Two-Fluid Modification into Monotonic Heating Regime Thermal Diffusivity Measurement

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Several ways are available to experimentally obtain thermal diffusivity [1]. Applying indirect method one can measure thermal conductivity and calculate the discussed parameter knowing the specific heat and the density of the investigated substance. The problem is that due to the uncertainty transfer law the final result cumulates uncertainties of all of the components. Moreover, conventional measurements of the thermal conductivity are usually time consuming because of a need to ensure steady state conditions for the experiments. The thermal diffusivity can be measured directly in transient experiments. The problem is that direct techniques usually require sophisticated and expensive instrumentation but a few simple and low demanding methods are also available. The monotonic heating regime method, based on Kondratiev's theory, is one of them [2]. The problem in this case is that it is difficult to ensure boundary conditions that fit the theory precisely. This results in an increase in the uncertainty or in a limitation of the material types suitable for investigation.

In the case of a Heaviside's type first order boundary conditions applied in monotonic heating, the main problem is to correct the results regarding non-zero surface heat resistance effect. When the investigated specimen is rapidly immersed in a certain fluid it means a finite Biot number value. Corrections for that effect need precise evaluation of the convection type, fluid speed, temperature distribution, etc. These data are rather difficult to obtain regarding the changes of the thermophysical properties of the fluid with the temperature changes.

In an attempt to overcome this difficulty, a measurement technique based on the classical monotonic heating regime method that does not required the fluid speed has been developed. The measurements are carried out in two stages applying two different fluids (comp. also [3]). This allows us to eliminate the Biot number from the final formulae. The thermal diffusivity is determined from the characteristic time of the temperature equilibration. The experiment can be performed using just a simple thermostat and a one-channel temperature recorder. The technique preserves all advantages of the classical monotonic heating regime method: simple methodology, simple instrumentation, relatively fast measurements, and versatility in view of types [4] and shapes of the investigated specimens.

In the paper a basic theory of modification is provided together with some practical formulae. The methodology is illustrated with the examples taken from measurements of the thermal diffusivity of differently shaped solid specimens. The measurements have proved good accuracy and a good temperature resolution of the described technique.

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