NON-CONTACT TEMPERATURE MEASUREMENT – PART 1

Using an IR pyrometer for temperature measurement is becoming increasingly common. However, to avoid the risk of large and unnecessary measurement errors, knowledge is required about the radiation pyrometer's function and properties.

In this first of two articles about non-contact temperature measurement with IR pyrometers, we will review some underlying concepts. In the next article, which you can read in the upcoming issue of *Pentronic News*, we will also look at some special measurement solutions for pyrometers and what sort of things are important to keep in mind.

THE IR PYROMETER IS BEST AT COMPARATIVE MEASURING

To start with, it is important to understand that a radiation pyrometer is seldom suitable for measuring a single, absolute temperature. The strengths of IR pyrometers are to be found in processes with continual and comparative measurements. An example is a fixed installation where influencing factors such as the material, temperature level, wavelength, surface properties, and angle of incidence are very similar on each measurement occasion. Even if the absolute level of the temperature deviates from the actual one, you will get repetitive values, which can be used to steer the process. Handheld pyrometers for low temperature use can be utilised in a similar way, for example to discover inadequate pipe or wall insulation, overheated cabling and similar situations.

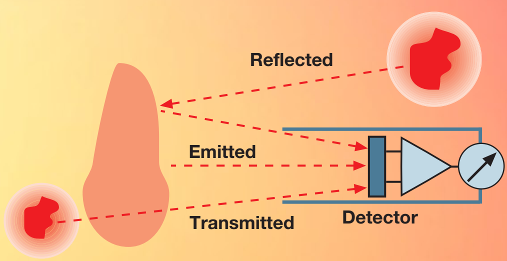
FUNDAMENTAL TECHNOLOGY

A radiation pyrometer measures the thermal energy which all bodies with a temperature above absolute zero radiate within the infrared (IR) wavelength range, normally within the interval 0.7 – 20 µm. Industrial instruments are built for the measuring ranges between approx. -50 and 3000 °C but no single instrument exists for the entire measuring range.

In principle, a pyrometer consists of a detector which measures the incoming thermal radiation. Unfortunately, not all incoming radiation stems from the object's surface temperature. In addition to the radiation emitted from the surface, there is reflected radiation from heat sources in the surroundings, and in some cases also transmitted radiation through the object, such as when you measure plastic film. The detector senses the total radiation within the wavelength range.

THE ε FACTOR

The emission factor (ε) is the relationship between the object's stated temperature radiation and the given thermal radiation of a non-reflecting body (called a black body) at the same temperature. A black body emits only its own thermal energy. In contrast, most shiny metals have a low self-radiation and also reflect the temperature radiation of their



The pyrometer senses the sum of the emitted, reflected and transmitted radiation. For measuring purposes, only the emitted radiation is of interest. Shielding and the choice of wavelength can reduce reflection and transmission.

surroundings. The factors influencing the emission factor of a surface are: material, temperature, wavelength, surface properties, and angle of incidence.

