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 members Scott Bishop and Joel Watts, Alabama Power Co., Birmingham, Ala.

Maximize your convection oven by using infrared

In the 1990's, a primary sales pitch for the use of infrared (IR) by equipment manufacturers was the promotion of the technology as a booster, or gelling oven. This application would boost the part temperature with IR (thus causing the powder to flow or gel) prior to the part entering in a convection oven used for curing the powder. Generally, this solution would be implemented to allow customers to increase throughput while reducing the amount of floor space required when compared with adding more convection ovens. It didn't take long before we began to see IR move from outside the oven into the vestibule of the oven to save even more floor space.

In the past couple of years, we're starting to see great success with IR being installed inside the convection heat zone, especially with regards to convection batch ovens. This application not only eliminates any need for additional floor space, but also takes advantage of the added energy (BTUs) coming off the IR heaters to the overall heat balance of the convection. There are two major advantages for this type of application:

1. Heat large geometrically complex parts that provide a reduction in both cycle time and energy.
2. Batch small and large parts together without under- or over-curing any of the parts inside the convection oven.

In this article, we'll examine two applications that compare the use of a straight convection oven with the use of a combination IR-convection batch oven where the IR is placed inside the oven.

First application: Large geometrical parts. Several industrial customers use pure convection to preheat and cure heavy parts of various shapes. In many instances, their large convection ovens (usually gas-fired) must be turned on a couple of hours prior to operation to allow the oven to completely heat up before production can begin. Once the oven is at temperature (usually 400°F-500°F), the part is then placed in the oven to soak. Generally, the parts are left in the oven for 1-2 hours to make sure the part has reached temperature.

For our example, we'll examine the benefits of using electric IR inside a convection oven. The tests employ a standard 300 kilowatt (kW) electric convection oven (Figure 1) that was retrofitted with approximately 127kW (ten 12.735kW heaters) of electric IR

Figure 1

Typical electric convection batch oven 300kW

(Figure 2). The part used for the test was a 350-pound pipe casting (Figure 3). Two tests were performed to examine the amount of energy and time it took the casting to reach a temperature of 350°F in 300kW of convection only (test #1) and a combined 300kW of IR-convection (test #2). Thermo couples were placed at different points on the casting to make sure it had been heated throughout. In each test, the oven was set to 400°F, and a total of 300kW was used. During the IR-convection testing, the IR heat source was left at 100 percent (no modulation or control) while the convection oven cycled to maintain oven temperature at 400°F.

Test #1: Convection only. Figure 4 shows the temperature profile of the part through the use of 300kW of convection only. The part reached a temperature of 350°F within 61.7 minutes by using 177 kilowatt hours (kWh), shown in Figure 5.

Test #2: IR-convection combination. Conversely, Figure 6 shows the temperature profile of the part through

