IR Curing ShopTalk

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 Marty Powell, Carlisle Fluid Technologies, Scottsdale, Ariz.

How IR can improve productivity in your plant

Adding infrared (IR) to a powder coating system can provide many benefits, but there are several things that must be taken into consideration before you take that step. Most importantly, there needs to be an understanding of what IR is, how it differs from convection, and how it can help your process.

While IR isn't the answer for every project, it is often the best choice for curing products consistently and efficiently. Using IR can lead to line speed increases, curing time decreases, energy conservation, and other cost savings. This article will define terms, dispel misconceptions, and discuss costs to help you choose the right oven for your application.

Explaining some terms

There is a lot of misinformation on IR's capabilities. Some of these misconceptions include:

- IR only heats what it sees in its direct line of sight.
- IR only works on flat surfaces.
- IR ovens are more costly to operate than convection ovens.
- IR ovens require more maintenance than convection ovens.
- IR is harmful to the oven operator.

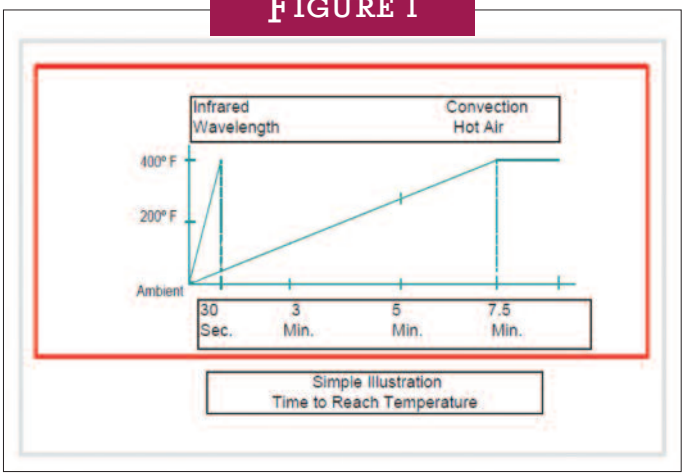
These mistruths can be dispelled simply by learning what IR is and how it works within a powder coating system. Let's start by taking a closer look at the several different types of IR emitters. An emitter gives off different wavelengths that equals the intensity of the energy or heat. This is directly related to a coating's emissivity, which is the amount of heat wavelength given off from an IR emitter source and how much of the energy is absorbed.

Emissivity is a ratio of energy radiated from a material's surface to that radiated from a black body (a perfect emitter) at the same temperature and wavelength under the same area and viewing conditions. A perfect emitter value is 1; a perfect reflector is 0. Most coatings and materials fall in between 0 and 1. For example, most organic paints and coatings have an emitter value between 0.92 and 0.95. The closer to the perfect emitter value of 1, the better the absorption of radiated energy because emissivity is equal to the absorptivity in a thermal dynamic equilibrium. Put simply, the better the coating absorbs, the quicker it gets hot. The key is matching the right IR for the coating and process.

There are a few types of IR, including gas fired; gas catalytic (medium to long wavelength); gas radiant (medium wavelength), which is gas fired over a ceramic mold; and electric. Electric can emit short, medium, and long wavelengths depending on the type of emitter used. For example:

- Short wavelength with a T3 emitter — used for pinpoint accuracy, rapid heat-up, and instantaneous cool down. It offers infinitely adjustable power and a long life of over 5,000 hours for the tube.
- Medium wavelength with a tubular element emitter — a reliable nickel chromium resistance coil is housed in a quartz tube, providing a nonvertical burn design. This is most effective in applications requiring surface temperatures in the 120°F to 325°F (49°C to 163°C) range.
- Medium wavelength with a coil emitter — a sheathed tubular element with nickel chromium resistance coil packed in magnesium oxide. This is ideal for applications with complex geometric part profiles and temperature requirements of 250°F to 450°F (121°C to 232°C).
- Long wavelength with a cone emitter — utilizes a high-grade chromium wire that is helically wrapped around a ceramic cone-shaped core. This is popular for heat-sensitive substrates such as wood and plastic. It is an excellent choice for applications requiring temperatures of 300°F (149°C) and below.

