

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, Alabama Power Co., Birmingham, Ala., and Baskar Vairamohan, Electric Power Research Institute (EPRI), Knoxville, Tenn.

Designing effective and efficient curing processes with infrared to meet convection oven challenges

Industrial customers are often faced with the challenge of heating different size parts in a common convection batch oven or continuous oven. While the larger and heavier parts take more time to absorb the heat, the smaller and thinner gauge parts take a shorter time for heating and curing. However, the batch process cycle time (or line speed for a continuous oven) is typically the same for both part types, which may result in the under- or over-curing of parts. This condition can also lower productivity since operators are unable to do any further processing while the parts are being heated.

Another challenge faced by industrial customers is the aging convection heating system. Many of the convection heating systems currently being used are close to the end of their lifetime and are ready to be retired and replaced. However, they are still in operation at many facilities because of various reasons, such as a lack of capital to replace the ovens, lack of awareness of newly available technologies, familiarity with the older equipment along with an unwillingness to make a change, and so on[1].

This article will explore two possible solutions that can help increase the productivity of industrial plants in the scenarios described above. In the first option, the batch or continuous oven is fitted with infrared (IR) emitters inside the oven that are turned on as needed to boost heat to the parts. In the second option, a totally separate IR oven is used as a second batch oven in order to augment the existing convection oven. Case studies will be presented and analyzed in an effort to examine the advantages and disadvantages of each of these options.

Option I: Combination IR-convection oven (IR booster)

In the past couple of years, there have been great successes with IR being installed inside the convection heat zone in both batch as well as continuous 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 process. There are two major advantages to using this type of application:

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

Case 1: Heating large geometric parts. Several industrial customers use straight convection to preheat and cure heavy parts of various shapes. In many instances, these large convection ovens (usually gas-fired) must be turned on a few hours prior to operation to allow the oven to completely heat up before production can begin. Once the oven is at the setpoint temperature (usually between 400°F and 500°F), the part is then placed in the oven to soak. Depending on the desired preheat temperature, the parts are left in the oven for 1 to 2 hours to make sure the entire part has reached temperature.

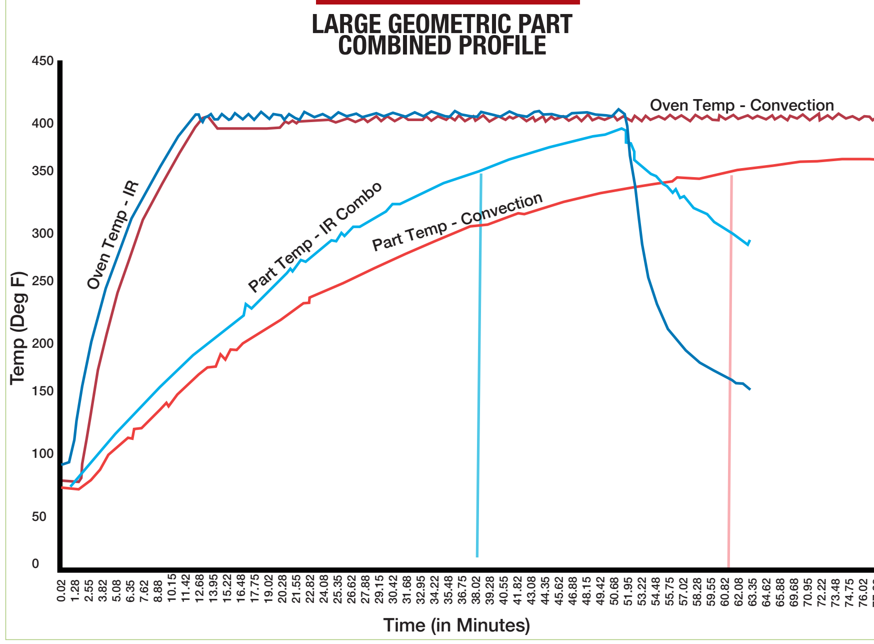
Independent testing was performed with a convection oven to determine the energy savings through this approach. During testing, the benefits of using electric IR inside a convection oven were examined in detail. The tests employed a standard 300 kilowatt (kW) electric convection oven that was retrofitted with approximately 127 kW (ten 12.735 kW heaters) of electric IR. The part used for the test was a single 350-pound part, as shown in Figure 1.

