to maximize overall process efficiency.

Define premix air/gas delivery system

If the decision is made to use a gas-fired oven, proper sizing of the air/gas delivery system is critical. In the design phase, gas-fired IR burners can be coupled to the air/gas delivery system. In a retrofit situation, a new option exists. A plug-and-play type of operating and control module is commercially available at a fraction of the cost of the individual components. This unit can power up to two 10-foot-long burner arrays while conforming to National Fire Protection Association (NFPA) codes. It has a blower, mixer, double blocking valve assembly, ignition transformer, and flame-monitoring module in a self-contained unit. This makes it simple and affordable to add IR burners to any oven or process line.

Zoning of the heaters can also be defined in the design stage or added in the retrofit stage through the use of the operating and control module. Using gas-fired IR, turndown ratios are typically 2.5 to 1. Using electric IR, modulation can be as high as 10 to 1.

Summary

The gradual evolution from solvent-based coatings to powder coatings has made considerable progress. However, the evolution from convection ovens to IR-based ovens has often lagged. In the past 5-10 years, IR heater technology and IR heat delivery methods have greatly improved. Smaller, more efficient ovens are now possible. Greater line speeds can be achieved with gelling of the powder occurring several feet into the oven, reducing floor space, contamination, and scrap.

The bottleneck of a powder coating line is often the dry-off oven. Again, IR heating has the capability to improve the process efficiency, reducing waste and increasing productivity.

A decision-tree analysis can be used to methodically determine how IR should be added to a coating process. Other tools, such as a BTU calculator, allow for optimal sizing of the heating system. Infrared technology is advancing—and so are the ways to implement it. **PC**

For more information or to submit a question, contact Anne Goyer, executive director of IRED, at 859/356-1575; e-mail [aygoyer@one.net]. See also [www.IHEA.org]. Click on the IRED link.

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