A Study on the Feasibility of Measuring the Emissivity with the Laser-Flash Method

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The laser-flash method is a widely used and well established technique to measure the thermal diffusivity. Major advantages of this method are its high measurement speed and its application over a wide temperature and thermal diffusivity range. Since its introduction in the 1960s it was proposed to expand this technique to the measurement of heat capacity and emissivity. The specific heat can be measured using a comparative method. However, this requires careful calibration of the instrument. The direct measurement of the additional properties requires, however, the accurate knowledge of the absolute laser heat pulse energy and the resulting temperature rise. These parameters are difficult to gain. For example, the emissivity at high temperatures is more or less unknown, but very important to the lamp industry and fusion research. In the present work, we give a first theoretical study on the possibility of emissivity measurement using the laser-flash method. We derive an implicit equation for the true temperature of the sample, which can be calculated from the temperature rise, the energy of the heating laser pulse and the knowledge of some material parameters (i.e. heat capacity and mass of the sample). With the known true temperature of the sample and the measured thermal radiation of the sample at different wavelengths, one can derive the emissivity at these wavelengths. Another important topic which has to be considered is the influence of geometrical effects on the measured temperature rise with a radiation thermometer. Especially the cavity-like geometry of the furnace, with the sample as the cavity bottom, has a significant influence on the measured value of the temperature rise, as we demonstrate by numerical simulations. We also discuss the influence of these effects on the traditional laser-flash method, which to our knowledge is not generally considered so far. These theoretical studies are supplemented by first measurements with a laser-flash instrumentation modified for high temperature emissivity measurements.