Understand Convection Cure Oven Design for a Well-Controlled Powder Coating Process

Convection ovens use heated air to cause the powder to melt, flow, create a film, and finally to cure on your parts. The key to convection oven technology is to efficiently heat this air and circulate it around the parts, without disturbing the powder coatings on the substrate surface. The burner combustion air is used to directly heat the part without the use of a heat exchanger. This heated combustion air is normally distributed through the oven and around the coated parts using a circulation fan and associated ductwork. The oven chamber is exhausted to remove byproducts of combustion and byproducts of powder cure. Understanding how these oven features relate to each other is important to operating a well-controlled powder coating process.

Burner Sizing

All gas convection burners are sized using the product load, the hanger load, and the conveyor chain load (in pounds per hour). This load is multiplied by the specific heat of the metal (i.e., steel, aluminum, etc.). This answer results in BTUs per hour and is added to the heat loss through the walls, through the part openings, and up the exhaust stack to ensure the burner has enough capacity to heat the coated product to the desire temperature.

Circulation Fan Turnover

The circulation, or supply, fan must deliver the BTUs from the burner to the coated products using the air volume it generates. This fan must "turnover" the oven volume at least three times per minute to deliver these BTUs efficiently. If the fan does not perform up to this level, the BTUs will be left in the burner box and not be transferred to the parts.

This circulation turnover can be checked in an existing oven by the following formula:

Circulation Fan (ft^3 per minute)÷ Volume of Oven Chamber (ft^3)= Turnovers per minute

This circulation fan volume is much different than the actual air velocity exiting the oven ductwork. The number and size of the ductwork openings determine exiting air speed for a given fan volume.

For reference, air speed is calculated by the following formula:

Circulation Fan Volume (ft^3 per minute) ÷ Total Ductwork Opening Area (ft^3) = Air Speed (FPM)

> **Under no circumstances should your oven exhaust fall below the minimum requirements to safely operate your oven.**

Exhaust Rate

All direct-fired convection ovens circulate the byproducts of combustion throughout the oven to heat the parts. Additionally, the air within the oven expands as it is heated. Even with the best air seals, this air will enter the plant as it expands beyond the surrounding plant atmospheric pressure. Therefore, exhausting air from the oven is an important safety issue to remove the combustion byproducts from the plant.

Secondly, thermoset powder coatings emit by-products of cure as they goes through the exothermic reaction to cure the coating. Most of these byproducts of cure are moisture, but some are more onerous (i.e., carbon monoxide and ε-caprolactam). These also must be exhausted from the oven to prevent oven fouling, normally witnessed as sticky black or brown tar-like streaks on the oven walls. How much oven exhaust you need depends on the type of powder coating you are doing:

- Non-Appearance and dark colors = 3 turnovers per hour
- Clears = 6 turnovers per hour
- High Appearance and light colors = 8 turnovers per hour

Under no circumstances should your oven exhaust fall below the minimum requirements to safely operate your oven. National Fire Protection Association (NFPA) 86 guidelines must always take precedence and will dictate the minimum exhaust requirements.

The exhaust turnover rate can be checked in an existing oven using the following formula:

Oven Volume (ft^3) ÷ Exhaust Fan (ft^3 per minute) = Minutes per Air Change

60 minutes per hour ÷ Minutes per Air Change = Air Changes per Hour

Purge Time

The exhaust fan must also purge the oven of uncombusted gasses before the igniting the burner. NFPA guidelines stipulate that the oven chamber must be completely exhausted four times before the burner can ignite.

Calculating purge time in an existing oven is done using the following formula:

(Oven Volume (ft^3)x4) ÷ Exhaust Fan (ft^3 per minute) = Purge Time (minutes)

Now that you have a better understanding of how these oven design features relate to one another, you are better equipped with the knowledge for operating a well-controlled powder coating operation.

Nick Liberto, P.E., is president of Powder Coating Consultants, division of Ninan Inc., an independent technical consulting firm in Bridgeport, Conn. He can be reached at pcc@powdercoat.com.