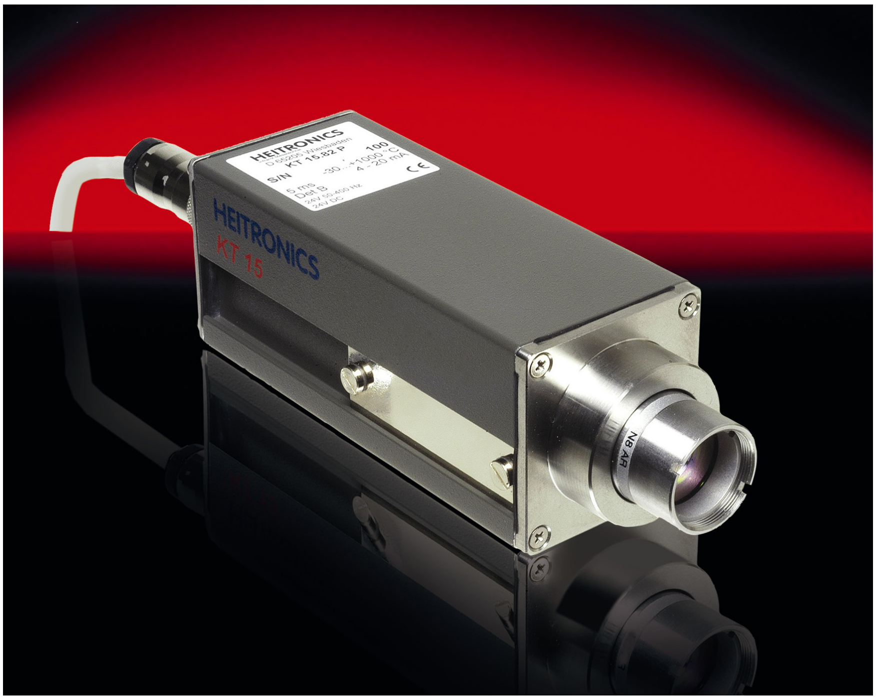
The most common situation is that the pyrometer is used to measure surfaces that are not black bodies, that is, they have the emission factor $\varepsilon < 1$.

When we measure materials with low emissivity, our measurements are very sensitive. If a surface has $\varepsilon = 0.12$ and the pyrometer is set at $\varepsilon = 0.1$, you will get a measurement error of tens of degrees depending on the object's temperature. The relative difference is a full 20%. In addition, situations of low emissivity are highly sensitive to reflected radiation. For example, if you try to measure the temperature in a refrigerated room and aim the pyrometer at the stainless steel wall opposite you, the pyrometer will mostly detect the reflected radiation from your body and will display too high a temperature.

In the next issue of *Pentronic News* we will examine solutions and adaptations that can be done for measuring materials with a low or varying emission factor.

WAVELENGTH RANGES

The IR radiation from an object to the pyrometer normally passes through air containing a greater or lesser proportion of water vapour.



There are a number of wavelength bands between 0.7 and 20 µm in which the radiation is minimally dampened in the water vapour. Depending on what type of material you want to measure, and on the pyrometer's intended temperature range, you can improve your measuring processes by selecting a suitable wavelength range.

From this it is clear that any one individual pyrometer cannot handle all measuring tasks. Handheld universal pyrometers for temperatures under 500 °C often use the wavelength range 8 – 14 µm whereas for higher temperatures narrower ranges are normally used with shorter wavelengths. By selecting a wavelength range you can optimise the IR pyrometer for the application. The table to the right gives some general guidelines for common applications.

You are welcome to contact Pentronic's sales team for advice on suitable products and solutions.

Wavelength (µm)	T_{min} ...T_{max} (°C)	Material
0.85 - 1.7	125...2500	Metal, semiconductor, ceramic
2.0 - 2.7	250...2500	Metal, glass, ceramic
2.0 - 4.5	100...1200	Metals
3.43 ± 0.15	80...350	Plastic film
5.7 ± 0.1	40...400	Plastic film
6.8 ± 0.1	50...400	Plastic film (PE etc)
7.93 ± 0.15	0...400	Plastic film (polyester, PVC etc)
8.05 ± 0.15	0...400	Plastic film and ceramic
3.9 ± 0.1	200...2500	Glass, measuring through gases
4.9 - 5.5	100...2500	Glass
7.5 - 8.2	0...2500	Glass and ceramic
4.26 ± 0.13	300...2500	CO_2 gas
4.5 ± 0.1	300...2500	CO and CO_2 gas
4.66 ± 0.1	300...2500	CO gas
5.3 ± 0.1	300...2500	NO gas
8 - 10	0...1000	Thick film, ceramic
8 -14	-50...1000	General measuring
8 - 20	-50...1000	Low temperature high resolution
9.6 - 11.5	-50...200	Through the atmosphere at a far distance

The table gives examples of the optimal wavelength ranges for various materials. Reliable measuring is best done with instruments chosen and installed for the right application.