ADVANCED ENERGY

Infrared Thermometry

Introduction, History, and Applications

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In manufacturing environments, measuring the temperature of an object without contact has proven to be a complex and daunting task. Objects in motion are often difficult to touch, and objects that are too hot will damage the temperature sensor. Dependable means for gauging high temperatures have evolved over the centuries, from the primitive visual methods used by blacksmiths as they forged steel, to today's highly accurate means of industrial temperature measurement.

This paper discusses sensor methods that yield repeatability irrespective of the process operator and the environment. With the introduction of optical fiber thermometry (OFT), an entirely new and repeatable method of measuring temperature was born. The introduction of new sensor types and integration of multiple optical detectors and electronics into a single instrument resolved many of the issues that traditional pyrometers faced.

Optical Pyrometry

It is a well known phenomenon that hot objects emit light. The hotter, the brighter. In fact, this phenomenon is one of the more important cornerstones of many modern technologies. Among them is radiometric temperature measurement, otherwise known as optical pyrometry.

This emission occurs according to some fairly well-known and understood physical principles. Before going any further, we introduce several concepts that are important to understand.

The Concept of a Blackbody

Briefly speaking, a blackbody is the ultimate emitter. A blackbody is a theoretical construction so named because it appears infinitely black. Light incident on the surface of a blackbody will yield no reflections because the object is completely black. Thus, it is the ultimate absorber of energy.

If such an object is in equilibrium, or balance, with its surroundings, it must both absorb and emit the same energy. This means that a blackbody, being the ultimate absorber, must also be the ultimate emitter. The more an object absorbs, the more it must emit in order to remain in equilibrium.

The energy emitted by a blackbody has been experimentally observed to be a function of its temperature. Early physicists mapped the distribution of energy of near-blackbody emitters across many wavelengths at different temperatures. Their results are shown in Figure 1 on page 2.

In 1900, Max Planck accurately described the fundamental relationship between the absolute temperature of a blackbody, the intensity of that emission, and the wavelength of the emitted energy, thus explaining the observed data. From the principles of quantum mechanics, he was able to clearly predict the energy distribution that one would observe looking at a blackbody at a given temperature.

$$E_{\lambda,T} = \frac{C_1\lambda^{-5}}{e^{C_2/\lambda T} - 1}$$

E is the energy, λ is the wavelength of the light, or energy, and T is the absolute temperature of the body in question. C_1 and C_2 are compilations of fundamental constants.