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A REVIEW OF DIFFICULTIES IN THE MEASURING TECHNOLOGIES OF THERMOGRAPHY

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Abstract

Thermography, a non-contact measuring technology for determining temperature, is becoming more and more widespread nowadays. The use of this imaging method assumes simple usage, but for the declaration of appropriate and correct temperature values, a complex measurement routine and in-depth theoretical knowledge are essential. In my articles I will draw attention to the most important factors influencing measurement, both from a theoretical and practical point of view.

Keywords: *thermography, thermographic camera, measuring technology.*

1. Introduction

Today's modern technological diagnostics would be simply unthinkable without non-contact temperature measuring technologies. High intensity research and serial production have made the presence of thermographic cameras a lot more accessible in the field of periodic status examinations. User friendly handling and easily adjustable measuring parameters suggest an extremely simple measuring method for the average user. However, without appropriate theoretical and practical knowledge, thermography as an imaging method produces false, invalid and incorrect temperature values in almost all cases. From a safety aspect it generates life threatening conditions and is an occupational hazard.

2. The basics of thermography

Temperature measuring based on infra radiation and the thermographic camera measurement method both depend on the bodies' heat emitting ability. Heat radiation is the process that emits electromagnetic waves because of the body's thermal movement [1, 2]. A large amount of this energy may be emitted when transferred to another body and may also be reflected or transmitted if the examined sample absorbs 100% of the radiation targeted at it, then, we speak of a black body. If it reflects all radiation, then we speak about a completely reflective body and if it lets through all radiation it is a completely transparent body. On examining radiation parameters from in terms of the First Law of Thermodynamics we can establish the following correlation:

$$\varepsilon_\lambda + \rho_\lambda + \tau_\lambda = 1 \qquad (1)$$

where:

ε_λ – emissivity constant;
ρ_λ – reflectivity constant;
τ_λ – transmission constant.

Table 1. *Physical characteristics of bodies*

Matter	Modulus	Correlation
Black body	ε=1	τ=0, ρ=0
Completely reflective body	ρ=1	ε=0, τ=0
Transparent body	τ=1	ε=0, ρ=0
Non-transparent body	τ=0	ε+ρ=1

According to the practical conclusion from the **Table 1** the completely reflective body and the completely transparent body cannot be measured by heat detecting methods, as they do not emit significant radiation. Their material qualities do not allow the thermographic measurement of their surface. These bodies on the other hand, are widely used in measuring technology due to their characteristics mentioned above.

2.1. The basic law of radiation

Heat radiation as an electromagnetic wave does not need a transfer medium. The fundamental law of heat radiation is the Stefan-Boltzmann law [3]:

$$E_{(f)}(T) = \sigma \times T^4, \quad (2)$$

where:

$E_{(f)}$ – emissivity of the black body;
σ – Stefan-Boltzmann constant $5.67\ 10^{-8}$ J/m^2 K^4;
T – temperature [K].

According to this law the radiation of the T temperature black body for unit area and during unit time is proportionate with T4. It can be seen that in an ideal event only the black body is able to absorb and emit all heat energy. But this is just a model. Different materials can emit different energy. The more similarity they have with the ideal black body, the more exact results these materials give. In case of measuring, the black body like material gives exact results. In case of different materials, we need to correct the result.

3. Measurement influencing factors

We do our measurements in real circumstances that differ from the ideal ones. Our thermographic analysis is in all events influenced by the heat emitting capacity of real bodies (radiation) and the circumstances of measurement. The most important parameters are the following:

– emission factor, ε<1;
– wavelength of measuring device
– characteristics of measuring stage.

The most important of these factors is the emission factor. If it is incorrectly chosen, it can cause a big difference in temperatures. It is also called degree of blackness and simply put, it expresses the ability the object's surface to radiate. Its extent shows the departure from the ideal radiance. In all cases it depends on the surface material and roughness of the measurable object and the angle between object and the measuring instrument (thermographic camera) [4, 5]. Our temperature measurement is also influenced by the background and object temperature. Many of those carrying out temperature detecting do not take into consideration the amount of radiated heat emitted by the objects around the body to be measured. This heat will reflect on our object changing the real amount of infrared radiation getting into the thermographic camera. If we give the emission factor incorrectly, the two errors will strengthen each other. On the graphs below (Figure 1, 2) the incorrect heat determination of the feed roll of the electrical cabinet can be seen. The 20 °C difference of the background temperature and the (25 %) underestimated rate of the emission of the metal surface resulted in a 20,2 °C difference.

In the case of metals, crystalline structure changes according to temperature, which can mean different emission factors [6, 7]. In Figure 3 we can see the temperature dependability of the emission factors of different metals, depending on the temperature of the object surface [8, 9].

It can be seen from the diagram that the change in the emission factor is relevant only at higher temperature. But we have to consider it in this range to get a more exact heat analysis.

