10 Infrared Heating Questions and Answers

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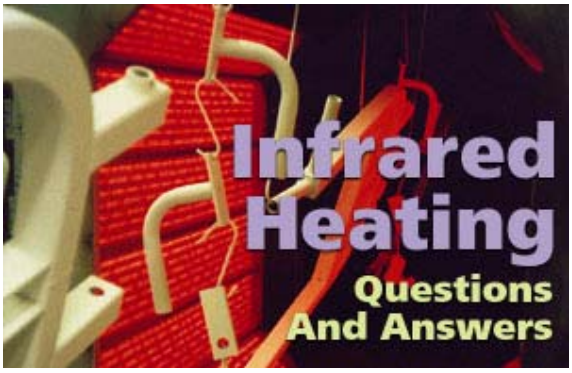

Do you have questions about how infrared heating works? Not certain that it can get the job done -- or done well -- in your process? Get the answers that will allow you to make an educated decision.

The same series of questions about infrared process heating seem to arise on a regular basis. Most of these questions may be the result of confusing terminology and some on-going myths that have surround infrared heating. Addressing the most frequently asked questions will help demystify this useful process heating tool.

Figure 1. This oven is designed to dry coatings on two-dimensional products that are moving up to 300 ft/min. More complex, three-dimensional products can be processed by slowing down the heating rate.

1. What is the difference between infrared and radiant heating?

Infrared heating and radiant heating are the same. In fact, the proper term is infrared radiant heating. Radiant heating applies to any heat transfer method where energy travels directly from the source to the object being heated. Microwave and dielectric heating also are forms of radiant heating. Radiant heating does not require any other material to transfer energy from an emitting source to a body to be heated. The transfer rate is expressed by the following equation.

$Q = EO (T_h^4 - T_p^4)$

where

Q is the energy transfer rate.

E is the emissivity of the product. This value varies from 0 to 1.0, where 1.0 is a perfect black body. Most materials, other than polished metals, will have an emissivity of 0.8 to 1.0.

O is a constant based on an ideal black body.

T_h is the temperature of the heat source.

T_p is the temperature of the product being heated.

The important thing to note is that energy transfer rate is a function of temperature difference to the fourth power. Basically, this means a small increase in source temperature has a large effect on the heating rate.

2. Infrared equipment suppliers claim the technology can heat products up to 10 times faster than a conventional convection oven. How is that possible?

The time required to heat a product is directly proportional to the rate at which energy is transferred to it. For convection, energy transfer can be expressed as follows:

Q = h x A x DT

where

h is a heat transfer coefficient that is a function of the flow direction and velocity.

A is the area being heated.

DT is the temperature difference between the body to be heated and the air flowing past it.

There are two important things to note. First, the energy transfer rate for convection is a function of the temperature difference to the first power. By comparison, the energy transfer rate for infrared is a function of the temperature difference to the fourth power.

Second, with convection heating, this energy transfer must take place twice: Energy must transfer from the heat source to the air, then from the air to the product. These two factors cause convection to be slower and usually less efficient.

3. What does wavelength mean? Does it matter?

Figure 2. Infrared ovens can gel a powder coating on an assembly of parts with varying masses and cross-sections.

Wavelength is a function of the frequency of the radiation coming from the energy source. The higher the frequency, the shorter the wavelength. The frequency, and therefore the wavelength, of radiation is solely a function of the energy source's temperature. Higher temperature equals higher frequency and shorter wavelength.

Does wavelength matter? The answer is sometimes. Most opaque materials -- other than highly reflective surfaces such as clean metals -- will absorb most wavelengths at similar rates. Bright metallic surfaces are poor absorbers of short-wave infrared radiation, but their surfaces will be heated more efficiently by medium- and long-wave infrared radiation. Clear materials, especially clear coatings and plastic films, are transparent to some wavelengths, and therefore wavelength will affect the efficiency of the energy transfer.

4. Is infrared safe?

Figure 3. Combining infrared and convection heating will effectively dry a coating.

Infrared radiation is safe. If you stand in front of an electric space heater, you are subjecting you body to radiant heating. The only way that infrared radiation can cause harm is if you get so close that your skin becomes overheated or if you touch a surface that has been heated by infrared (and thus get burned). Take the same precautions necessary around any heating device.

5. Will infrared heating work on 3-D products? I heard it only works for line-of-sight.

Three-dimensional products are being heated successfully in infrared ovens every day. It is true

that the fastest heating is going to occur with two-dimensional products that easily can be heated uniformly. For example, a coating on a steel or aluminum strip on a coil-coating line can be dried and cured to a temperature of 300°F (149°C) or higher in less than 5 sec. High density, short-wave infrared ovens often are used to dry coatings on two-dimensional products (figure 1).

More complex, three-dimensional parts can be processed by slowing down the heating rate so that convective heating and conduction within the three-dimensional part help provide uniform heating (figure 2).

6. Can I combine infrared and convection to get the best of both technologies?

Many industrial process heating applications benefit from a combination of heat transfer techniques. Any process involving drying will require some airflow to carry away the vapors generated. Heated air also will help equalize temperature distribution in parts with complex shapes or those with a variation in material thickness (figure 3).

7. Do I need special coatings or materials to use infrared heating?

Infrared radiant heating will work with any material that can be heated. Unlike ultraviolet, microwave and dielectric heating, which usually require the material or coating to be modified with special additives, infrared can be used to heat standard materials.

8. How close do the infrared heaters have to be in relation to my product?

The distance from the infrared source to the product is not directly important. However, the geometric relationship between the source and the product will have an effect on heating-process efficiency. Geometry relates to the relative shape and position of the source and parts; geometry affects how much of the energy leaving the source actually strikes the part. Selecting the correct size heaters and the use of reflectors will minimize the need to place the infrared source close to the product.

9. How do I control infrared heaters to make sure my product reaches the required temperature or dryness level?

Infrared heaters lend themselves to precise control. If the temperature of the energy source is varied, the amount of energy striking the product will vary proportionally. By varying the voltage to the heater, the temperature of an electric infrared heater can be varied linearly from 0 to 100% of its rating. Solid-state SCRs or relays can provide a means for controlling voltage. The voltage, and hence the energy output of the infrared source, can be changed manually with a potentiometer. It also can be changed automatically by measuring the temperature of the product or the emitter with a thermocouple or noncontact sensor and feeding the signal back to the power controller through a solid-state temperature controller.

10. Is infrared process heating efficient?

One way the efficiency of an industrial heating process is defined is as the ratio between the amount of energy purchased and consumed to the amount of energy that has to end up in the product to complete the process. In a properly designed electric infrared oven, 60% or more of the input energy will end up in the product. In a gas-fired infrared oven, because the combustion process adds another factor to the overall efficiency, efficiency will be in the range of 30 to 40%. By contrast, the best convection ovens will offer about 20% efficiency because of the indirect heat transfer path.

Infrared radiant heating is safe and efficient. Having a basic understanding of how it works may reveal additional benefits for your specific application.