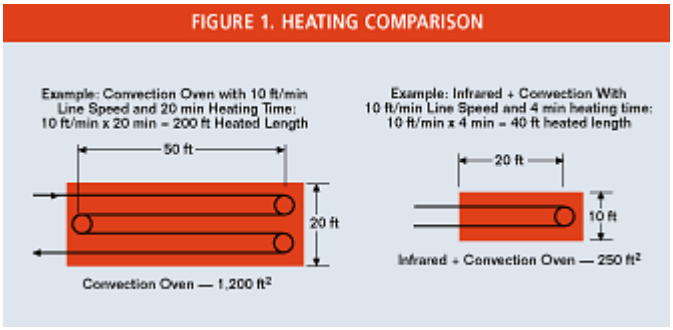
Combining Infrared & Convection Heating

By Michael Grande, Wisconsin Oven

If you require a continuous oven to dry or cure a wet coating or powder, look into combining infrared and convection heating. Often, it can provide the same results as a conventional convection oven within a smaller equipment footprint.



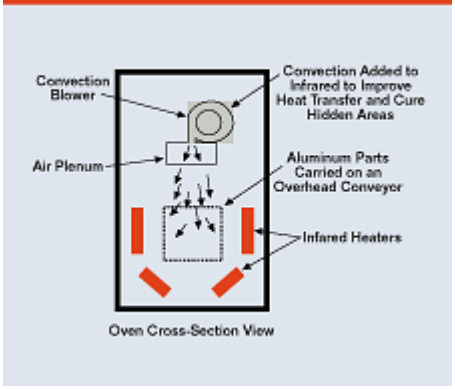
By combining convection and infrared technologies, heating time can be decreased by 75% or more, resulting in a dramatic reduction in floor space requirements.

Traditional convection ovens use heated, forced air to provide the necessary cure. Because the heated air thoroughly bathes the parts and evenly cures all areas -- even deeply contoured and hidden ones -- they heat a range of part sizes and shapes. The air being delivered is held at temperature using closed-loop control, which provides predictable, repeatable results. One disadvantage of convection is its fairly long heating time due to air being at the same temperature as the part (typically 250 to 500°F [93 to 266°C] for paint or powder).

Infrared heating, by contrast, uses radiant heat generated by infrared emitters to quickly heat part surfaces. The emitters operate at a higher temperature than the cure temperature -- typically 1,100 to 4,000°F (593 to 2,204°C). This is ideal for flat or fairly regular part surfaces. However, because the radiant energy travels only in a straight line as it leaves the emitter, it cannot reach hidden areas of the parts except by conduction or reflection. In other words, areas of the parts not in the heater's line of sight do not heat quickly. By combining both technologies in the same oven, the advantages of both can be realized while minimizing the disadvantages (figure 1).

There are two ways of combining infrared and convection technologies. The first is to combine infrared and convection heating inside the same oven chamber. In this design, infrared heaters are mounted inside the oven along with a recirculating air system. Heat is provided in radiant form, and the air system delivers heat to hidden areas that the infrared cannot reach. A supply plenum delivers the air in much the same way as in a traditional convection oven. In some cases, the recirculated air also is heated separately using burners or electric heaters to provide better temperature control within the heating chamber.

FIGURE 2. CURING PAINT AND POWDER



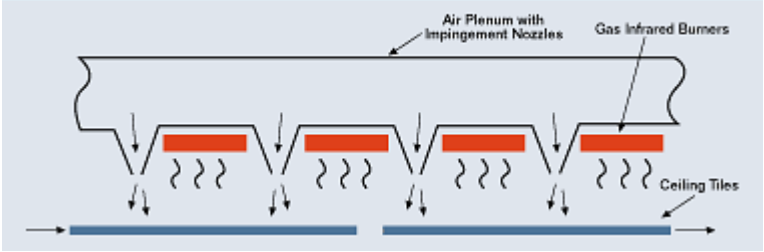
When curing paint or powder on aluminum castings, infrared heaters provide accelerated heating and convection air transfers heat to the hidden areas.

An ideal application for this type of combination technology is curing paint or powder on aluminum castings. In-frared heaters provide accelerated heating, and convection air transfers heat to the hidden areas (figure 2). Aluminum parts conduct heat well, which also assists in heating the areas not in the infrared heater's direct line of sight.

