10 Pounds in a 5-Pound Bag

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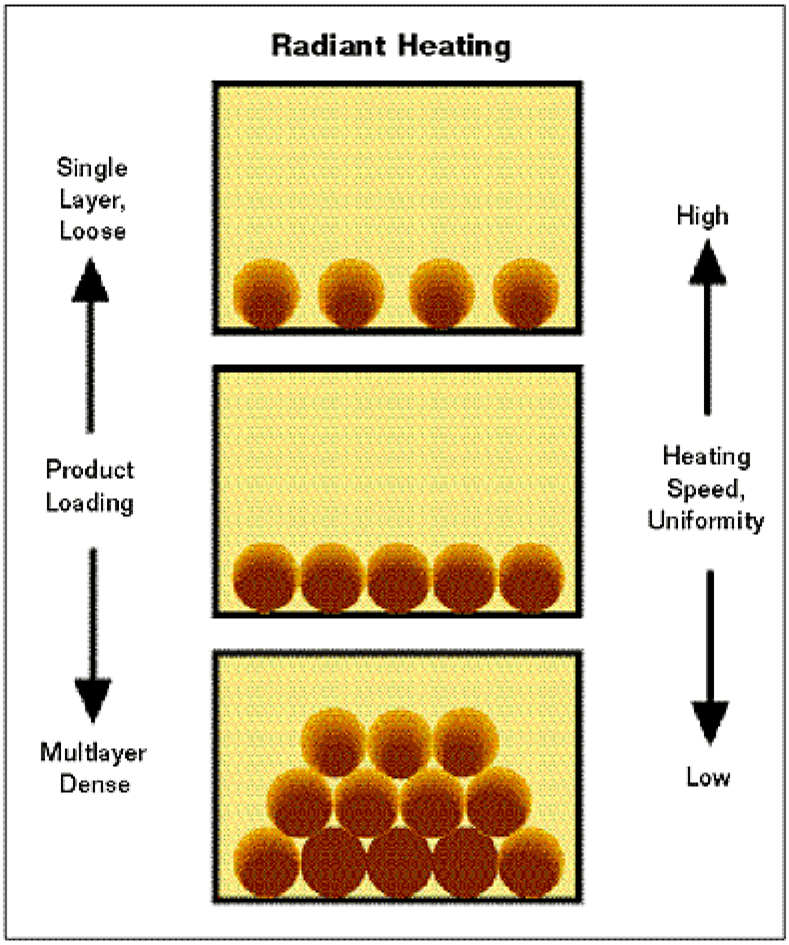
Sometimes, Less Is More

In last month's column, I looked at the criteria for determining how much recirculating airflow an oven should have. I also mentioned that all the airflow calculations are based on the assumption that you can get the heat transfer rate you need. Maintaining sufficient air velocity at the load surface is a big part of this. Another, often overlooked -- or even abused -- part of heat transfer is getting proper exposure of the load to the heat source.

One of the cardinal rules of heat transfer, whether it's by convection, radiation, conduction or any combination of these, is that the more load surface you expose to the heat source, the faster you'll be able to heat it. Common sense? Sure, but you'd be surprised how often people lose sight of it.



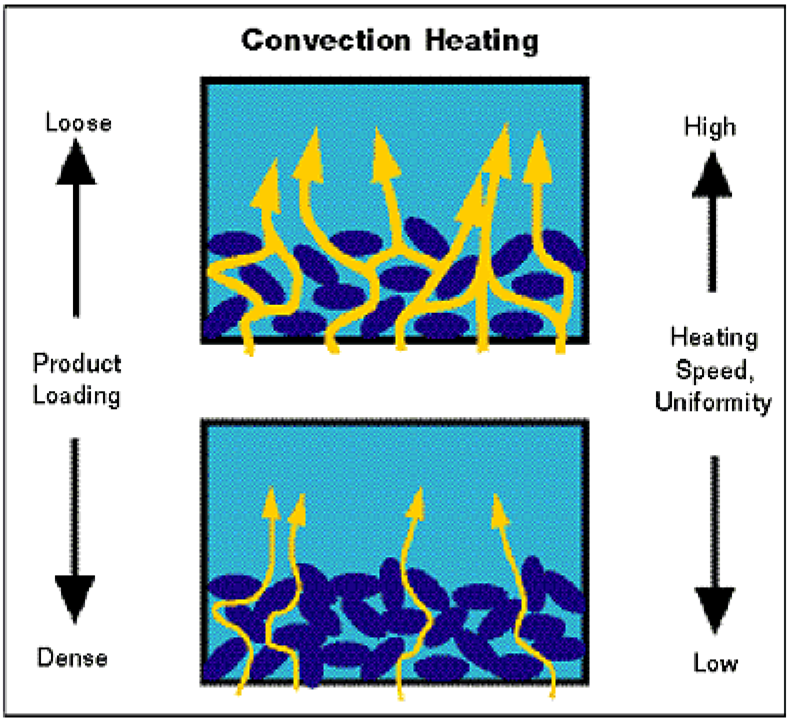
Loading product deeper and denser shields much of it from radiation heat transfer.

