Investigating the Surface Tension of Steels Using Electromagnetic Levitation, Part I: Iron-Nickel Alloys

Thomas Leitner [S] and Gernot Pottlacher [C]
Institute of Experimental Physics, Graz University of Technology, NAWI Graz, Graz, Austria
pottlacher@tugraz.at

Accurate experimental thermophysical property data of liquid alloys describing the temperature dependent behaviour of the materials' physical properties in the melt, among them surface tension, are crucial parameters for various applications in today's metalworking industry, e.g. for simulation of casting processes. However, common surface tension measurement techniques, that are usually contact-based, face the challenging characteristics of melts: high temperatures and chemical reactivity. Thus, a non-contact, container-less measurement technique like the oscillating drop (OD) method combined with electromagnetic levitation (EML) is favorable. Here, the liquid sample is levitated freely by applying a high-frequency electromagnetic field, only environed by an inert gas atmosphere. By means of the OD method, surface tension of the liquid sample can be related to its surface oscillations. Consequently, surface tension is determined by evaluating the surface oscillations' frequency spectrum that is generated from a time-series of images acquired by high-speed cameras and subsequent application of edge-detection algorithms to get the sample radius as a function of time. Temperature is simultaneously monitored by contact-less pyrometers. Recent investigations on the binary iron-nickel system to study the influence of the composition on surface tension showed a significant shift to lower surface tension values compared to literature data that are in general scarce for binary, ternary, and higher order alloy systems. Moreover, all samples showed a similar (low) surface tension, almost independent of the composition. To support our hypothesis that this phenomenon results from the "non-academic" purity of the sample material, comparison measurements were conducted at the electrostatic levitation (ESL) facility of the NASA Marshall Space Flight Center (MSFC). Those measurement results, together with data obtained from self-fabricated high-purity iron-nickel alloys will be presented and compared to results obtained from our EML measurements.

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