Modeling of Effective Thermal Conductivities of Alloy Series as a Function of Temperature in the Liquid Region

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Iron, nickel, platinum and copper along their alloys have many applications in science and industry. Their thermophysical properties play an important role in casting processes and are required as input data for casting simulation. The goal of present work is to simulate and predict these properties through modeling. Model calculations for thermal conductivities of three alloy series in the liquid region have been performed to get a deeper insight of their thermodynamic behavior based on temperature-dependent experimental data obtained by an ohmic pulse heating technique. This technique delivers thermophysical properties of electrically conducting materials in the solid and the liquid phase. Samples are resistively volume heated as part of a fast capacitor discharge circuit, heating rates up to 10^8 K /s are achieved and the samples reach the liquid phase about 30 µs after starting the experiment. Time resolved electrical measurements with sub-µs resolution allow the calculation of specific heat capacity and temperature dependencies of electrical resistivity, enthalpy, and density of these alloys in the solid and liquid phases. Thermal conductivity and thermal diffusivity as a function of temperature are estimated from resistivity data using the Wiedemann-Franz-law for temperature regions between several hundreds of degrees below and above the corresponding melting points. Three different models are proposed for the prediction of effective thermal conductivities of alloy series taking into account the thermal conductivities of the constituents, the temperature, and a fit parameter. For such calculations, it is of special importance to choose model functions that are both physically relevant and numerically robust. It is observed that the values of the effective thermal conductivity predicted by the models are in agreement with the experimentally determined thermal conductivities by pulse heating technique within 5%.