FIGURE 2

Typical electric convection batch oven 300kW with infrared installed

FIGURE 3

Standard pipe casting weighing 350 pounds

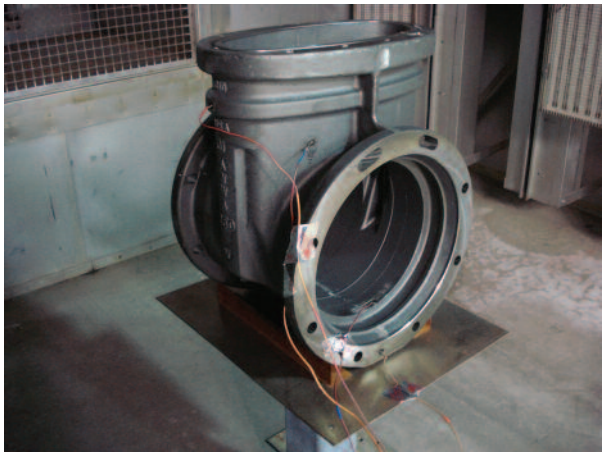


FIGURE 4

Temperature profile for 300kW convection-only oven

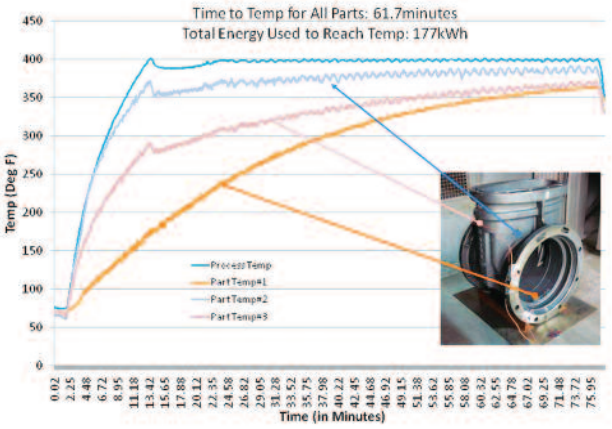


FIGURE 5

Temperature profile for 300kW convection-only oven with part reaching 350°F using 177kWh

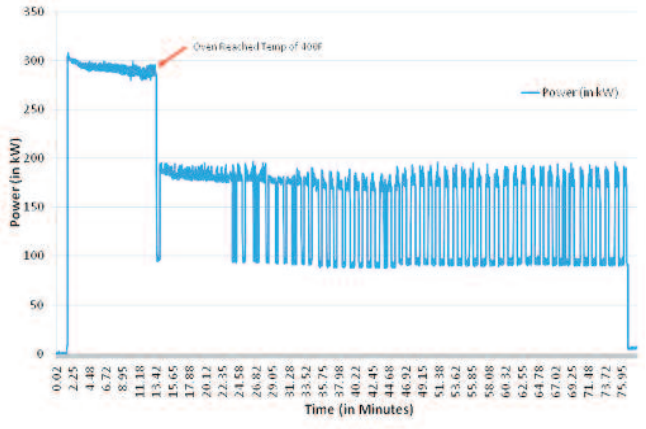
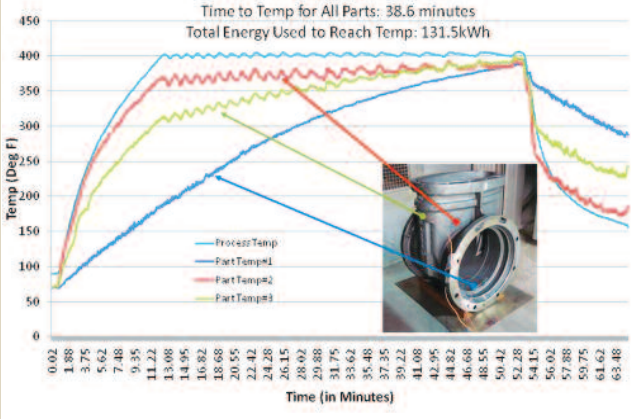


FIGURE 6

Temperature profile for 300kW infrared-convection oven with part reaching 350°F in 38.6 minutes



the use of 300kW of a combination of IR (127kW) and convection (173kW). In this test, the part reached temperature in 38.6 minutes while using 131.5kWh (shown in Figure 7 and Figure 8).

In summary, the combination IR-convection oven had both a shorter heat-up time as well as a reduction in energy usage. It allowed the part to reach temperature approximately 37 percent faster than with convection only. As a result, the energy required to heat the part was reduced by approximately 26 percent.

Second application: Multiple-size parts at one time. At times, industrial customers may need to batch multiple-size parts (different thickness and weight) within the same convection oven. Most customers who

FIGURE 7

300kW infrared-convection oven used 131.5kWh to get the part temperature to 350°F; infrared at 100 percent (~130kW) while convection (~170kW) oven controls oven temperature

