The Art of Thermocouple Measurement

by Kassandra Kania
Managing Editor

Heat-seal equipment suppliers debate the most accurate means of measuring the heat-seal temperature.

The MPS 14000 high-speed continuous band sealer from Emplex features variable speed up to 15,000 in./min.

Maintaining consistent temperature is an essential feature of all medical heat sealers. Temperatures that fall outside of parameters and variations along the heat-seal bar can adversely affect seal quality. To monitor these temperatures, many heat-seal machine suppliers use thermocouples. But the location and number of these devices differ from one type of machine to another—as do opinions about their role in controlling temperatures to ensure an accurate and repeatable process.

LOCATION, LOCATION

Kent Hayward, marketing manager of Alloyd Co. (DeKalb, IL), notes that different manufacturers measure the temperature at different places. While Alloyd's blister sealers measure the temperature with a thermocouple at the heater, Hayward believes that the best place to measure the temperature is at the sealing surface. "We're all attempting to get as close as we can to the sealing surface," he says, "but it's difficult for the heat-sealing or tooling manufacturer to measure that temperature."

Mark Finneran, sales engineer for O/K International Corp. (Marlborough, MA), agrees that thermocouple placement is important, and the location depends on what type of machine you select. The company offers both hot-air and band sealers. "You want to position it for a stable process," he says. On a band sealer, the thermocouple is located directly on the heating element. Or the heating element is inside a heating block, which generates heat that is transferred to the band. "We measure the temperature of the heating block," he explains. However, the location of the thermocouple on the heating element is not required. "You can buy heating elements with an imbedded thermocouple, but that's not necessarily going to give you a better process," says Finneran. "Closer to the actual location where the bag is being sealed is more consistent with a stable sealing process."

Charles Schapira, president of Aline Heat Seal Corp. and Aline Medical Packaging Machinery (Cerritos, CA), refers to thermocouple reading as an art rather than a science. "Often, customers will want to take measurements across the heat-seal band," he says. "That's an art, because the placement of the thermocouple is important relative to the width of the band you're using." Typically, companies take three to five readings, he says. If the temperature controller is not accurate, they are likely to see a wide variance in measurements. "The consistent way to measure the temperature would be to place your thermocouple underneath the heat-seal band," says Schapira. "If you measure it through a Teflon tape, you're going to lose temperature, and you're not going to accurately reflect what your controller is doing."

The location of the thermocouple is also dependant on the type of heat sealer, note some suppliers. "For bar sealers it's probably important," says Stan Hall, Saxon product sales manager, Fischbein-Saxon (Statesville, NC).

CAN HEAT-SEAL TEMPERATURE BE MEASURED?

by Charles Trillich, president, PackworldUSA

Experienced users of heat-sealing equipment seem to agree that it is difficult to accurately measure the temperature of the sealing device at the point where it engages the workpiece. Wafer-thin thermocouples can be used as a referee for monitoring, but it is a challenge to have them produce accurate measurement. When inserted between the workpiece and the heater, the thermocouple measures a temperature that is somewhere between the heat source temperature and the heat sink temperature.

PackworldUSA PW3016 with TOSS technology employs thermal coefficient of resistance for precise, validatable temperature control.

The task is further complicated by the fact that some heating systems are not uniform; the measurement taken at one time or place is not the same throughout the length of the seal. In addition, increased productivity requires greater speed and shorter sealing cycle times. With heating cycle times of less than 0.5 seconds, the peak temperature of the workpiece may be maintained for only 20 milliseconds. This leaves insufficient time to obtain an accurate measure of temperature.

Resistance temperature detectors (RTDs) face the same obstacles, and optical pyrometry is useless because the site to be measured cannot be observed.

There is, however, a way that this task can be accomplished. It requires the ability to measure the internal molecular activity within the heating element itself. This may seem to be complex, but it is not. The level of molecular activity is directly related to the temperature of the heating element. This activity is manifested by a proportional increase in the electrical resistance of the heating element. If the thermal coefficient of resistance (TCR) of the heating element is known, the electrical resistance of the heating element can be precisely measured. An electronic monitor then translates it into a digital display of heating element temperature.

There is little magic here. This technique uses the same physical principles that are used in the design of conventional RTDs. There is, however, a critical consideration. The TCR of the heating element must be known, and it must be quality controlled to ensure that each and every heating element conforms to the design specifications and prescribed TCR. If the heating element is a heat-seal band of uniform shape and cross-section, the temperature along the length of the heat-seal band will be absolutely uniform. It will also cool rapidly to create a secure seal while the workpiece is held firmly between the sealing jaws.

These things done, a high response controller can simultaneously monitor the temperature and control the electrical current to the heating element, thereby attaining and maintaining the heating-element temperature throughout a preprogrammed heat-sealing cycle. Not only can the temperature be monitored and controlled, but controllers can also be set with a variable time/temperature profile and high/low limits that, if violated, will activate an alarm. Controllers are also fitted with system diagnostics that detect, report, and activate the alarm if any inconsistency in controller performance occurs.