FIGURE 1



Choosing the best type of IR for your product can be complicated on your own, so the best thing is to contact suppliers who offer testing and installing of IR ovens. These types of suppliers will have a solid grasp of which oven or emitter will work with a particular product or powder coating. Testing is the best thing you can do to ensure that the right wavelength is used. Even slight changes in coating composition can change the emissivity of the coating and change the oven requirements. Testing will catch these changes. Testing can also determine if IR heat will affect the gloss or texture of the coating. It cannot be emphasized enough that testing, testing, and more testing should be done before you choose and install any type of IR.

Saving money

To justify the cost of adding an IR oven to your powder coating process, you have to ask some key questions. What is the revenue of the system (the money generated) where the oven is going? How much revenue per hour does this production line generate? How much revenue does the system generate per foot related to fpm?

You need to know these things in order to base your cost savings on more than just capital cost. Here are a few things to consider in terms of cost savings:

- Capital cost
- Operating cost
- Ease of future expansion
- Service costs (labor and parts)
- Life expectancy of the oven and/or main components
- Other considerations

Boosting productivity

Productivity can be improved in different ways, but typically it is achieved by speeding up the line or maintaining a more constant line speed. When you have products of different sizes and shapes, it is sometimes hard to cure them at the same rate. This is where IR can help.

If you have a product that takes longer to cure, IR can be used to apply direct heat and bring the product's surface temperature up very quickly. IR can also melt and begin the flow of the powder faster than convection heat can. An example of a temperature chart is shown in Figure 1.

Booster ovens are often used to improve existing systems. It may be as simple as installing a 1- to 3-minute booster oven in front of an existing convection oven. This boost will take the surface of a given part from ambient to anywhere between 300°F to 500°F, depending on what is desired to melt and flow the powder. This boost in temperature will then allow the existing convection oven to complete the cure of the powder. Bottom line, you can increase the line speed of your system or maintain your line speed with the heavier products by adding a booster oven.

If you are putting in a new system and manufacturing a consistent line of products, then it is quite possible that an IR oven can be utilized as the sole oven for the system. IR ovens can accomplish cure in a third of the time that a convection oven can achieve the same task.

As for the misconception that IR only cures what it can see or what's in its direct line of sight, this is absolutely incorrect. Heat transfers through the material being coated from the exterior to the interior whether it's a powder coated or painted part. For instance, a filing cabinet with a fairly thin gauge of steel can be cured inside and out using IR ovens without any problem. From complex heavy parts to complex thin sheet metal, IR has proven to be an excellent oven choice.

Conserving energy

Let's go back to some of the more basic math. A certain amount of energy is required to be transferred into the coating and the part to cure a product. Once the coating and part are at temperature and the cross-linking of the coating molecules is achieved (the time element), cure is achieved. The quicker this can be done, the quicker the process is done.

IR ovens heat the coating and surface of the part to achieve cure. Convection ovens heat the entire product to its core before the surface can reach the desired temperature. This is referred to as "heat sink" and it exemplifies the time difference between the two types of ovens.

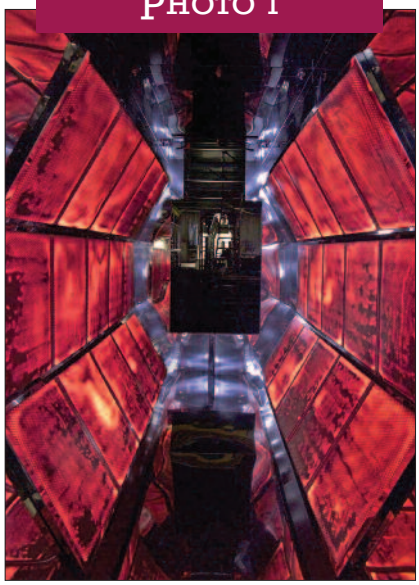
Many convection ovens, when started, are designed to be at full temperature between 30 minutes and 1 hour before production can start. Compare this to cooking in your kitchen, where you need to preheat your oven to a specific temperature before putting the food inside to bake. A 30-minute heat up time of a very large oven requires a large burner and fans to supply sufficiently hot air and energy into the convection oven chamber. This means that everything inside the oven has to reach that temperature before the parts start entering the oven, enabling the parts to reach the required cure temperature for the powder. Every piece of ductwork, every