Two tests were performed to examine the amount of energy and time it took the part to reach a temperature of 350°F in 300 kW of electric convection only compared to a combined 300 kW of IR (130 kW) and electric convection (170 kW). The results show that the 300 kW combination IR-convection oven used only 131.5 kWh (kilowatt hour) to get the part temperature to 350°F while the

FIGURE 1

Large geometric part with IR inside a batch convection oven

FIGURE 2



Temperature profiles of large geometric part with and without IR

electric convection oven alone used 177 kWh to reach the same temperature.

The results from these tests showed that the combination IR-convection oven had both a shorter heat-up time as well as a reduction in energy usage. These results are shown in Figure 2. The combination oven allowed the part to reach temperature approximately 37 percent faster than the convection only oven. As a result, the energy required to heat the part was reduced by approximately 26 percent.

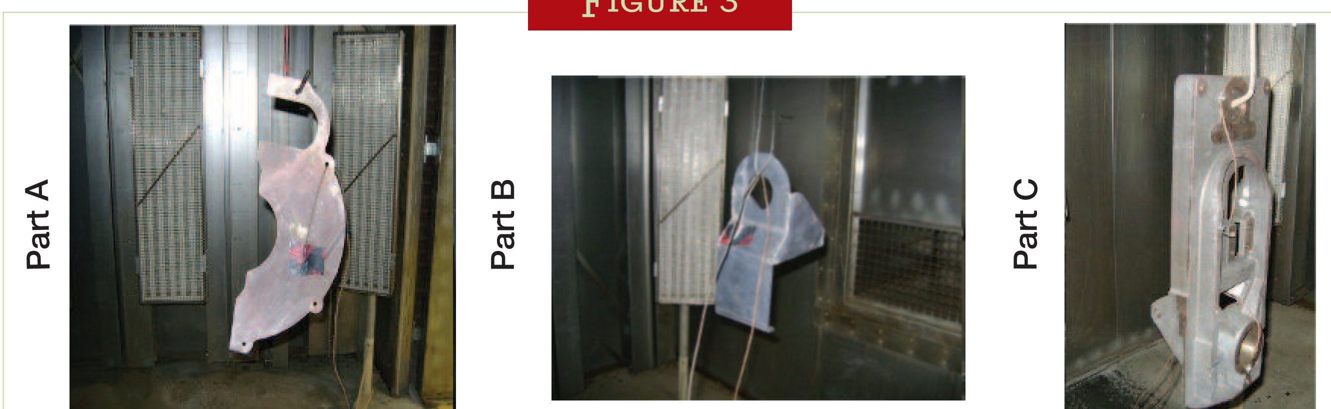
Case 2: Heating different size parts at one time. At times, industrial customers may need to batch different size parts with varying thicknesses and weights within the same convection oven. Most customers who desire to use this style of batching want to reduce cycle time, which improves throughput (or plant productivity) and eliminates the need for multiple recipes.

In this second case, testing involved the heating of multiple parts of different sizes and shapes. The main objective of this test was to determine whether different parts of various thicknesses and weights could be heated simultaneously without overbaking the small parts or under-curing the larger parts. The first part was made of 18-gauge steel (Part A); the second part was made of 12-gauge steel (Part B); and the third part was a 2-inch-thick heavy metal casting (Part C). These parts are depicted in Figure 3.

For 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. During this test, the 18-gauge steel Part A reached temperature in 5 minutes while the largest part, the 2-inch casting Part C, reached temperature in approximately 29 minutes. The results of this test are shown in Figure 4.

Even though the first part reached temperature 24 minutes faster than the smaller part, it was only 40 degrees hotter than the heavier part and did not exceed the overbake 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. This test produced approximately the same percentage savings as the IR-

FIGURE 3



Heating of different part sizes in a combination IR-convection oven convection test for large geometrical parts.

The combination of IR and convection provides the flexibility of operation to the customer by reducing overall curing time and energy as well as providing the ability to heat multiple parts of varying dimensions without over- or under-curing. All necessary quality specifications are also being met. Whether a customer is 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 a convection oven. Those benefits can ultimately lead to increased throughput as well as lower energy costs on a per-part basis.