3.1. Wavelength of the measuring instrument

Non-contact heat measurement is carried out mainly through air. This raises physical properties in designing measurement devices. There are

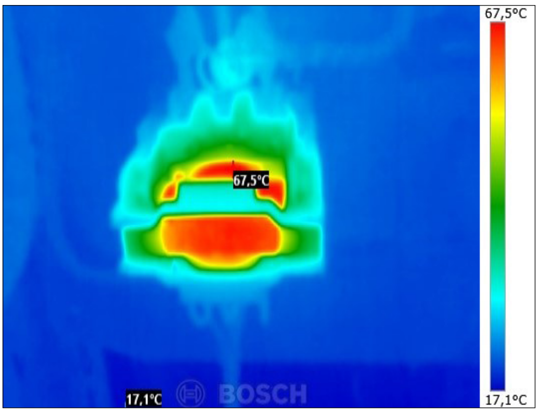

Figure 1. *Thermal image of feed roll*

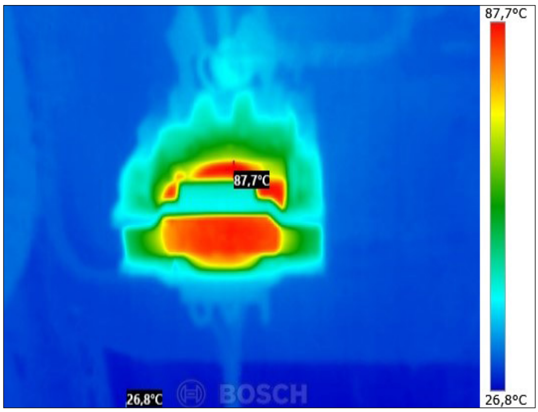

Figure 2. *Thermal image of feed roll*

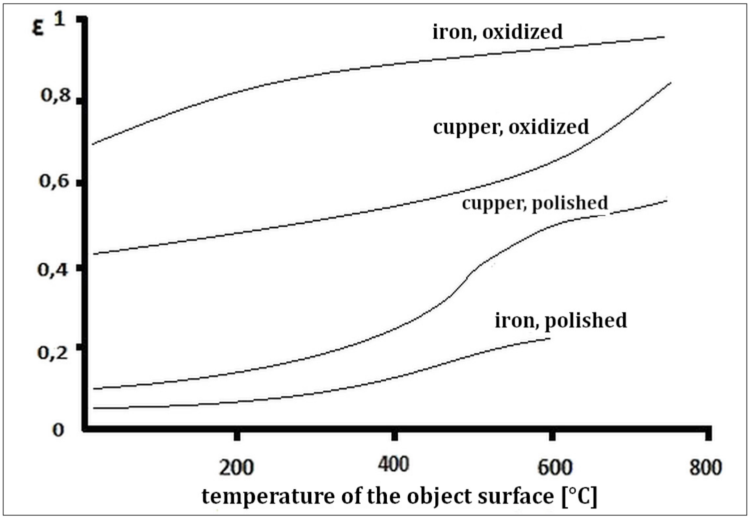

Figure 3. *Temperature dependence of the emission of different metals*

basically three spectral domains in use. We can speak of long wavelength (8–14 μm), medium wavelength (3–5 μm) and in special cases short wavelength (1–2 μm) thermographic cameras. It is the task of the expert dealing with termography to decide which one is the most suitable. A badly chosen range of measurement can influence the measurement result. Practice shows that although the medium wavelength measuring instrument does not detect low temperatures, it does enable more exact measurement in a higher (400 °C) range. In the case of lower temperatures it is more efficient to use a long wavelength camera. Long wave cameras most common in industrial practice; they are used universally for detecting both low and high temperatures. With a small correction we can get a fairly exact result in the area of unwanted warming in the electrical industry. In special cases when we have to consider the spectral emission of the object to be measured, we can use thermographic cameras measuring at short waves at high temperatures.

3.2. Characteristics of measuring stages

Our measurements are influenced – among many other variables – by the space between the source of the infrared radiation and the measuring instrument. With some exceptions (e.g a vacuum) this space is the air. The pollutants found in the air like dust, carbon deposits, smoke and various chemicals can also adversely affect our measurements. Vapour, oxygen, carbon dioxide nitrogen and hydrocarbon in the atmosphere are also an influence. Our results can also be distorted by interfering radiation sources, as well as the temperature of the air. These precipitating factors can adversely influence transparency even at distances of a few meters. Finally, we need to consider the physical characteristics and transfer parameters of air. Not all wavelength ranges have a possibility to detect maximum intensity infra red radiation. In a counted and experimental way, so called ‘defined atmospheric window places’ are formed which have good transfer properties. Manufacturers adapt their measuring instruments produced at different wavelengths to these windows.

4. Conclusions

In this article I have attempted to present the basic but non exhaustive list of difficulties in determining thermographic temperature.

Behind the trivial operability there is a technological measurement process that requires a complex and extensive knowledge base. One can acquire exact diagnostic examinations only when in possession of a knowledge of thermodynamics and physics, and with many years’ experience of field measurements. This technology has proved its worth in various areas of life from the electrical industry through military appliances to healthcare. A knowledge of factors influencing thermographic measuring technology is important.

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