Figure 2

Infrared Type	Source Temperature	Peak Wavelength	Response Time
Short Wave	Up to 4000° F (2200° C)	1.2 um	<1 second
Medium Wave	Up to 1800° F (980° C)	2.3 um	60 seconds
Long Wave	Up to 1000° F (540° C)	3-5 um	5 minutes

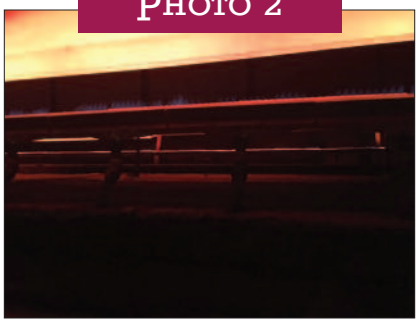
Emitter wavelength comparison

Photo 1



Gas catalytic IR oven

Photo 2



Gas radiant burners

bit of structural steel, and all the inside surface areas of the insulated panels will absorb energy to become hot. That energy can cost a lot of money in terms of a gas and electric bill.

As you can see, it does not cost more to operate an IR oven than a convection oven as the myth claims. Many IR ovens have a heat-up time of just a few minutes to almost instantaneous, allowing them to heat and cure parts extremely quickly and efficiently and at a lower cost than convection ovens.

Deciphering operating costs

It may be true that electricity costs more than natural gas, but it does not necessarily follow that IR costs more to operate than gas fired convection ovens as the myth claims. In fact, IR often costs less. It all comes down to timing.

Let's look at the operating cost of a convection oven in comparison to the revenue expected in fpm or revenue per hour. The preheating time needs to be factored in first. It will take at least 30 minutes and up to 1.5 hours of preheat time for a convection oven, depending on the temperature and the size of the oven. While the oven is preheating, the gas burners, the recirculating fans, and the exhaust fans are all running, costing money.

Convection ovens also have a stream of exhaust air at 350°F to 500°F that can be put to good use in the facility. However, if you're using an air make up unit or a heat exchanger to conserve energy, those costs should be factored in as well. It is considered more "green" to reuse the exhausted air, but you have to somehow get that money back. This is where a powder coating booth can come in handy. IR ovens also require exhaust, but not at the same high volume as convection ovens, so that is another consideration when you are factoring in the air make up and replacement costs.

With IR, the heat up time is from just a few minutes, say 15 minutes on the high side, down to 15 seconds for ovens that use T3 lamps. IR heating is also much more efficient than convection heating, although more sophisticated IR ovens will need PLC controls for zoning in the oven. This means some emitters can be turned down while other emitters are kept at a higher temperature, allowing optimal heat transfer for more efficient curing. This is difficult, if not impossible, to control in a large multi-pass convection oven.

In addition to the timing, don't forget to compare footprints. IR ovens require about 2/3 less floor space than convection ovens. IR ovens are also easier to elevate, if that's a possibility for your plant. Elevation saves on floor space, which is a big bonus when you are updating an existing powder coating system or have limited space in your plant.

