

In the (Process) Zone

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Split-case, infrared heat tunnels incorporate design principles that heat narrow and multiple-strand products uniformly.

For years, manufacturers have relied on infrared for drying and heating of medium- and wide-width webs and fabrics. However, successful process heating of products that are processed in multiple ends has proven to be more difficult for infrared. This includes narrow webs and strand-like products such as tubing, thread, wire and metal strip.

Investigations into the problem have shown that often there are variations in the product temperature even with a constant output from the radiant source. Adding to the difficulty is the fact that temperature variations occur at random locations on the product and to different degrees. The primary cause is air currents. Air, which in the case of medium and wide webs accelerates infrared drying, in narrow web and multiple end applications cools the product even while the infrared source is supplying a constant level of energy to the product.

TABLE 1. BENEFIT OF CONTROLLING OR EXCLUDING AIR IN PROCESS ZONE		
Heater Used to Heat Strip	Power (kW/ft ²)	Seconds to Reach 450°F (232°C)
Air-Cooled Short-Wave Infrared Lamps	21.6	17.0
Split-Case Infrared Heat Tunnel	9.6	10.2

Table 1. With air excluded from the process zone, this heating application is much more efficient. Even with less than half the power density, the split-case infrared heat tunnel heats the product to temperature in 40 percent less time.

Narrow and multiple-strand products such as wire and thread absorb infrared energy from a flat radiating surface just as efficiently as wider web products. On a per unit area basis, both strands and flat webs absorb the same amount of energy. However, because the area of the strands is smaller, they receive less total energy. When both types of products are exposed to cooling ambient air currents -- as happens in manufacturing processes -- stranded products cool more readily because they have less mass and there is little resistance or obstruction to the airflow in the process heating zone. By contrast, web products have more mass and therefore are not as easily cooled. Furthermore, the wide, flat structure of webs provides more of a physical barrier to cooling air currents. The result is that stranded products suffer more temperature variations from the cooling effects of unmanaged, ambient air in the process zone.

Control or Eliminate Air

To prevent random cooling and to permit even heating of narrow and multiple-strand products, the infrared oven should utilize the following design principles that address the cooling air problem. At a basic level, one should control the temperature and volume of air in the process zone

TABLE 2. VERSATILITY FROM VARYING WIDTHS			
Heated Width x Heated Length (in)	Metal Case Across Machine x in Machine x Depth (in)	Input Voltage	Power (kW)
7.5 x 40	16 x 42 x 16	480, 240, 208 or 575, three-phase	12
15.0 x 40	23 x 42 x 16	480, 240, 208 or 575, three-phase	27

Table 2. More versatility comes from the varying widths, voltages and power ratings of the heat tunnels. Split-case infrared heat tunnels deliver large amounts of infrared energy to a product in a short dwell time.

and also the means by which air enters and exits the process zone. Better yet, one should exclude air from the process zone.

Split-case, infrared heat tunnels incorporate these design principles to heat narrow and multiple-strand products uniformly. The benefit of controlling or excluding air was demonstrated recently in laboratory tests. A polished bronze strip 0.006" (6 mils) thick was heated by both air-cooled short-wave infrared lamps and with a split-case infrared heat tunnel. The results are shown in table 1.

How do split-case infrared heat tunnels do this? First, they incorporate wire heating elements that maintain a high temperature in the process zone. Furthermore, infrared heat is delivered from the top and the bottom of the tunnel. Even heat distribution is enhanced further by offsetting the infrared heating elements in each half of the heat tunnel.

The mechanical construction of the heat tunnel also improves heating efficiency and uniformity. Although heavy-gauge aluminized steel is necessary for long operating life under rugged conditions, and the cases need to be hinged to ease access to the interior for product threading and maintenance, air infiltration into the heat zone itself is prevented by a gasketed seal between the top and bottom cases of the tunnel. Air infiltration and heat losses are further prevented by adjustable, insulated reflectors at both the entry and exit ends. Finally, the enclosures are well insulated to maintain uniform internal temperature.

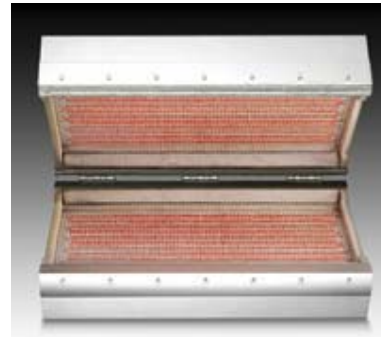


Figure 1. The exclusion of air from the heat process zone enables a rectangular split-case infrared heat tunnel to maintain efficient and uniform heat transfer regardless if they are mounted horizontally or vertically.

The exclusion of air from the heat process zone enables the rectangular split-case infrared heat tunnels to maintain efficient and uniform heat transfer regardless of whether they are mounted horizontally or vertically. More versatility comes from the varying widths, voltages and power ratings of the heat tunnels as shown in table 2. As you can see from the power rating in relationship to the in-machine length, split-case infrared heat tunnels deliver large amounts of infrared energy to a product in a short dwell time. Figure 1 shows the larger infrared heat tunnel rated at 27 kW with a heated area of 15 x 40".

Temperature Control. Figure 2 shows the exterior and interior of a typical control system for split-case infrared heat tunnels. The control system uses SCRs to regulate power input to the electric infrared heating elements via thermocouple feedback control loops. Temperatures are adjustable but, once set, require no further attention. The control system is packaged in a NEMA-rated enclosure with digital user interfaces. An infrared heat tunnel with feedback control is a cost-effective, field-proven heater and control package for heating and drying narrow products and multiple end products.

