BriskHeat®

INDUSTRIAL HEATING AND CONTROL FOR CURING ADVANCED MATERIALS

Advanced materials such as liquid resins, fiber cloths impregnated with resin (prepreg), and bonding adhesives are engineered to have specific curing regimes required to maximize strength and durability. In many instances, resins and adhesives will harden at room temperature; however, heat may be required to complete or speed up the chemical reactions necessary. This article will examine how surface heaters are used in manufacturing environments to cure these materials. Determining heater requirements, heater selection, and proper control are the first steps to successful curing. Next, specific applications from several companies are highlighted to illustrate the heaters and controls used in the manufacturing process of their products.

Advanced Materials

Thermoset resins are polymers used when products require high-structural strength created by molecular cross-linking of the material. They will typically withstand higher temperatures than thermoplastic materials; once cured, they will not melt or flow. Examples of thermoset resins are polyester, epoxies, and phenolics.

Using adhesives to bond structures will transfer loads more efficiently than traditional fasteners as more surface area is bonded as opposed to traditional fasteners with unbonded surfaces. Adhesives may include thermoset resin material and often require heat for complete curing.

Hot bonders are specialized controllers used for ramp/soak applications that may require vacuum for debulking. Typically, they are used for repairs but may also be used for co-bonding parts during the manufacturing process.

Heater Selection

Manufacturers of advanced materials will provide instructions for using their products. This includes potentially mixing the resin or adhesive, applying materials including film thickness and environmental conditions, and curing cycles defined by time and temperature. Surface heaters are often used to cure composite resins and adhesives as direct contact provides efficient heat transfer. Follow instructions as written to obtain the full benefit of the material. Heaters that will meet the manufacturer's requirement for curing should be selected.

When considering which heater to select, choose one based on:

1. Temperature limits – blankets should be able to withstand a temperature range beyond what is required
2. Flexibility – blankets should be flexible to fit tightly against the material to be cured
3. Construction – blankets should be constructed for durability and uniformity and suitable for the environment

