

Density and Viscosity of Liquid Ternary Ni-Cu-Fe Alloys

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For technically important ternary alloys, such as Ni-Cu-Fe, systematic information about thermophysical properties in the liquid state is sparse. Data often exist for the binary phases only. In this paper, we report on density and viscosity measurements; properties which are fundamental for both technical applications and a general characterization of the system.

The densities have been measured using the non-contact technique of electromagnetic levitation. In order to determine the volume, V , of a levitated sample, a CCD camera records a series of side view shadow images. The volume, from which the density was derived, was calculated afterwards from an average of the profile lines. It was found that density was a linear function of temperature above and below the liquidus point. The experimental density results were compared to the regular solution model and it turned out, that they could not be predicted from the binary phases alone. Instead, a ternary interaction parameter had to be included into the excess volume calculation.

The viscosities have been measured using an oscillating cup viscometer. This method employs a suspended crucible containing a liquid sample. The crucible performs angular oscillations which are damped by the inner friction of the liquid. Viscosities are calculated from the time period and the decay of the amplitude by solving the Roscoe equation. The temperature dependency of the measured viscosities could be described by an exponential Arrhenius law, taking into account an apparent activation energy for the viscous flow. The activation energies for the ternary alloys were found to be linear combinations of the corresponding activation energies of the pure elements Cu, Ni, and Fe. Similar to the density, a non ideal behavior is found for the viscosities of this system as well.