Special Pyrometers

Fiber-optic Pyrometers

Pyrometers with fiber optics are used for applications involving strong electrical or magnetic interference fields for measurements at high ambient temperatures, under vacuum conditions or where only little space is available. This makes it possible to place the sensitive electronic system outside the danger zone. Typical of these applications are induction heating and induction welding. Since the fiber optics themselves contain no electronic components, the operating temperature can be raised significantly without the need for cooling up to 300°C (572ºF). Installation and continuous operating costs per measuring point are low since no water cooling is required.

Single fibers or multifiber bundles are used. Multifiber bundles have the advantage of allowing a smaller bending radius.

With modern devices, it is possible to replace the fiber-optic cable and optics without recalibration. Simply input a multi-digit factory calibration number. Fiber-optics are available for wavelengths of 1µm and 1.6 µm. Targets from 250°C (482ºF) can be measured with these.

Ratio Pyrometers

Special pyrometers (also called two-color or dual wavelength pyrometers) have two optical and electrical measuring channels identical in structure. Both wavelength ranges are placed as close as possible to each other and set very narrow-banded, so that the effect of material-specific peculiarities (reflectance, emissivity) from the target is near-identical to both wavelengths. By means of a mathematical calculation of ratio, certain influences on measurement can be eliminated. The following procedures have proved successful:

1. Splitting the measured radiation using two filters which revolve in front of a radiation detector (filter wheel). Measurement in both channels takes place alternately which, in the case of fast moving targets, can result in errors in ratio calculation (channel 1 sees a different point on the target than channel 2).
2. Splitting of the measured radiation using beam splitters and two radiation detectors fitted with filters.
3. The measured radiation reaches - without the beam-splitter - a double detector (sandwich design) fitted with filters. Here, the front detector represents the filter for the second detector behind it.

Using the pyrometer equations /5/ for channel 1 with wavelength λ_1 and channel 2 with λ_2 The result for the measured temperature Tmeas :

$1/T_{meas} = 1/T_{target} + (\lambda_1\ \lambda_2)/(c_2\ (\lambda_2 - \lambda_1))\ \ln(\varepsilon_2/\varepsilon_1)$ (3)

If the emissivity in both channels is the same, then the term after the plus sign becomes zero and the measured temperature corresponds to the target temperature T_{target}. (c2: second radiation constant in µm·K).

The same can be applied to the target surface A, which as A_2 and A_1 is of course identical in the case of both channels, meaning that here too the term after the plus sign is dispensed with.

$1/T_{meas} = 1/T_{target} + (\lambda_1\ \lambda_2)/(c_2\ (\lambda_2 - \lambda_1))\ \ln(A_2/A_1)$ (4)

Thus, the measurement is independent of the size of the target. Moreover, the object radiation being sent to the pyrometer becomes reduced proportionally, not only when there is a smaller measuring surface, but also when the pyrometer "gets to see" the target for a shorter time span. By this means, targets that are in the line of sight for a shorter period than the response time of the pyrometer can also be measured.

Changing transmittance characteristics in the measurement path are eliminated in the same way. The devices can be used where there is dust or smoke present, or any other interfering factor that reduces radiation from the target. Modern devices can apply this effect (attenuation) to their own optics, and send out an alarm signal at the appropriate level of contamination (e.g. air purge failure with the air-blowing attachment)

Summary

Ratio pyrometers can measure temperature when:

1. The target is smaller than the spot or is constantly changing in size (background cooler than target).
2. The target moves through the spot within the response time.
3. The line of sight to the target is restricted (dust or other particles, vapor or smoke).
4. Emissivity changes during measurement.

The attenuation factor provides additional information about the technological process or can be used as an alarm in the case of overcontamination of lenses or windows.