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Technical Bulletin—Infrared Emitters

Wilsonart International—Technical Services

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Special points of interest:

- A heating element converts electricity into heat by means of electrical resistance of the current.
- Infrared heating is a direct form of heating that involves transfer of energy directly from the emitter to the object (line of sight).

Inside this issue:

Hot Processing Laminates

High Pressure Decorative Laminate (HPDL) processing machinery continue to improve in design and performance. The demand is for faster processes with greater throughput. Bonding lines, postformers, machining processes and edgebanders have all improved efficiency and speed. Much of this equipment involves the need for heat which can come from several sources.

Postforming processes and some bonding/laminating lines utilize various forms of radiant emitters to generate the required temperature needed for the respective process. Many different types of infrared emitters may be found on these machines. Selection of the specific emitter is usually at the discretion of the machine supplier. Some of the factors that can determine the type of emitter used include economy (cost), space limitations, response times, etc.

Although many different types of emitters are used, it is important to understand how different HPDL materials respond to the various radiant sources.

Laminated components are subject to a variety of heat assisted processes.

Overview—Infrared Technology

There are two basic means of heating a product electrically, by direct and indirect methods. With direct heating, heat is generated within the mass of the material (e.g. by microwave and radio frequency energy in the case of dielectric materials or by induction or resistance heating in the case of electrically conducting materials). With indirect heating, heat is transferred to an article by any of the three familiar methods of conduction, convection, and radiation.

Conductive heating is achieved by placing an article into touch contact with a heat source (i.e. Platen Heat, Forming Bar). The rate of heat transfer is determined by several factors, not just the thermal properties and temperatures of the two bodies.

Convective heating relies on the movement of a hot fluid or gas, such as air, which acts as a carrier of heat from one body to another. Natural convection occurs when different zones of the gas or liquid have different temperatures and densities. Industrial process heating commonly makes use of forced

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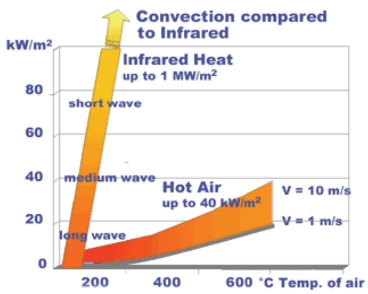
Overview—Infrared Technology continued

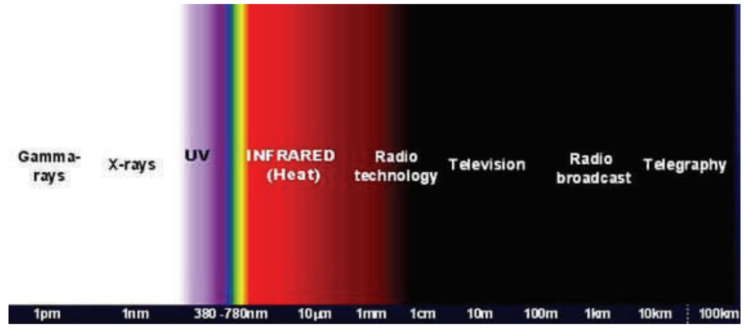
Conduction, convection, and radiation are all forms of process heat used in laminate fabrication.

(air) convection, whereby the air is directed towards the substrate by a fan (i.e. Heat Gun, "Leister" process heater).

The rate of heat transfer depends on many factors including the temperature differential between the heating air and the substrate, and the density and rate of movement of the air.



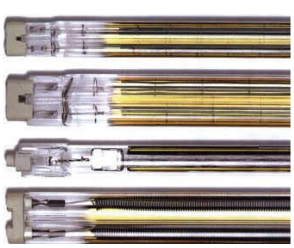
Thermal radiation takes place without the need for an intermediary agent such as air because energy is transmitted as electromagnetic rays emitted from a heated body. The rate of heat transfer depends on such factors as the temperatures of the heater and the receiver, the ability of each to emit and absorb radiant heat, their geometrical shape, their active areas, and relative positions or proximity.



The human eye differentiates between light-producing or glowing sources and invisible emissions. Infrared radiation occupies a waveband immediately adjacent to the red end of the visible spectrum. "Black heat" is a term sometimes used to describe the infrared band.

Heaters of visible radiation produce thermal radiation within the IR band as well as the visible band. Even at the very intense light producing temperatures in the order of 5000°C, a heater produces more energy in the infrared than in the visible band. Heaters that produce some light energy are also classified as infrared, although in scientific terms the description is not absolutely accurate.

