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Thermal modeling and measurement of LED optical power using IR thermography

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Abstract

The optical power of light sources is usually measured with the Ulbricht integration spheres. The integration spheres require calibration and certified equipment for precise measurements. This means that the measurement of optical power can only be performed in laboratories equipped with the expensive measuring systems. In many practical cases, there is a need to measure the optical power of LEDs. They emit light in one or more narrow bands. This makes it difficult to measure optical power using standard systems.

Nowadays, we have more and more efficient LED light sources. This means that significant part of the electrical power is converted into radiation. On the other hand, the high power is dissipated in form of heat that increases temperature. Knowing the radiation power helps to develop an effective heat management system for LED light sources.

We have developed a simple method to evaluate the optical power of LEDs by measuring temperature with IR thermography. First, heat transfer modeling was performed to estimate the temperature rise above ambient. Two models were elaborated: 2-dimensional in ANSYS environment and simple compact model for fast estimation of LED temperature in steady state. An example of the simulation result is presented in figure 1.

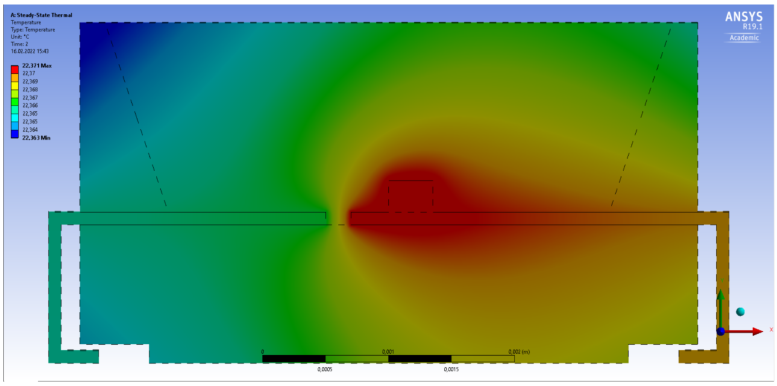

Fig. 1. *Temperature distribution inside the LED enclosure in steady state*

The optical power evaluation is carried out in a comparative way by performing 2 measurements. In both cases temperature value of the measured elements must be exactly the same. The temperature is measured on the upper surfaces of the elements with an IR camera. First, the measurement is performed on a LED at nominal power conditions - P_{el}. Then electrical power P'_{el} is supplied to a specially prepared element with the same geometry and a similar heat source inside. Exactly the same housing ensures the same power dissipated to the environment if temperature of the heat source and ambient in both experiments is the same.

$$P_{el} = P_{heat} + P_{rad} \tag{1}$$

$$P'_{el} = P_{heat} \tag{2}$$

The optical power P_{rad} is simply estimated from the difference in electrical power obtained from both experiments. The same environmental conditions in both measurements are very important. In order to obtain the same thermal environmental conditions, the experiments were carried out in specially prepared insulated cavities with optical paths used both for the removal the emitted LED light and for temperature measurement with an IR camera.

$$P_{rad} = P_{el} - P'_{el} \tag{3}$$

The obtained results of the LED radiation power obtained by the proposed method are compared with the optical measurements made with the integration sphere.