Flexible heaters:

Crucial Considerations when Building Flexible Heaters

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Introduction

An electronic heater is created by driving electric current through a resistive element. As the current is drawn through the element some of the energy is expelled as heat. That heat can then be transferred to other surfaces with positive effects. It is a convenient way to keep components above damaging temperatures. Or or to heat surfaces to a specified temperature and keep them there. Some of the first heaters were simple Nickel Chromium wires attached to a power source and wrapped around a mass to transfer heat. This is effective, but not practical in all applications. Heaters that are designed on flexible material can be attached to flat surfaces, equipped with temperature sensing devices and monitored constantly so that adjustments are possible as the ambient surroundings change. There are two types of flexible heater material that are common, silicon rubber and polyimide. We will focus, in this article, on **flexible polyimide heaters.**

Common Uses

Flexible heaters are used to keep components, typically microprocessors, at a consistent temperature in devices that are exposed to conditions that are nothave varying temperatures. They are used to heat surfaces as well. For instance, the seat or steering wheel in your car. Biological samples are sometimes better analyzed at the typical body temperature for a human or animal. Whichever the case may be. Batteries and electronics in aircraft that must operate normally at 30,000 feet above the earth are kept warm with flexible heaters. Handheld electronics as well as ATMs machines that must operate accurately in cold climates will use flexible heaters to keep critical components in the specified temperature range. The uses are not trivial and one may say critical in many applications.

No matter the product or what function it provides, flexible heaters are an important element in the electronic industry.

Design Criteria

For a flexible heater to be designed accurately, we must first understand a few things.

1. The material to be heated
2. The temperature range of the product's surroundings
3. How fast the heat must be transferred to the material
4. What temperature the material should be during the process
5. The power source available
6. Will the heater be monitored? And how?Whether the heater will be monitored and how it will be monitored

Armed with this information, an engineer can confidently design a heater may be designed confidently that will fit the application and heat it to the prescribed temperature in the specified time range consistently.

Conductor Options

Conductor choice is important to a flexible heater design. The most cost-effective choice is standard copper, which is available on pre-laminated material and used extensively worldwide in flexible circuits. However, a heater designed with copper requires a lot of surface area because of its low resistivity of $669.29 \times 10^{-9}/in^2$, thus it is typically used for very low resistive designs. Heaters that are designed for small areas with high heat requirements are typically designed with some type of nickel/copper alloy such as Inconel or Constantan. They have resistivity levels of $40.55 \times 10^{-6}/in^2$ and $19.29 \times 10^{-6}/in^2$ respectively and allow for higher resistive circuits in much smaller areas. Nickel/copper alloys are not widely available pre-laminated on polyimide and therefore are less cost effective because the processes and material costs are higher. However, heaters designed with these conductors are just as robust as standard copper and perform very well in all applications.

A key specification is the target temperature of the material being heated. Once the required temperature is known, it can be converted to Watts/in² and Ohm's Law may be used to calculate the proper resistance required for the heater. Obtaining the required resistance on the circuit in a pattern that emits consistent heat across the surface is easily accomplished with an interlocking serpentine pattern of the correct trace width and length. It is important to note that this pattern is best suited for the heated area and must be adjusted in 'non-heated' areas of the circuit, such as a tail that carries the signals outside of the heated product. More on that later.

Temp Sensing

Most heaters will include some type o f sensing device that can be monitored continually, allowing the mass to be kept at a steady temperature. A Resistance Temperature Detector (RTD) placed strategically in the heated area will alert the monitoring device when the temperature climbs above or below the specified range. The monitoring device then can adjust the power to the heater and bring the temperature of the mass back to its required temperature. RTDs come in many different shapes and sizes. Some are tubular, like a thermocouple. Others are flat, like a ribbon. Yet others look like standard surface mount resistors. Whatever method is used, the concept remains the same. Monitor the temperature and adjust the power source to keep it in the desired range.

Fusing

We've mentioned earlier that some applications are very critical. In those cases, redundant safety features may be prudent. In applications where the heater is being continually monitored, it is intuitive to believe that the monitoring device will detect any issues with the heater running too hot or too cold. However, the device, which is controlled by a software program, might not detect these issues. Software programs often cannot prepare 100 percent for scenarios in practice. As well, a defective component that fails at an inopportune moment can cause the monitoring device to think all is well, when in fact it is not.

In these cases, a redundant safety measure is designed into the heater. A common method is to attach a thermal cutoff device (TCO). A thermal cutoff is an electrical safety device that interrupts electric current when heated to a specific temperature. These devices may be for one-time use, or they can be reset manually or automatically. In the case of a heater that is being misunderstood by the monitoring device, as needing more power, the TCO will heat up and eventually open like a switch. Thus, cutting off all power and preventing an unacceptable event such as a heater catching fire in an operating room

Connection to Power Source and Monitoring Device

Once the heater is designed for power, monitoring and safety, it must have a method of attachment. Several methods are commonly used. Bare wires that may be soldered, a cable with connector that may be plugged or a zero insertion force, (ZIF) connector that also may be plugged. These methods have all been used extensively and work equally well. When a cable is used, with or without a connector, it is typically soldered to the heater and then routed to the power source for attachment. A ZIF connector however is an inherent part of the flexible heater and requires less cost and inventory. There are no wires or connectors to stock or assemble. It only requires a mating connector on the power/monitor device circuits. This area of the heater is usually a "non-heated" area. The signals must be adjusted so that the power travels through them without heating as they do in the designated heated area.

Attachment Methods

If the flexible heater is to transfer its heat to a mass or surface, it must be firmly attached to that surface. Some methods that are typical are adhesion, clamping or blanketing. A standard adhesion scenario would include a pressure sensitive adhesive (PSA) attached to either the flexible heater or the surface to be heated. The clamping method is as its name implies, a heater clamped between two surfaces. And the blanketing method is also intuitive. The flexible heater will be wrapped or blanketed around the mass that requires heating. In all cases, it's important that the heat is transferred evenly across the entire surface. Any void in the transfer will create hot spots and deter the heater from performing as intended.

Heat Spreaders

One way to help ensure that there aren't hot spots is to include a heat spreader on the back side of the flexible heater. This would be a good practice if the blanket method is used to transfer the heat. Since the blanket method doesn't provide a solid method of transfer, spreading the heat on the heater itself is necessary. A spreader of a good thermally conductive material such as aluminum can be adhered or laminated to the flexible heater and ensure that the heat is spread evenly. It isn't necessary in all applications, but is very useful in some and is easily done.

Conclusion

Flexible heaters are used throughout the electronics industry because of their lightweight and inherent flexible capabilities. Their use as critical components in aircraft and medical devices require a thoughtful approach to their design. As well, their use in products such as heated automobile seats or clothing allows them to provide comfort to their user. They keep electronics warm to provide endless amounts of uninterrupted use in the roughest of conditions. Flexible heaters are useful for many applications and will continue to be valuable far into the future.

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