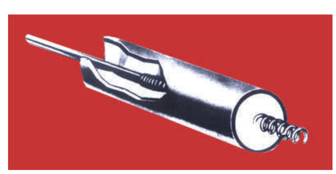
Emitter Types



Quartz Tube Heaters

Electric infrared heaters produce radiant heat through the ohmic heating effect of an electric current flowing through a spiral coil of wire such as a tungsten filament or a suitable heating element alloy. The hot wire itself may radiate or alternatively conduct its heat to a surrounding material which then becomes the source of radiant heat. Heater surface temperatures in the range of 400°C to 2200°C are normally required to produce acceptable heating rates for the wide variety of processes to which infrared systems are commonly applied. For a given radiant output low temperature heaters have a far larger radiant area than those of higher temperature. Each type of industrial heater in the long, medium and short wave bands has a role to play in the process heating field. Infrared radiation is generally classified as: short wave - less than 2 microns, medium wave - between 2 and 4 microns, and long wave - longer than 4 microns.

Metal sheathed elements Elements in the form of tubular rods are probably best known for their widespread use as boiling rings and grill elements on electric cookers. Surface temperatures up to 850°C



(depending on the sheath material) are obtainable, although a limit of 750°C is recommended where a long operating life is required. Typically, the metal sheathed element runs at a dull red heat along its working length, but running conditions from true "black heat" to orange can be selected, bridging the medium and long wavebands. The elements consist of a nickel-chrome resistance spiral mounted concentrically inside a tubular metal sheath. Electrical insulation between the two parts is provided by compacted magnesium oxide powder so that the sheath can operate safely at ground potential.

Mediumwave Quartz Heaters The most common type of medium wave heater is the tubular fused quartz unit. An alloy

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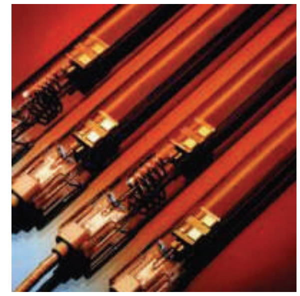
spiral element is housed inside a linear quartz tube, which is open ended. There is minimal contact between the spiral and the inner wall of the tube. The peak wavelength is around 2.5 microns, and as quartz transmits infrared radiation efficiently up to 4 microns the quartz temperature is cooler than the spiral element. This means that convective losses from the quartz outer surface are minimized, while the secondary radiation from this source at a temperature of 650°C contributes to the total output from the heater.

Shortwave Quartz Tube Heaters Short wave tubular heaters in basic form comprise a linear coiled filament surrounded by a clear quartz glass tube. The tube is evacuated, the electrical connections being taken through seals at the ends. They are suitable for many industrial and research applications.

Basic air- cooled units are the most commonly used short-wave heaters, and are manufactured in single and twin-tube versions, single tubes of around 10 mm outside diameter and up to 1 meter in heated length have power ratings from 0.5 to 5 kW. Twin tube heaters are nominally 11 mm by 23 mm in cross section but have longer heated lengths up to 3000 mm. Power ratings are from 0.25 to 15 kW. In general, short wave tubes operate with a filament temperature of 2200°C corresponding to a peak wavelength of 1.2 microns.

Carbon Heaters High heating efficiency and rapid cool down make the medium wave infrared carbon heater [see figure right] an excellent choice when shortwave response times are required. Suitable for all medium-wave applications, carbon heaters also offer the capability to match temperatures to the optimum absorption wavelength for each application. These features eliminate overheating and contamination of sensitive substrates.



