MODELLING AT DIFFERENT SCALES OF PROCESSES INVOLVING MELTING AND SOLIDIFICATION OF METALS

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In this Mini Symposium, we will focus on the modeling of manufacturing processes that involve the melting and solidification of metals, including Additive Manufacturing (AM), Casting, and Welding. Although these processes differ in their specific applications, they share key thermomechanical characteristics that significantly influence the final material properties at the macroscale.

To accurately characterize the factors impacting the properties of the resulting parts, it is essential to address the multiscale and multiphysics phenomena involved. For example, understanding how cooling rates affect the microstructure—such as phase formation and grain texture—and how these microstructural changes influence macroscopic properties is crucial. Additionally, accurate modeling of heat sources in processes like AM or welding, and the adoption of advanced multiphysics approaches that account for fluid flow, solid mechanics, gas or plasma interaction, and species transport, are critical for predicting and mitigating defects such as porosity, segregation, or cracking. Assessing the impact of these defects on local properties and overall part behavior is equally important.

Modeling these phenomena across different scales presents significant challenges and requires a variety of approaches traditionally used in multidomain modeling, such as level-set and phase field methods. Moreover, recent advancements in model order reduction and data-driven methodologies offer new opportunities for exploration and will also be a topic of discussion in this symposium.