Selecting a handheld surface temperature sensor

Measuring surface temperature with handheld sensors is tricky. Even if the indicator shows the temperature in tenths of a degree, the real value is often very different. You can choose to measure with a thermocouple, a Pt100 sensor, or an infrared pyrometer. They all cost about the same but have different features.

Of these three kinds of sensors, the thermocouple and the Pt100 are both contact thermometers and the IR pyrometer is non-contact. Contact thermometers require heat from the surface in order to become (at best) as warm as the surface. Even if the heat transfer can occur without any insulating air pockets, a heat flow will arise. This first heats the probe and then dissipates via the probe out into the surrounding environment. It is the temperature difference between the measured surface and its surroundings which drives the heat flow. (See diagram 1)

The thermal load of the surface lowers the surface temperature at the point of contact. Good heat conductors such as copper are affected far less than materials like wood and plastics, which have a very limited ability to supply more heat. If the contact is then worsened by the probe's angle to and pressure on the surface, then the heat transfer is further reduced.

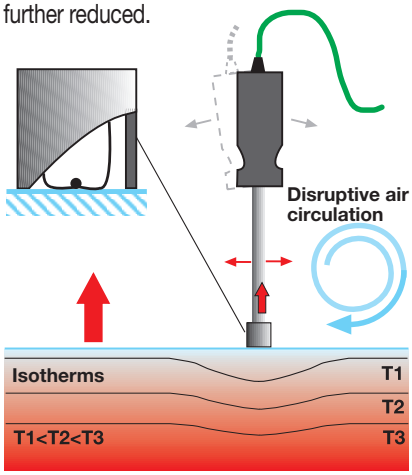

Diagram 1. A thermocouple sensor creates thermal load and heat dissipation at the point of contact, thereby lowering its temperature. The magnitude of the error increases with rising temperature.

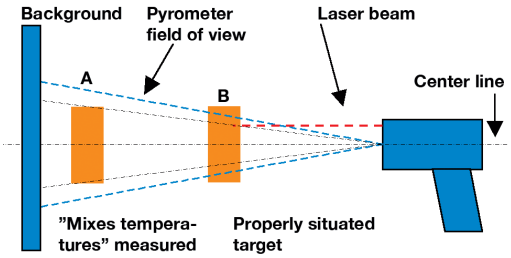

Diagram 2. B indicates the correct placement of the object being measured. In situation A, you will also be measuring the background between the blue and black lines. The laser beam of low-cost IR pyrometers does not coincide with the centre line of the pyrometer's field of view, which can cause problems at a short distance. At a longer distance the measuring spot becomes very poorly defined.

You might think that because the Pt100 sensor is so precise it would measure more accurately than a thermocouple, but this is not in fact the case. Thermocouples used to measure surface temperature often have their measuring junction in direct contact with the surface being measured, and this junction is usually in the form of a wire or ribbon. The Pt100 only provides indirect contact with the surface because the Pt100 must be sheathed. True, there are thin film Pt100s for mounting on or inside the end of the probe tip, but even with these, the platinum layer does not come into direct contact with the object being measured. As a result, thermocouples are the better choice for contact measurement in most cases.

NO LOAD FROM IR

The IR pyrometer takes non-contact measurements. As a result, no thermal load is created. Instead, there are at least two other significant sources of error which are common to all pyrometers.

First, the user must ensure that the object being measured and the pyrometer's optics are set up correctly. The pyrometer's instructions for use stipulate the correct relationship between the measuring spot and the measuring distance. For example, 1:10 means that a distance of 1 metre gives a measuring spot with a diameter of 0.1 metre. A laser beam is often used; this roughly pinpoints the centre of the measuring spot and sometimes also measures its diameter. If you measure outside the measuring spot, the result will be roughly the mean value between the temperature of the object and the background temperature weighted by the relationship between their areas. (See diagram 2)

The second source of error is linked to the measured object's type of material(s) and surface structure, and the angle of incidence, wave length and temperature. These factors taken as a whole result in the object's emissivity, which varies between the extreme values of 0 and 1. An emissivity close to 1 ensures that most of the radiation perceived by the pyrometer originates from the object's surface. The rest of the radiation is reflected from the various heat sources in the object's surroundings. An emissivity less than approx. 0.5 means that the pyrometer will be highly sensitive to reflected IR radiation from oven walls, sunlight, and similar sources. When goods in frozen food cabinets are measured, the radiation from the body of the person operating the pyrometer can actually increase the temperature reading.

THERMOCOUPLES MOST RELIABLE

An IR pyrometer is useful for comparing surface temperatures in different conditions, but the accuracy of the absolute temperature in degrees Celsius measured by a pyrometer is comparable to or worse than that measured by handheld contact thermometers. High emissivity is a feature of natural organic materials such as skin, wood, textile, paper, etc. Shiny metals also give very unreliable readings.

When choosing a type of sensor, the first decision is whether it should be non-contact or not. For moveable objects, non-contact measurement is often preferable. For fixed objects, the choice is not so obvious. IR sensors require knowledge and measurable surfaces. Of the handheld contact sensors, thermocouples perform the best, especially with carefully constructed measuring junctions. By far the best solution for surface temperature measurement is to use a fixed mounted thermocouple or Pt100 sensor.

Opinions and questions are welcome at: hans.wenegard@pentronic.se