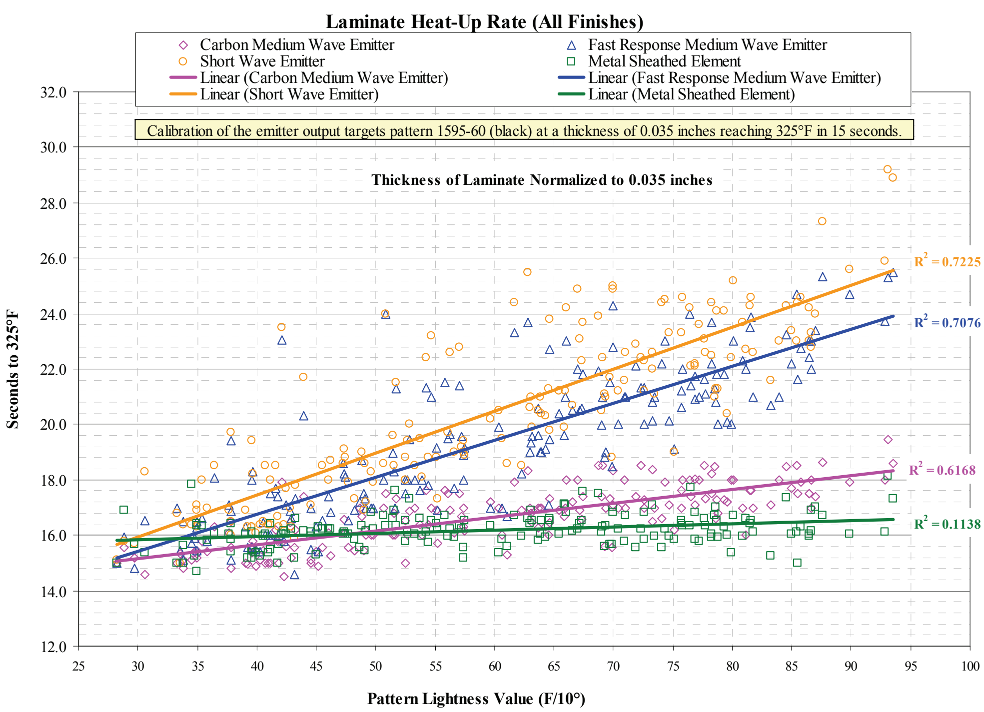
Carbon Heaters

The key to process consistency is controlling all the variables. With laminate in a heated process, color is often a contributing variable. How many colors do you work with?

Effects of Color with Different Emitters

Radiant Energy absorption can vary greatly depending on the color/finish and the wavelength of the emitter. Similar to the comparison of a white car versus a black car in the summer sun, different colors absorb radiant energy at different rates. This variation becomes more prevalent as the energy wavelength approaches the visible light spectrum.

A comparative study was conducted of various laminate colors heated to 325°F by various types of emitters. All emitters were calibrated to heat black laminate to the target temperature in 15 seconds. The actual time to 325°F for all colors were arranged by the "Lightness Value" of the respective design.



Color and Lightness values of laminates range dramatically by intended design.

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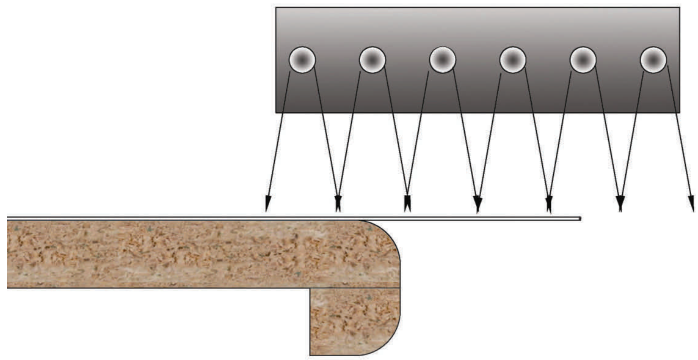
In addition to the emitter wave length and HPDL Color considerations, it is important to understand an emitters focal characteristics. This is primarily a function of the reflector housing which can be shaped by the manufacturer to reflect radiant energy in a desired path. Knowing this angular distribution of the energy will allow the most effective distance adjustment for uniform heating of the laminate. This illustration below is a visual simulation of an emitter bank for a postformer. If the distance between the lamp and laminate were increased/decreased, the overlap of the radiant energy would potentially create "hot/cool" zones that may be difficult, or impossible to adjust-out by the emitters set-point (output).



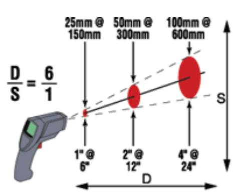
Monitoring Heat Assisted Processes

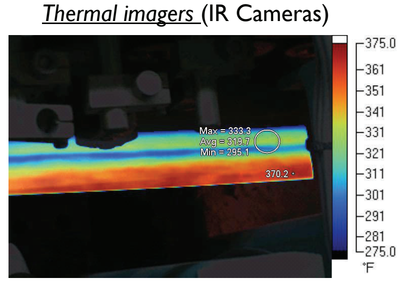
Many of the fabrication processes used for laminated components are heat assisted. Although HPDL can tolerate high temperatures, controlling the temperature level and placement of heat is extremely important for a robust process. There are three primary ways to monitor heat in a process.

Contact type (thermocouple) probes may be used to measure static (fixed) object with a high degree of accuracy. The limitation of this test method is the inability to monitor moving parts in a machine line. On the other hand, this method works well for monitoring platen or cove bar temperatures.

Multimeter with Thermocouple

Non-Contact type (Infrared) meters or imagers can measure temperatures using the same energy radiation principals as described earlier. The emissivity of the material being measured will affect the accuracy of the measurement. *Hand-held thermometers* will have various "Field of View" (Distance-to-Spot-Size Ratio) which will determine the average of the area being monitored. *Thermal imagers* (IR Cameras) can create a gradient map of the varying temperatures on the product being measured. This technology is very helpful in understanding heat distribution however; it is also prone to the same emissivity variations as the hand-held thermometer.





Temperature indicator liquids/crayons (Tempilaq/Tempilstick) are tempered wax materials that are manufactured to activate (melt) at a predetermined temperature. These indicators are generally accurate to 1% at determining the surface temperature of the object being measured as well as the distribution of heat.

Properly monitoring the heat in a process may involve one or all of these technologies.

Special thanks to: Heraeus

Heraeus Noblelight for providing reference information and images. For more on infrared energy and/or emitters, visit www.noblelight.net