Option II: Additional IR oven to augment the convection batch oven

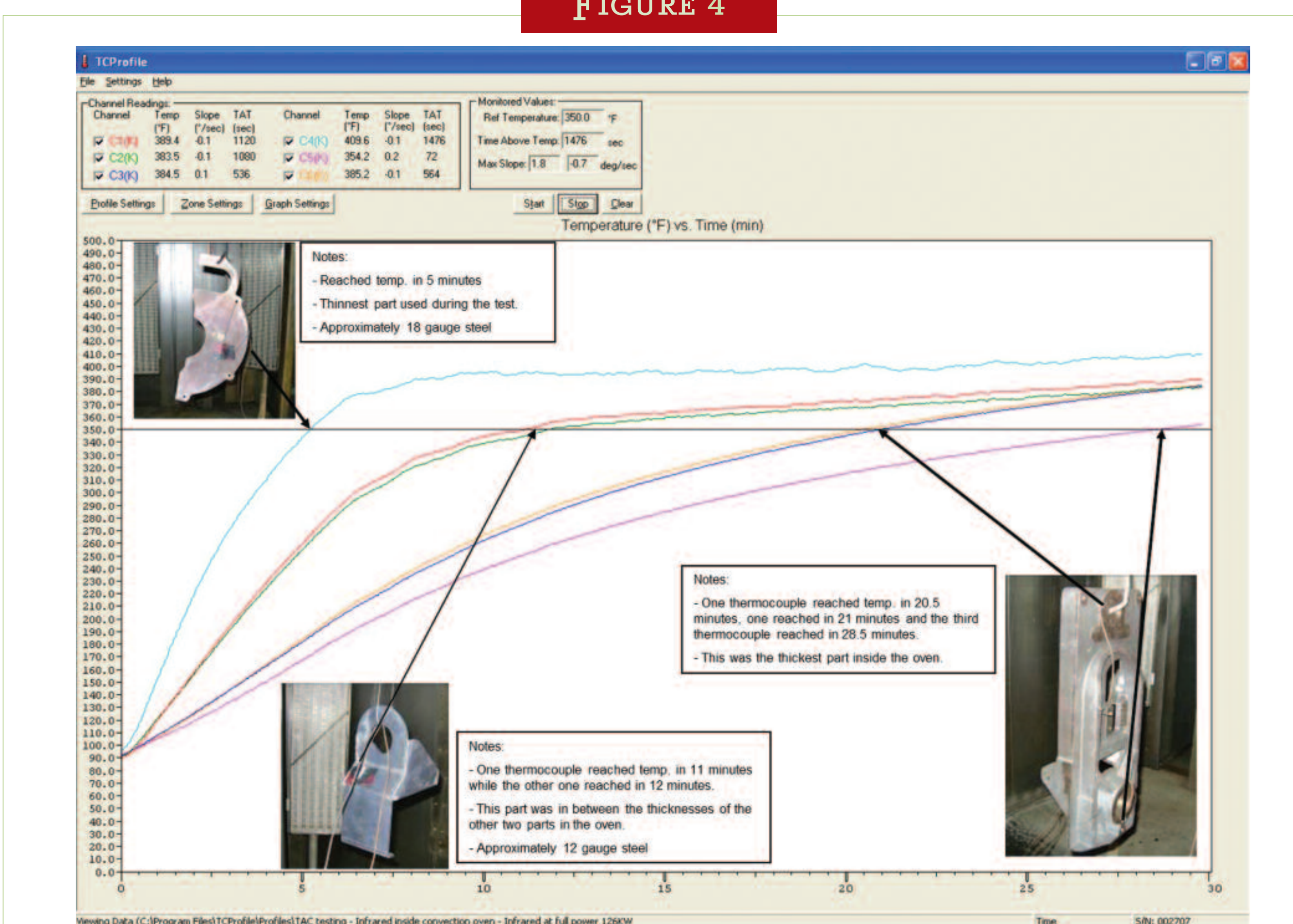
Another option to increase the productivity of industrial customers who are processing multiple parts through a convection oven would be to install a separate IR oven for just the smaller parts. Convection would not be used at all for these smaller parts.

