Density and Surface Tension of 304L and 16MND5 Liquid Steel Using Droplet-Based or Bubbling Techniques

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Within the framework of the welding of steel components in Pressurized Water Reactors (PWR), the optimization of the weld pool penetration is a major issue, both from safety and economical viewpoints. Among other phenomena, the thermalhydraulics of the molten steel pool may be driven by Marangoni surface flows at the top of the wielding bath. To compute these flows, liquid steel ThermoPhysical Properties (TPP) such as density and surface tension as functions of the temperature, are required. The TPP at liquid state are scarce for austenitic steels and missing for the 16MND5 ferritic steel. Moreover no experimental data are available above 1850°C, due to technological issues.

The VITI test facility has been designed to implement various techniques for TPP measurements, such as Sessile Droplet (SD) and Maximum Bubble Pressure (MBP) techniques. By application of Laplace-Young law, these techniques have allowed to determine original data for both austenitic (304L) and ferritic (16MND5) vessel steels. Thanks to the innovative design of MBP configuration, original experimental measurement have been obtained from the melting point up to 2200°C.

Thus, some original experimental correlations for density and surface tension have been established as functions of the temperature over a wide temperature range, seemingly with no equivalent in the existing literature, for a variety of liquid steels, with different techniques. In particular, for the first time, an experimental evidence of McNallan and Debroy (1991) model is provided, emphasizing the decisive role played by sulfur concentration [S] on surface tension for austenitic 304L steel. The measurement uncertainties are presented together with a few post-test chemical analyses for assessing the composition evolution after the tests.

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