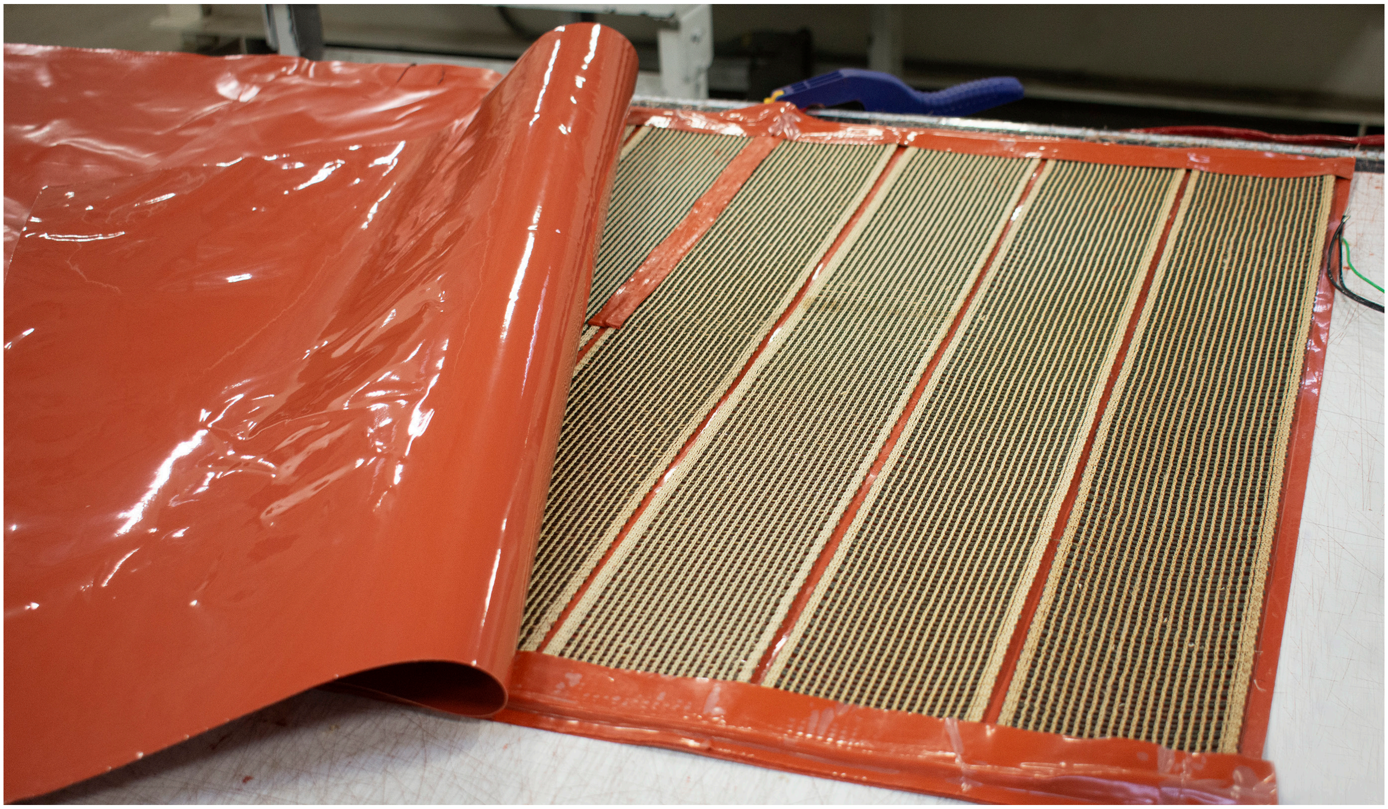

Figure 1 *- Heater construction provides durability and temperature uniformity. (Photo courtesy of BriskHeat Corporation)*

Determine wattage - The first step in heater selection is determining the wattage required for curing the materials to be processed:

1. Heater wattage should be calculated by determining the power needed to raise the temperature from ambient to the maximum required for curing.
2. Specific heat and density of the materials must be considered, as well as the volume of material in the structures to be heated.
3. Insulation placed over the heater increases energy efficiency and temperature uniformity. Using insulation will reduce wattage requirements and is highly recommended.
4. It is best to add 20% additional capacity to provide a built-in safety/buffer factor.

Determine heater materials – The material to be cured will dictate acceptable heat levels. Most thermoset resins can be cured at temperatures below 450°F (232°C), making flexible silicone heaters the best choice ***(Figure 1)***. Some blankets can conform to a ¼ inch (6 mm) radius under vacuum, and silicone is usually moisture and chemical resistant for easy clean-up. Choose blankets with smooth surfaces if they will be in close contact with a resin surface. Otherwise, pressure from debulking could result in a pattern from the heater being transferred to the surface being cured.

Curing thermoplastic resins may require temperatures exceeding 450°F (232°C), where flexible silicone blankets cannot be used. High-temperature cloth blankets are capable of higher set points and are a good high-temp solution if they won't be exposed to moisture ***(Figure 2)***.

Figure 2- Cloth heaters can be used for curing resins with higher temperature requirements (Courtesy of BriskHeat Corporation)

Determine heater locations - Heaters should allow for heat distribution to the entire area to be cured. They must have intimate contact with the surfaces to be heated. Gaps between surface heaters and the surface to be heated can cause blankets to overheat, material to scorch due to poor heat transfer or imperfections in the cured part. Pressure-sensitive adhesive allows heaters to be affixed directly to tooling for injection molding of liquid resin parts, reducing the potential for gaps. Other considerations for heater placement:

1. The entire surface area of the material being cured must be heated either through direct contact with a heater or by heat transferred from a heated mold.
2. Several heaters can be used to apply heat uniformly such that materials will cure at about the same rate.
3. Heat should be applied from multiple sides for double-sided curing of thick parts.
4. Irregular shapes may require multiple temperature sensors and controllers.