To illustrate, the following case study highlights a solution that was implemented at a customer's facility to increase their productivity. The customer was heating and curing metal parts of varying sizes in a 60 kW electric convection batch oven. The typical temperature of the oven during normal operation was 375°F, and the parts were soaked in the oven for 20 minutes and controlled by a timer.

The challenge faced by this facility was that the smaller and thinner parts were soaked in the oven longer than necessary (over-cured) because they were placed together with larger and heavier parts that needed more time to heat. The facility had only one electric convection batch oven, so they had to use the same oven for all parts. The soaking time in the oven was found to be a bottleneck and was preventing the facility from meeting the production line demand.

In this case, the customer was willing to separate the small and thin parts from the rest of the larger parts in order to speed the heating process. They were also willing to add an additional IR batch oven right next to the existing electric convection batch oven. Luckily, the facility had enough space to install a IR batch oven because, inherently, these ovens have a smaller footprint than comparable gas-fired or electric convection ovens. The IR batch oven, as shown in Figure 5, was rated at 162 kW with multiple zones (Z1, Z2, and Z3) and zone control. The IR emitter banks were also placed on a skid with wheels that can be moved sideways to provide adjustable widths to handle different size parts. The result was that the IR batch oven could heat the small and thin parts in just 5 minutes as opposed

FIGURE 4



Temperature profiles of various size geometric parts with and without IR

FIGURE 5

IR oven with adjustable emitters

to 20 minutes for the traditional oven, thereby lowering the cycle time by 75 percent.

Some of the immediate benefits realized by the customer after installing the new IR batch oven include:

- The heat cycle time was reduced from 20 minutes to 5 minutes, which is a 75 percent reduction in cycle time.
- Productivity has increased by at least four times for the smaller and thinner parts.
- Zone control has provided significant energy savings. Based on the production line requirements, fewer parts have to be heated and, since these parts are small, the entire IR oven need not be operated. Instead, only the zone where the parts are placed has to be run. In the traditional method, the oven was operated at full power regardless of the number of parts inside it.
- Reduced downtime has occurred because operation may continue even if a problem occurs in one or two of the zones. Maintenance may also be done at a later time when the production is low. In comparison, if an element failed in the electric convection oven, the entire oven had to be shut off for maintenance.
- Because of the smaller footprint of the new IR oven, it can be placed adjacent to the existing convection oven. This means that the parts don't have to be transported from one section to the other inside the plant, resulting in increased productivity.
- This new oven did not replace the traditional oven, but it supplemented the production capacity of the plant. From one shift operation, the plant doubled its production line with the addition of one new IR oven.
- Due to the controllability and the flexibility of the IR oven with different zones and the ability to run the small parts in a different oven, the plant has seen a reduction in the scrap rate being produced because of over- or under-curing of parts.

In summary

Using IR as a combination IR-convection oven or as a standalone IR batch oven augmenting an existing convection batch oven offers significant benefits to customers. They not only increase plant production, but they also offer flexibility to plant managers to optimize production. They also have an inherent benefit of saving energy while also reducing the cycle times of part heating and curing.

Some of the key benefits for customers who use IR as standalone oven or as a combined IR-convection oven are:

- Reduced cycle times, which can lead to increased line speeds and throughput.
- Reduced convection energy source (gas or electric) when IR is placed inside a convection oven because the energy being produced by the IR oven will be captured in the convection oven.
- Increased flexibility with part sizes, which will minimize the number of recipes for various parts.
- Overall reduction in energy intensity, which is the amount of energy per part produced.

The two options discussed in this article may help your customers extend the life of their existing ovens while increasing the productivity of their plant. The combination of the IR and convection systems is equivalent to upgrading the aging convection system to newer controls and standards, resulting in an increased bottom line because of the reduction in overall curing time and energy as well as increased throughput. **PC**

Endnote

1. For more information on the aging convection heating systems, please refer to the article *The IR-convection curing system: Designing effective curing processes to meet today's production needs* written by Sherrill Stoenner in the November 2006 edition of Power Coating magazine. The article can be found in the online Article Index at www.pcoating.com.

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