

Comparison of Thermal Diffusivities for a X153CrMoV12 Steel Obtained with a Laser Flash Technique and Calculated from the Wiedemann-Franz Law

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The two closely related properties, the thermal diffusivity and conductivity, are of great interest for all questions concerning heat transfer and thermal effects (e.g. heat transport, conduction, dissipation, etc.). However, measurements of these properties still lead to widespread results depending on the respective measurement technique used. This experience was used as a starting point for a common research project with Böhler Edelstahl GmbH & Co KG supported by FFG, whose main target is to compare directly and indirectly obtained diffusivities of highly alloyed steels. For this purpose, thermal diffusivity is on the one hand directly measured by means of a quasi-static laser flash technique (LFA) and, on the other hand, indirectly calculated via the Wiedemann-Franz law (WFL) from electrical resistivities. The latter are measured by means of a fast dynamic ohmic pulse-heating system capable of measuring a wide range of thermophysical and optical properties of conducting materials up to temperatures beyond melting into the liquid state.

A drawback of the calculation via the WFL is the often unknown Lorenz number (L) for the respective material. Though its value can theoretically be derived for materials with a simple crystal structure, the actual values of L for more complex systems (such as alloys) may vary drastically and are furthermore temperature dependent (in the solid state) due to lattice contributions to electrical and thermal conduction phenomena. Comparative measurements with direct and indirect methods may be helpful to quantify these effects and to improve measurements deploying the indirect WFL approach. As a first step in the current research project, the industrially used X153CrMoV12 steel was investigated with both mentioned methods (LFA and pulse-heating including WFL calculations); other alloys will follow. Besides focusing on thermal diffusivity and the Lorenz number, an entire set of thermophysical properties (enthalpy, electrical resistivity, volume expansion, isobaric heat capacity, and thermal conductivity) was measured and will be presented for the investigated steel in the range from room temperature up into the liquid state.

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