Heater Temperature Controllers

Almost all industrial heaters require some type of temperature control. Manufacturers requiring accurate process control temperatures usually select digital temperature controllers with discrete setpoints and alarms. There are three common control schemes - On-Off, PID, and Ramp/Soak. On-Off types operate as the name would imply. Without a limiter feature, once the temperature is set, the controller will drive the heater at 100% capacity until the setpoint is reached. Next, the controller will stop supplying power to the heater until a low threshold is reached, and then the heater is supplied with 100% power again.

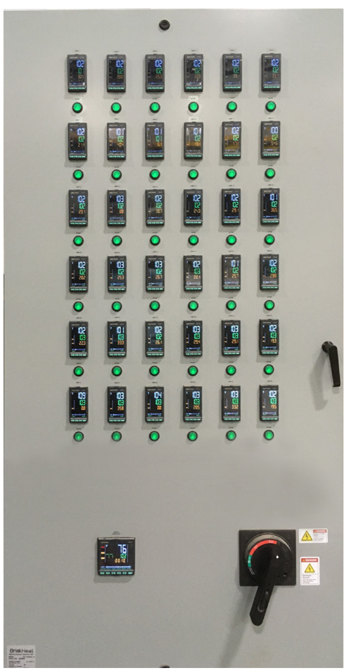

Figure 3- *Control panel for 36 zones (Courtesy of BriskHeat Corporation)*

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Figure 4- *Heating blankets secured to mold (Courtesy of BriskHeat Corporation)*

PID controller (proportional - integral - derivative) uses a control loop with feedback to reduce the output power as the heater approaches the set point. This controls heat much more accurately, with less over-shooting of the setpoint temperature.

Ramp/Soak temperature controllers are most often used to cure advanced materials. Manufacturers often specify a ramp cycle to prevent materials from being heated too quickly. As an example, a material may require a ramp speed of 5°F per minute from ambient to a specific temperature such as 250°F. The controller automatically increases the setpoint temperature every minute and powers the heater appropriately. Once the material being cured reaches 250°F, the soak feature of the controller will hold the temperature of the product for the prescribed time by cycling the power to the heater as required.

Heater Applications

A manufacturer of Fiberglass Reinforced Plastic (FRP) vessels and structures uses the spray-up method as one of their manufacturing processes. A reusable mold is covered with silicone blankets placed end to end for equal heat distribution ***(Figure 3)***. Temperature sensors are placed on each blanket to monitor and control the temperature during curing. Each blanket and sensor is connected to a control panel with separate controllers for each blanket ***(Figure 4)***. The controllers are programmed for a 2-stage ramp/soak schedule as prescribed by the resin manufacturer. By using individual blankets and sensors, areas requiring more or less power during the cycle can operate independently from other sections.

Manufacturers use secondary bonding processes to perform operations such as potting or gap-filling when accessories are added to a product. Adhesives are used to join two precured parts. The bond requires localized heat to cure the adhesive while protecting the precured parts from damage that could be caused by heat. This process may require a special 3D molded heater constructed to the profile of the joint to be cured. One method used to make these heaters is to coat a form with a release agent or film. Liquid silicone is applied to the form and allowed to dry. Resistance heating wire is laid over the silicone in a precise pattern to provide the required wattage for the curing application. Lead wires are added to provide power to the heater. A second layer of silicone is applied over the heating wire. Heaters with built-in vacuum ports may be an option (***Figure 5)***. The end user may use hot bonders to apply heat and vacuum for the secondary bonding process or composite repair. ***(Lead photo)***.

Advanced materials are replacing metal parts in everything from planes to sporting goods because they are lighter weight while maintaining the strength required of the product. Electric surface heaters with accurate temperature control are used to obtain the maximum properties of the material. One manufacturer uses a variety of surface heating products throughout its manufacturing process. See the sidebar for more information.

Figure 5- *Combination reusable heater with vacuum capability (Courtesy of BriskHeat)*

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