Airflow arrangement is an important design consideration. The air velocity impinging on the parts must be reduced at the oven entrance end to prevent the powder from being blown off. After the powder has gelled, higher velocity air can be used to increase the heat transfer.

Combining the technologies can pay other dividends as well. For example, a manufacturer of satellite dish components in California combined infrared and convection and reduced its powder cure time from 20 to 4 min. With a line speed of 2.5 ft/min, the oven floor space requirement was reduced from 50 to 10'.

FIGURE 3. DRYING WATER-BASED PAINT



Combination convection/infrared commonly is used for drying water-based coating on ceiling tiles. Convection helps speed drying by removing the microscopic layer of moist, saturated air that forms on the surface.

Combined infrared/convection heating also is particularly useful for drying water-based coatings. As these coatings release their moisture during drying, a microscopic layer of moist, saturated air forms near the surface. This boundry layer forms a barrier to further drying. It must be penetrated for the coating to dry. Traditional in-frared heating does not penetrate the boundry layer. With the addition of hot air convection, however, this lay-er of moisture is removed, greatly accelerating the drying process and allowing the full benefit of infrared heating to be realized.

An example of this approach is in the drying of water-based paint on ceiling tiles. The tiles are carried on a chain- or belt-style conveyor through an oven with hot air impingement nozzles, directing the air onto the tiles. Gas infrared burners located between the nozzles

provide the heat (figure 3). The advantages of both technologies are utilized; the infrared burners provide the heat and the forced air removes the moisture.

The second manner in which infrared and convection technologies are combined is through the use of infrared to preheat parts prior to entering a convection oven. After the parts are coated, they are passed through an infrared oven section before entering the convection oven. Infrared provides an initial heat boost to gel the powder or bring the wet coating to temperature. The convection oven then provides the additional heating time required.

This technique often is used to speed up an existing line, with minimal increase in floor space. A short infrared section is added at the entrance to an existing convection oven to provide 3 to 5 min of preheat. The convection oven then evens out the temperature and helps heat hidden part areas.

This approach also is used when a change from solvent-based to water-based or powder coatings becomes necessary due to air quality or other environmental concerns. Water-based coatings often require a longer cure time and higher temperature than solvent-based coatings. An electric or gas infrared booster can provide this without requiring the convection oven to be lengthened. Installation involves simply locating the infrared section in front of the entrance to the convection oven.

Where an existing line needs to be sped up but there is no additional floor space available, infrared heaters can be added inside the first several feet of the convection oven. This provides the additional advantage that any infrared heat not absorbed by the parts will be contained by the convection oven.

Select the Best Heater

This combination convection/infrared oven cures powder on aluminum castings with complex shapes.

Whether infrared heaters are to be used inside a convection oven or as a preheat booster, be sure to use the type of heater best suited for your process. Not every heater is right for every application. If possible, work with a supplier who sells several different types of heaters and who will not be biased towards a particular style.

If the part conveyor stops in an infrared oven, the parts can overheat, resulting in burned coating and loss of product. If this is a concern, use low thermal mass heaters such as medium-wave quartz tubes or short-wave T3 lamps interlocked to shut off in the event of a line stoppage. Lower thermal mass allows the heaters to cool quickly when shut off.

If durability is a major concern, use flat panel or ceramic heaters. They can survive moderate impact without failure. These heaters have a greater mass than quartz tube or short-wave heaters and take several minutes to cool down after being turned off.

Gas catalytic heaters and gas burners often provide reduced operating cost in comparison to electric but have low turndown ability, which can lead to difficulty controlling the temperature. They offer durability and either high or low thermal mass, depending on the specific heater selected. One important feature of gas infrared is that it typically has less line-of-sight problems than electric due to the air added for combustion. Combustion air provides some agitation within the heating chamber and helps heat the hidden areas by

providing a slight convection effect.

Test, Test, Test

Due to the nature of infrared heating, testing prior to oven design always is recommended to confirm the performance of a specific type of heater with your coating and substrate. This is true whether infrared heaters are to be used inside a convection oven or as a preheat booster.