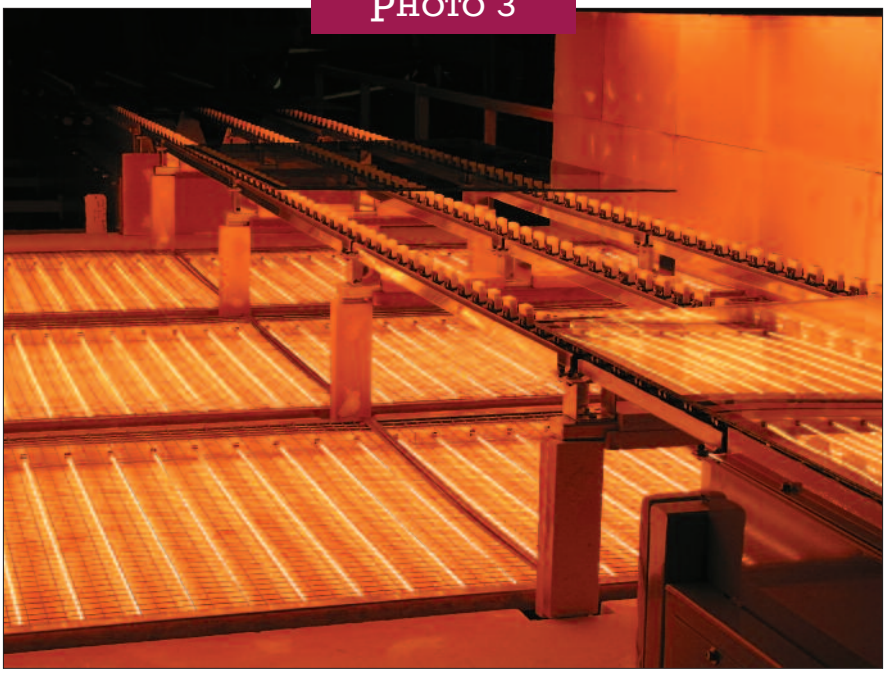
Considering additional factors

IR ovens offer an ease of expansion that convection ovens cannot. IR oven modules are easy to ship and install if you need or decide to lengthen your oven. If expansion was factored in during the design process, you may even have the extra heating capacity built into the IR oven and all you have to do is turn up the heat. There are more floor space and labor requirements for adding onto convection oven length. However, it all depends on the finishing system's size, length, and configuration. More often than not, adding an IR booster is going to be the best equipment choice for easy expansion.

Ease of service is a factor as well. If you are using a convection oven in your current process, hopefully whoever purchased the equipment thought about quality over capital cost. For instance, plug fans should have been installed instead of air kit fans. Air kit fans require some disassembly of the heater box so that service people can enter the heater box. Plug fans allow the fan to be lifted and hoisted from the exterior of the oven and easily replaced.

Convection burners are relatively easy to be serviced. For burners and fans, the delay is in the lead time to get the replacement parts. If revenue per hour and production time are critical to

PHOTO 3



Electric oven–short wavelength

your process, then the extra lead time for replacing parts will add up to lost revenue waiting on delivery. Not everything has a long lead time, and you could also keep those types of spare parts on hand in your facility, but it is another thing to think about in case of an unplanned shortage. Plus, even though some parts are very expensive to keep on hand, the possible loss of revenue may justify the cost.

With IR ovens, most parts are relatively inexpensive to keep on hand and also have short lead times. However, if the IR oven is using exhaust and recirculation fans, then you need to think about the lead time consideration here as well.

As far as oven life expectancy, if designed properly, an IR oven will last just as long as a convection oven will under normal operating conditions. However, if you operate at maximum capacity all the time, you will burn up elements and emitters much quicker than normal. The same is true for a convection oven. For instance, if the convection oven requires 1.5 million BTU to operate efficiently, then you have to install a 2.0 to 2.5 million BTU burner. Anything less and you'll burn through your oven much quicker.

Other factors may come into play with your process. If so, make sure you consider the capital cost, your budget, the return on investment, and any energy savings and you'll be able to make an educated decision on whether installing the equipment will result in any cost savings.