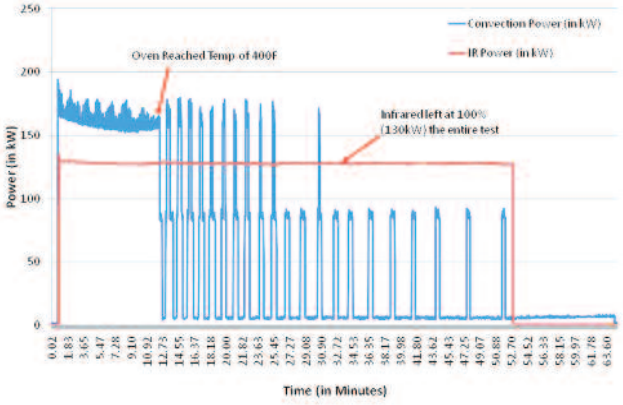
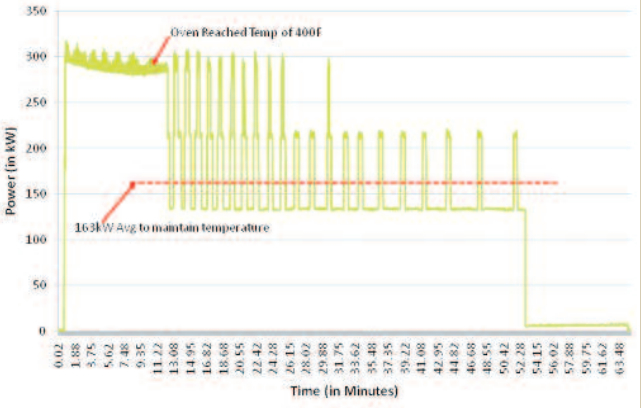


FIGURE 8

Combined power profile for infrared-convection oven



desire to use this style of batching want to reduce cycle time, which improves throughput and eliminates the need for multiple recipes.

In our example, we'll again examine the benefits of electric IR inside a convection oven. Our testing for this application was with a standard 300kW electric convection oven (Figure 1) that was retrofitted with approximately 127kW (ten 12.735kW heaters) of electric IR (Figure 2). This test examined whether three different parts of various thickness and weight (Figure 9) could be heated simultaneously without over-baking the small parts or under-curing the larger part.

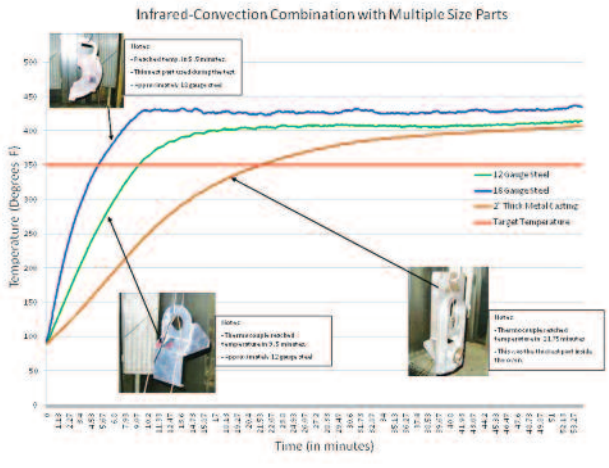
The first part was made of 18-gauge steel; the second part was made of 12-gauge steel; and the third part was a 2-inch-thick heavy metal casting. Thermo couples were placed on the three parts at different points to make sure they reached the desired temperature of 350°F. This temperature point was selected based on the fact that many powder cure temperatures range from 350°F-400°F with over-bake protection typically up to 450°F. During the IR-convection test, the IR was left on at 100 percent (no modulation or control) while the convection oven cycled to maintain oven temperature at 400°F.

FIGURE 9

Three different parts of various thicknesses and weights

FIGURE 10

Temperature profiles for multiple-size parts



IR-convection test. Figure 10 shows the temperature profile of the three parts processed through a combination of IR and convection. As you can see, the 18-gauge steel part reached temperature in 5 minutes while the largest part (the 2-inch casting) reached temperature in approximately 29 minutes. Even though the first part reached temperature 24 minutes faster than the casting, it was only 40°F hotter than the heavy metal casting and wasn't over our over-bake limit of 450°F. This is due to the recirculation fans inside the convection oven. The fans acted as an air conditioner for the small-gauge parts.

The advantage of the IR-convection combination while curing or preheating multiple parts is the flexibility that it offers. This type of flexibility can ease an industrial customer's mind: Not one part inside the oven is being under- or over-cured, and all necessary quality specifications are being met. This test produced approximately the same percentage savings as the IR-convection test for large geometrical parts.

In summary

Whether you're trying to preheat large complex parts or wanting to cure multiple size parts in the same batch, IR can offer many benefits when added inside your convection oven. Those benefits can ultimately lead to increased throughput as well as lower energy costs on a per part basis. **PC**

For more information or to submit a question, contact Anne Goyer, executive director of IRED, at 859/356-1575; e-mail anne@goyermgt.com. See also www.ihea.org/ired.cfm.

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