Electric Infrared Heating of Plastics

Basic Principle

Infrared (IR) energy is part of the electromagnetic spectrum and occurs between visible light and radio waves (0.75–1000 microns). Electric IR energy is produced by heating an emitter of IR radiation. The radiation is then absorbed at the surface by the substance at which it is directed, causing its molecules to vibrate and generate heat. Since the energy radiates directly to the substance, there is no need for convective airflow, minimizing energy losses and eliminating the need for air handling equipment. Additionally, IR lamps heat up relatively quickly; consequently, they can be deenergized between batches and during production stoppages.

System Description

A typical electric IR system includes quartz lamps and reflectors. Industrial systems are configured to expose production work to a bank of lamps fixed at a particular height, position, or angle, or placed in moveable arches. Portable arm-mounted lamps are available for smaller applications. An electric IR system reaches full power in less than 1 second and can be accurately regulated with simple controls. This responsiveness allows IR heaters to effectively complement an automated production line.

Applications of IR heating systems in plastics manufacturing include preheating plastic preforms and drying pelletized resin. Plastic preforms are shapes that are roughly the size of the production mold; they are used primarily in thermoforming and compression molding processes. Preheating the preforms facilitates molding by softening the plastic and lessening the time and energy required for the mold to reach the temperature necessary for curing.

Similarly, drying resin improves the production process by removing moisture that would otherwise interfere with molding and curing. IR energy relies on adequate surface area exposure to effectively transfer heat. Since resin is usually pelletized and therefore has a relatively high surface area per unit volume, IR energy is ideally suited for this application. This characteristic is exceptionally useful for processes that incorporate postconsumer recyclate (PCR) into the production stream. Most PCR is washed using aqueous techniques; therefore, moisture removal is essential.

Alternate methods of preheating include convection heaters (both gas-fired and electric), electric resistance heaters, and radio-frequency (RF) equipment. IR heaters offer the advantages of quick and accurate heating with relatively moderate purchase costs. RF heaters typically provide more penetrating energy; however, the complexity of the associated electronics pushes the cost of RF heating equipment well above that of IR systems.

In an electric IR system, 85–90% of the energy used is converted to radiation, and 50–70% of the energy is absorbed by the product. By contrast, a gas IR system transfers only 20–25% of the energy it uses to the product and produces emissions of its own.

Advantages

- Quick and efficient heating: Process time can be reduced 50–80% in comparison to convective ovens.
- Short ramp-up time: The responsiveness of IR heaters minimizes energy loss between batches and during production stoppages.
- Excellent results with pelletized resin: The large surface area of pelletized resin promotes effective heat transfer with IR emitters, thus improving polymer drying.
- Easily incorporated into existing production lines: The modular characteristics of IR equipment allow quick integration with existing production lines.

Electric IR Heating System Characteristics

Dimensions	IR heaters are modular units of 6–10" and can be built up incrementally and configured to meet the needs of any specific application.
Power Rating	8–15 kW per square foot
Energy Consumption	4160 kWh annually*
Key Inputs	
Power	Electricity
Other	None
Key Outputs	
Solid Waste	None
Air Emissions	None
Water Effluent	None
Cost	
Purchase	$1000–$250,000
Installation	Minimal
Other Supplies	None

* Assuming an 8-kW unit used 2h/d, 5d/wk, 52wk/yr.

- Little system support required: Air handling equipment, gas lines, and cooling water systems are unnecessary.
- Compact size: IR ovens, due to their increased energy intensity and efficiency, are generally much smaller than convection ovens and require less floor space.
- Long life and low maintenance: Electric IR emitters have a long life and require little routine maintenance. Bulb change-outs are infrequent and can be performed quickly.

Disadvantages

- Higher initial capital cost: IR systems have higher purchase costs than conventional heating methods; however, improvements in efficiency and productivity often result in short payback periods.
- Heat is transferred primarily to the surface of the target: IR energy does not have the penetrating qualities of RF systems. IR heating is limited by the ability of the target material to conduct heat away from the surface.

Commercial Status

A variety of IR systems are available through numerous vendors. Systems can be obtained with heating element temperatures of 600–4000°F, thereby producing radiation of 1–6 microns. Vendors can also provide IR systems with precise controls capable of achieving highly accurate process temperatures. Plastics manufacturers use IR heating for preheating and drying; temperatures less than 200°F are common.

Cost and Electrical Requirements

IR systems are usually custom-designed to meet specific applications; the price varies with the design. A basic IR spot heater or panel heater with two or three quartz emitters generally costs $1000–$2500. Small custom-designed ovens cost $10,000–$250,000.

IR ovens typically cost 10–20% less than gas convection ovens for the same application and features. This is due to the elimination of required gas safety controls as well as the reduction or elimination of air handling equipment.

EPRI

Technology Profile

TE-106676-P6OL

▪ Plastics Products, (vol. 13)