Custom-Engineered Infrared Heat Tunnels



Figure 2. A typical control system for split-case infrared heat tunnels uses SCRs to regulate power input to the electric

The application requirements and design principles of controlling air into, within and out of an infrared heat tunnel or completely excluding air from the heat zone can be applied to infrared heat tunnels that are engineered for specific process heating requirements. These custom-designed and -manufactured industrial ovens and dryers typically include one or more split-case infrared heat tunnels. They have gasketed seals between individual tunnels to prevent air infiltration. They often include pneumatic cylinders to open and close the infrared heater cases, painted steel framework and exhaust hoods. The custom-engineered heat tunnels usually include control systems that have digital operator interfaces, NEMA enclosures and SCR controls, which maintain oven temperature by feedback control loops. Many systems can be divided into separately controlled temperature zones for greater process control and product quality. Most importantly, custom-engineered heat tunnel systems should come with the oven manufacturer's full engineering support. It also is advantageous to get your oven system prewired and skid mounted to minimize installation time and to ensure oven quality.

infrared heating elements via thermocouple feedback control loops.

Figure 3 shows a vertical split-case infrared heat tunnel system that dries a water-based coating on narrow fabric up to six times faster than the process it replaced. After being coated, the fabric enters the oven from the bottom, passes through the dryer and out the top. The tower includes three infrared heat tunnels with seals between the modules to create a continuous hot environment that dries multiple ends of fabric totaling 12" wide. The volume and temperature of air in the tower are controlled by a hot air curtain at the bottom of the tower and two exhaust hoods. The heater supplies heated makeup air to eliminate the chimney effect.



Figure 3. After narrow fabric is coated with a water-based coating, it enters the vertical split-case infrared heat tunnel system from the bottom, passes through the dryer and out the top.

Like many infrared process heating systems, this split-case infrared heat tunnel dryer includes an SCR control system housed in a NEMA 12 enclosure. Temperature feedback is from embedded thermocouples within the infrared heaters. Four temperature control zones allow the customer to fine-tune product processing for optimal results in both quality and speed. Although the complete tower measures only 13.5' high (in-machine direction) by 3' wide (across-machine direction) by 2' deep, it is rated at 89 kW.

Figure 4 shows an example of managing the air in the heat process zone. This industrial oven dries and cures a solvent-based adhesive coating that is applied to both sides of a narrow steel strip. It combines hot air for solvent drying and lower explosive limit (LEL) control with infrared heat for drying and curing. The combination of two types of heat transfer in one oven increases line speeds and removes volatiles safely without sacrificing product quality. The narrow-web drying and curing oven measures 25' (in-machine direction) by 3.5' (across-machine direction) by 4.5' high. The total combined connected power of the hot air and infrared heat is 24 kW.



Figure 4. This oven dries and cures a solvent-based adhesive coating that is applied to both sides of a narrow steel strip. It combines hot air for solvent drying and lower explosive limit (LEL) control with infrared heat for drying and curing.

In this oven, the tunnel of uniform heat is created with infrared heaters that have a split-quartz cylinder (figure 5). The cylindrical design surrounds the product with intense infrared heat, making the heaters effective for heating tubing, extruded profiles, wire, cable and fiber optics. The hinged cases ease opening and access to the product.

In operation, as the coated metal strip enters the oven, drying is initiated by hot air that is supplied by two air-knife-type heaters mounted in separate air input plenums. Volatiles are removed through insulated exhaust hoods. As the narrow web moves through the dryer, infrared heaters aid in drying by supplying a blast of infrared heat. For coatings that need to be cured, on the exit end, a separately controlled infrared heater supplies infrared heat that raises the coating temperature to initiate curing.

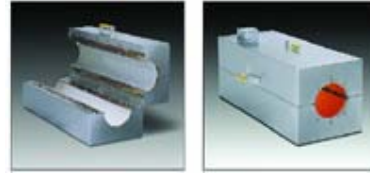


Figure 5. A tunnel of uniform heat is created with infrared heaters that have a split-quartz cylinder, which surrounds the product with infrared heat.

Drying and curing operations are controlled by a SCR control system, which is housed in an oven-mounted NEMA 12 enclosure. The control maintains constant hot air temperature for the hot air heaters and constant element temperature for the infrared heaters through a thermocouple feedback control loop.

If you need to dry, cure or otherwise heat narrow webs or products that are processed as multiple ends, consider using an infrared heat tunnel. An infrared oven that is designed and successfully used for medium and wide webs and fabrics cannot simply be applied to narrow products and multiple-end processing. Air currents in the ovens, which accelerate drying of the wider, flat products, will cool narrow products as they travel through the oven even while the products are receiving heat from a radiant source. Infrared split-case and custom-engineered infrared heat tunnels are designed for and have been successfully used for narrow webs and fabrics as well as for multiple-end products. They either control the airflow in the heat zone or exclude air from the heat zone to uniformly and efficiently heat narrow webs, narrow fabrics and strand-like, multiple-end products such as insulated wire, tubing, extruded profiles, thread and metal strip.

Sidebar: Applications for Infrared Heat Tunnels

Infrared heat tunnels surround the product to provide even and rapid heating making them suitable for processing narrow or strand-like products. Heat tunnels can be used to:

- Dry coatings on flat braid for electrical tape.
- Dry coatings on narrow fabrics.
- Heat-set narrow fabrics.
- Dry printing on narrow webs.
- Cure striping on cable.
- Heat-activate adhesives.
- Heat fiber tow.
- Heat or cure extruded products such as tubing, wire insulation, body-side molding or gaskets.
- Dry adhesives for label stock.
- Dry fiber optics.
- Preheat wire prior to extrusion.
- Dry fluoropolymer coatings on yarn, thread, roving and cordage.
- Dry coatings on metals.