"For continuous sealers, it isn't." The thermocouple location for a stable, steady, continuous process is not critical, says Hall. "It's a relative measurement to the bag seal temperature produced. Whether you measure it at the location where it's produced or some distance away, as long as there's a stable, steady-state process (characteristic of continuous-sealer temperature controllers) a direct relationship exists between the thermocouple temperature and the bag seal temperature... and the proximity to the bag doesn't matter as long as it's monitored appropriately by the controller."

ACCURACY

While some experts agree that the location of the thermocouple affects reading accuracy, they question how accurate does the process need to be? "With thermocouples, I don't believe that the issue is whether you have one model of thermocouple that is much more accurate than another," says Paul Irvine, CEO of Emplex Systems Inc. (Toronto), a manufacturer of continuous rotary heat sealers. "Even when you measure the temperature as close to the face of the bar as possible, there are hot spots along the bar. You may have a heat differential of 5°–10° from the middle to the ends of the bar," he says. Emplex measures the temperature as close to the surface of the bar as possible; however, Irvine does not see a need to improve on this. "You can't control the heating element at every portion of the bar so that it is, say, ±2° or 3°. In fact, we've never been involved with a customer that's so exacting they would require the temperature controlled within a range of 2° or 3°C, because in the end it does not affect seal quality," he says.

Chris Moore of Accu-Seal (San Marcos, CA) agrees. Improving the accuracy of temperature measurement alone for impulse or constant-heat sealers is not a priority, he says, as it will not improve the accuracy of your

heater or any other part of your control system. "Especially for most of the materials that the medical community is sealing," he says, "because they aren't that sensitive to differences in temperature. If you seal a pouch at 290° and then at 295°, you're not going to see a difference."

John Abraham, vice president–sales for Atlas Vac Machine, Div. of Planet Products Corp. (Cincinnati), agrees that a temperature difference of ±5° can produce a perfectly good package if you choose this parameter range and perform process validation accordingly. He admits that temperatures can vary across the bar or flat platen; however, "you don't want hot and cold spots of wide variation," he says. "You can measure the temperature with thermocouples, but just measuring it doesn't solve the problem." Wide temperature variations across the sealing platen could indicate a design flaw, says Abraham, primarily a lack of mass.

Another area that can affect temperature measurement is thermocouple calibration of the sealing platen. Typically, this is done by hand, says Abraham. As such, it is very sensitive to technique. "If you don't hold the pyrometer probe exactly right, you can get two different readings." (The pyrometer, which is used for measuring temperature, is not part of the machine.) In addition to using four thermocouples embedded in the plate, Planet Products provides an infrared vision system that directly senses the actual surface temperature of the heat platen. "The idea for the infrared system came from our customers," says Abraham. "They would call saying, 'I thought I had a problem,' but then discovered it was a difference of technique when someone else held the probe." With the infrared system, the user can determine if the infrared eyes are within a 10th of a degree of each other, which is important when controlling zones of surface temperature on the platen created by the underlying heaters and thermocouples that are subject to thermal lag. Differences between the zones become less probable given sufficient platen mass. By examining the true surface temperature, the infrared system can determine whether or not there's a problem with the thermocouple, says Abraham.

ALTERNATIVES

Charles Trillich, president of PackWorldUSA (Nazareth, PA), acknowledges that accurate thermocouple measurement of sealing temperatures is difficult. As a result, the company employs alternative means of measurement: a sealing system in which the heating element is its own temperature sensor. "The sealing temperature is determined by using a precision-made heat-sealing element in conjunction with a high-response power controller that monitors the resistance change in the heat-seal element," he explains. "This method is based on the basic laws of physics used in the manufacture of resistance temperature detectors (RTDs). As the heat-seal band increases in temperature, the controller monitors the resistance of the heat-seal band and adjusts the power supplied to the band to maintain the temperature at the preselected set point. The heat-seal band, being uniform in crosssection, is equally uniform in its unit resistance. Every part of the heat-seal band is elevated to the same temperature. The controller, being calibrated to the temperature coefficient of resistance (TCR) of the heat-seal band, monitors the relative resistance of the band 60 times per second and displays an accurate temperature continuously."

The high-response controller can be used in steady-state applications as well as to make impulse seals in less than 0.5 seconds, says Trillich. Both the controller and the heat-seal band are calibrated and validated during manufacture to ensure accuracy.

CONCLUSION

Experts agree that maintaining consistent temperatures is important, although how, where, and to what extent those temperatures should be measured is open to debate. The type of heat-sealing equipment used and how it is being used are factors to consider. Emplex's Irvine doesn't believe that monitoring systems need any improvement. "The next level of sophistication doesn't reside in a monitoring system becoming incrementally that much better," he says. "Customers are more interested in increasing speeds and automating bag flow to the sealer." The issue, then, becomes how to maintain accuracy at high speeds. Accu-Seal recently worked with a customer that wanted higher accuracy on the seal bar and a higher throughput capacity. The company went from an impulse sealer with a 10° to 15° variation to a constant heat seal bar with a ±1° variation. "What you want to do is maintain repeatability in high production," says Moore. In addition to monitoring temperature to achieve these goals, companies need to consider the design of the sealer—the mass of the bar, the controller, and the heater, he says. All of these elements are important when controlling temperature. ■