The proper design of an oven or furnace takes this rule into account. Loading patterns and conveyor systems will be designed for the best possible compromise between heating speed (and efficiency) and floor space requirements. The trouble often starts when someone, in the hope of increasing productivity, upsets these loading and space relationships by trying to pack more product into the available space.

Years ago, I worked with a number of customers involved in heating steel to high temperatures for forging, rolling and other forming operations. Many of them used batch-type box furnaces where the product was heated primarily by radiation from burner flames and hot refractory insulation. The intent of the furnace designers was that the customer would load a single layer of bars in the furnace at the beginning of the day, heat them, and then replace them, one by one, with fresh stock as the hot bars were pulled out to be worked. The designers even provided for empty hearth space between the workpieces.

This made no sense to many traditionalists, who saw the open spaces and single-tier loading as a waste of valuable furnace space. They opted instead to pack the furnace to the gills, seeing it as insurance against getting caught short of raw material during a production upswing. The other advantage to this, which few furnace crews would admit openly, was that loading a relatively cool furnace at the beginning of the shift was a lot more desirable than loading pieces, one by one, into a fiercely hot furnace in the midday and afternoon heat.

They might not have gotten caught short of material, but they paid a high price for it. First, in high temperature furnaces like these, exposing more product surface to the flames and hot refractories heats the product faster. Piling the steel bars like cordwood places most of them in the shade, and they don't really begin to get hot until the material above them is removed. Years ago, field tests proved what the calculations predicted: Loading the workpieces in a single tier, with spaces between them, permitted high production rates with lower energy consumption than if you stacked the work cheek by jowl or two or more layers deep.



Dense product loading interferes with the passage of hot air through it, slowing heating rates.

Convection heating is a little easier to live with. Unlike radiation, moving hot air will go around corners and through gaps in the load, so you don't need line-of-sight exposure to ensure the product will be heated. As long as you provide spaces for the air to pass through freely, you can heat most loads of stacked pieces effectively.

Trouble starts when these passageways are blocked or made unnecessarily long or tortuous. If sufficient air can't flow through them, they won't heat properly. Heating rates will slow down, temperature uniformity will be poor, and energy consumption will climb. What appears to be wasted space in an oven may actually be the key to its productivity, and trying to make that space "useful" by filling it with product could have the opposite effect.

There are plenty of variations on this packing problem. An oven might have been designed to carry a multitude of pieces or particles on a mesh conveyor or in trays with perforated bottoms. The idea, obviously, is to allow the heating air to flow up or down through the load and its conveyor or trays. Everything is fine while processing the material the oven originally was designed for, but suppose a change in production requirements introduces a new product, which sits more densely, to the oven. Even though the weight processed per hour has not changed, the new material takes longer to heat properly, and even then, it might be insufficiently dried or cured. The higher density (lower permeability) of the bed of material doesn't allow air to flow as readily through it.

Friable materials sometimes create a similar problem. Handling abrasion might cause unexpected spalling or dusting, and the fines this generates fill the spaces between the workpieces, strangling hot airflow and slowing the heating process.

The bottom line is that heating speed, uniformity and completeness, as well as energy efficiency, depend heavily on getting complete, intimate exposure between the work and the heat source, whether it's radiation, convection or conduction. Anything that interferes with that exposure will seriously impair the effectiveness of the process.