

Measurements of the Thermal Conductivity of Molten Lead Using a New Transient Hot Wire Sensor

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This paper reports new measurements of the thermal conductivity of molten lead within the temperature range 600 to 800 K. The measurements have been carried out using a new version of a modified transient hot-wire method. The hot-wire sensor is embedded within an insulating substrate with a planar geometry. However, unlike previous sensors of the same type, the new sensor works with the hot wire divided into two thermally independent parts, one shorter than the other. The short wire end effect correction is implemented automatically. The operation of this sensor, as well as this correction, have been modeled theoretically using a finite-element analysis, and have subsequently been confirmed by direct observation. The novel sensor is demonstrated to have a higher sensitivity and a higher signal to noise ratio than earlier sensors.

As in earlier work with this type of instrument, the thermal history of the hot-wire following the application of a step heating profile is measured over a period of one second after the initiation of heating. A finite-element implementation of a solution of the heat transfer equations for the sensor/fluid complex is then employed, in order to deduce the thermal conductivity of the fluid and the sensor in situ.

In the current study, we use as the test fluid molten lead which has the lowest thermal conductivity of any material we have yet studied, which allows us to probe the limits of our sensor system for the thermal conductivity of high-temperature melts. It is estimated that the accuracy of the measurements is $\pm 3\%$ over the temperature range studied. The results are used to examine the application of the Wiedemann-Franz relationship between the thermal conductivity and electrical conductivity for the melt.