Determination of Viscosity for liquid Fe-Cr-Mn-Ni alloys

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A precise knowledge of thermophysical properties, such as surface tension, viscosity, and density of steels in their liquid state is necessary for the understanding and modelling of their infiltration and gas atomization processes. The measurement of the viscosity of liquid Fe-Cr-Mn-Ni alloys (16 wt% Cr, 7 wt% Mn) as a function of nickel content (≤20 wt% Ni) is a key issue of the current work. A novel vibrating finger viscometer for high temperature measurement in liquid iron base alloys up to 1600°C was constructed. The finger is set in motion using a microcontroller powered field coil. The driven harmonic oscillation of the sine wave is at approximately 26 Hz frequency and 625 ± 1 µm peak-to-peak amplitude. The dynamic viscosity (η) of the liquid specimen is then measured as a product of (viscosity x density)$^{0.5}$ as a function of the relative change of the field coil current for a constant amplitude recording of the immersed vibrating finger into the liquid metal. Dimensionless Reynolds number (Re) is estimated according the Stokes boundary layer between the vibrating finger surface and the liquid steel. The characteristic Reynolds numbers are within the laminar flow condition in the present investigation of liquid steels. The viscosity of Fe-Cr-Mn-Ni alloys is decreasing at high nickel content of approximately 20 wt% Ni. The availability of viscosity data of TRIP/TWIP Fe-Cr-Mn-Ni steel alloys delivers relevant input to model the free fall gas-atomization and the infiltration of open foam ceramics using high manganese steel.