Changing colors — Mind the gap

Powder coating equipment manufacturers and spray booth manufacturers are continually working on reducing the time it takes to change colors in a powder coating line. When you have to change colors, there will be a gap of products in the line. This means there's a section of conveyor where no parts are hanging to be powder coated, creating an interruption in part production. This is done to allow the color change to

PHOTO 4

Electric oven–medium wavelength

Photo 5

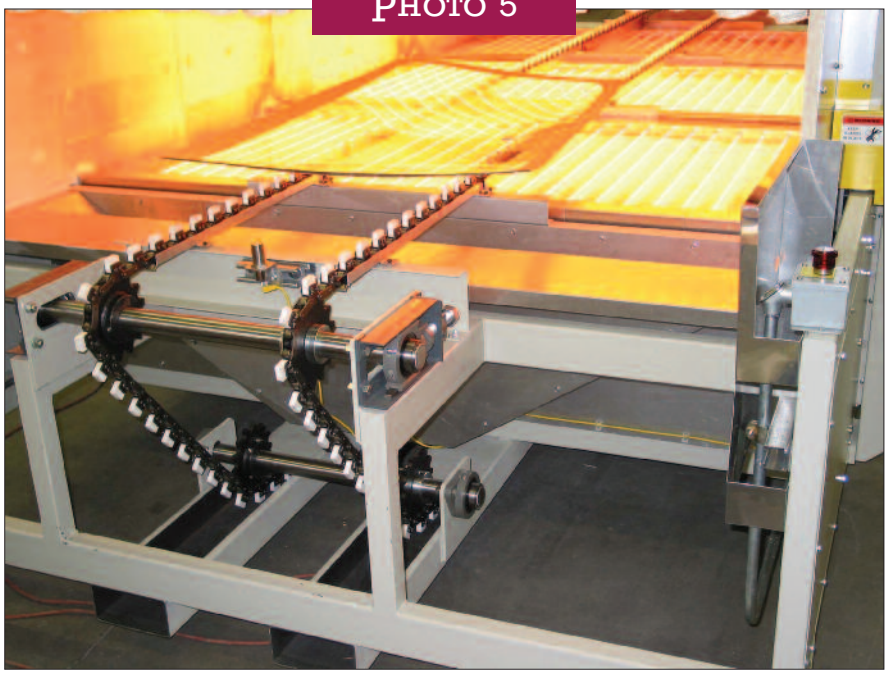


Photo 6

be timed with the line speed so that when the new color is ready to be sprayed, the parts will arrive at the powder coating booth.

One issue that arises with convection ovens and color changes is that the powder can become dislodged when the part first enters the convection oven. That dislodged powder is then blown onto a part of a different color, causing reject or rework. Thus, for convection oven lines, the gap in the line has to be large enough that parts aren't affected by this blow off.

To solve this issue and to minimize the part gap on the conveyor line, your best bet is to use an IR oven or booster to melt the powder quickly on the parts. This will minimize or eliminate powder particles being dislodged and blown onto a part of a different color. IR ovens apply direct heat to the powder and don't require recirculating air at the beginning of the curing process, allowing quick color changes without rejects or rework.

If you are dealing with a color change in your line, you'll need to address this issue when you think about increasing productivity. Hanging more parts on the line could definitely help production numbers. You'll also need to address this issue in terms of cost savings, since IR ovens have the ability to be switched off or dialed down in temperature until the new color parts arrive at the oven to conserve energy. It is not feasible to do the same with a convection oven.

Whether you're expanding or installing a new system or upgrading an existing one, you'll want to talk about this possibility with all of your finishing equipment suppliers to see what works best for your overall process. Double check what the revenue increase will be if you can produce more parts. Make sure you're operating as efficiently as possible in order to boost revenue.

Finishing up

IR ovens are an excellent choice and should be considered for any finishing system, powder coating system, or any heat process. IR is not necessarily the best choice for every process, but it does have many more applications than you might think. Put your misconceptions aside and give IR its due consideration, especially in terms of curing time decreases and production rate increases.

