A New Approach for Estimating the Thermal Diffusivity of Molten Metals at Very High Temperature

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The development of numerical simulations of industrial processes such as welding and additive manufacturing requires the knowledge of physical properties of metals from solid state to vaporization. In the case of thermal diffusivity, the higher the temperature, the more difficult it is to estimate experimentally the value of this property.

Indeed, multiple issues are encountered such as radiative heat loss, pollution of the sample or motion inside the molten sample, which makes the estimation of this property a challenging task.

In this communication, we develop a methodology to estimate the thermal diffusivity of liquid metals with a fusion point above 1500 °C. The set-up is based on the traditional front face laser flash method [1]. To avoid undesirable reaction of the molten metal with oxygen, the set-up is placed inside an inert chamber filled with protective argon gas, so the oxygen content in the surrounding atmosphere is less than 5 ppm. A 1070 nm fiber laser is used to heat the sample to the desired temperature and to apply a high power pulse. A high speed camera (10 000 FPS) is used to capture the emitted radiation during the experiment and the temperature field is then estimated by applying a gray-scale/temperature conversion [2]. Moreover, the recorded video is used to estimate the velocity field inside the melt pool by applying an image processing technique based on a non-rigid registration of the video stream [3] .The local transformations during the experiment are thus estimated allowing the characterization of the velocity field of the melt pool. Different strategies to validate the obtained data are presented. The extracted temperature and velocity fields are used as input data to estimate the thermal diffusivity by inverse techniques. Experimental and numerical challenges are also addressed The methodology is applied on pure metals and some alloys samples and first outcomes in both solid and liquid states are presented.

References

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