Contribution ID: **43** Type: **Oral Presentation**

A numerical study on the solidification shrinkage of the ingot in vacuum arc remelting (VAR) process

Tuesday, 24 September 2024 08:50 (20 minutes)

The Vacuum Arc Remelting (VAR) process is employed in the production of Nickel-based alloys, including Alloy 718. However, challenges arise during the process due to solidification shrinkage, leading to the loss of contact between the ingot and the mold. This phenomenon diminishes the cooling efficiency of the system, resulting in a deeper melt pool and a decline in ingot quality as heat removal becomes less effective. To comprehensively investigate the implications of solidification shrinkage, we introduce a sophisticated 2D axisymmetric Magnetohydrodynamics (MHD) model. This model incorporates calculations for electromagnetic, thermal, and flow fields. Also, the MHD model is fully coupled with a thermal stress-strain model, enabling the computation of solid mechanical parameters like stress, strain, and deformation within the ingot. Our coupled model provides essential insights, including the width of the air gap along the ingot, the precise position of contact between the ingot and mold, and the profile of the melt pool, among other critical parameters. Ultimately, the model's accuracy is verified through rigorous validation against experimental data, enhancing our understanding of the VAR process and its impact on the alloy quality.

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Session Classification: Session 2

Track Classification: Primary and Secondary Melt Processing including VIM, VAR, ESR, EBCHR, EIGA, Plasma Melting, Ingot Casting, Centrifugal Casting