Although this article has discussed convection ovens in not such glowing terms as IR, if you'll pardon the pun, that doesn't mean that convection ovens are bad. They are also excellent pieces of equipment and, in many cases, are the correct choice for a finishing process. The decision between IR and convection depends on your process and what you're ultimately trying to achieve.

In many cases, an IR booster followed by a convection oven is the most suitable choice for custom coating. Take this into consideration and do your due diligence with research and testing on both types of ovens to see how you can best meet your powder coating and finishing needs. **PC**

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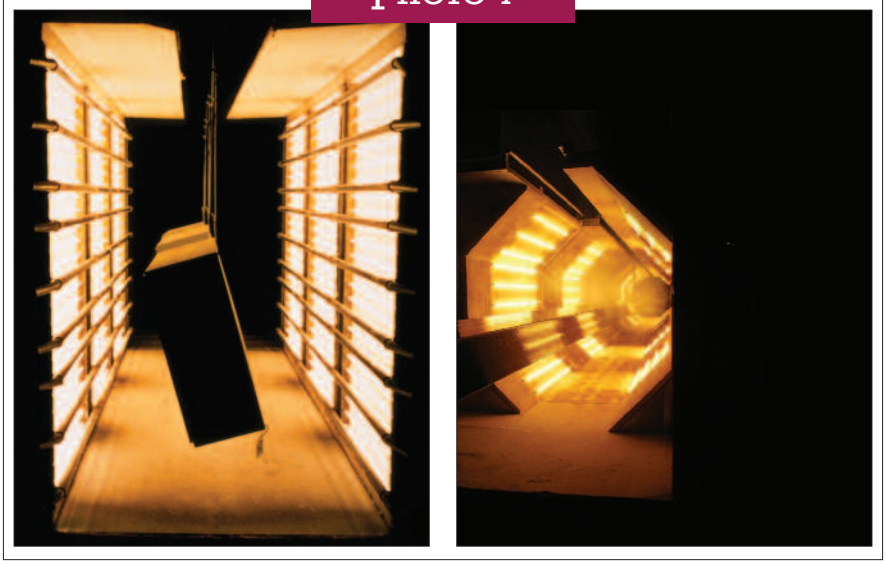
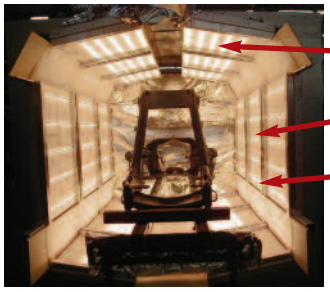
PHOTO 7



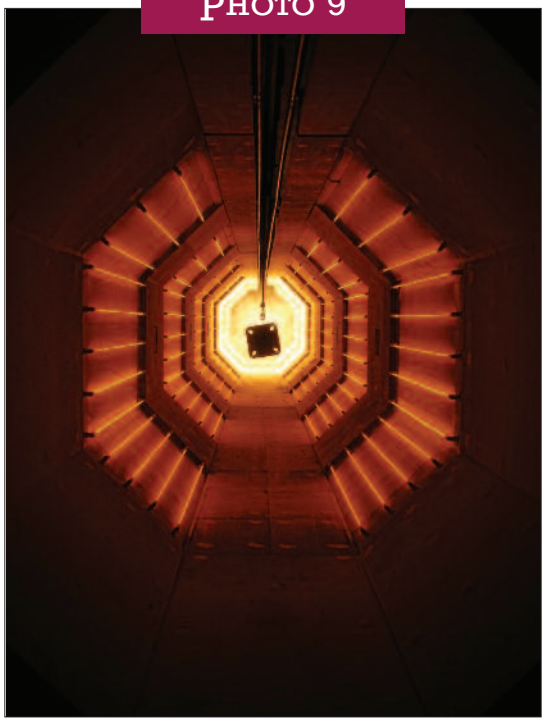
T3 lamp style IR ovens

PHOTO 8



PLC controls can be used to regulate temperatures in each zone

PHOTO 9



Part hanging in an IR oven