Influence of Radiative Heat Transfer on Thermal Conductivity Measurements with High-Temperature Guarded Hot Plates

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A collaboration of five European National Metrology Institutes (NPL, CMI, LNE, MKEH and PTB) is working on the project SIB52 "Metrology for thermal protection materials" (Thermo) of the European Metrology Research Programme (EMRP). One of the objectives of this project is to enable thermal conductivity measurements of thermal protection materials at temperatures up to 800 °C with an uncertainty better than ±5 %. The guarded hot plate method is a well-established steady-state technique to measure the thermal conductivity. While at room temperature the results of measurements performed on thermal protection materials at different locations with different apparatuses agree very well, at higher temperatures the results show considerable differences. One source of errors may be found in the complex nature of the heat transfer in thermal protection materials that are mostly porous and occasionally semi-transparent. At room temperature the heat transport is dominated by conduction whereby at higher temperatures the contribution of radiation to the overall heat transfer increases significantly. By means of theoretical modelling the radiative part of heat transfer in thermal conductivity measurements of thermal protection materials performed with a high-temperature guarded hot plate apparatus was investigated. The amount of the radiative heat transfer through highly porous semi-transparent samples as well as the radiative heat losses of the measuring instrument were modelled by finite element method. The investigation includes experimental measurements of the relevant thermophysical and optical properties. The results of the numerical simulation will be presented in comparison to appropriate analytical calculations.

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