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Numerical Simulation of Asymmetric Cooling in Vacuum Arc Remelting Furnace

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In the field of metallurgy, the optimization of the process has driven the integration of advanced numerical simulations to enhance the efficiency and reliability of industrial systems. This article focuses on the application of 3D numerical simulations to investigate the cooling system of a Vacuum Arc Remelting (VAR) furnace, an essential component in the production of high-quality alloys. The study not only focuses on the fundamental aspects of VAR furnace cooling but also explores the coupling between asymmetric cooling and thermo-mechanical deformation of the ingot.

The development of the model involves the creation of a 3D simulation using COMSOL Multiphysics to simulate the cooling system dynamics during the VAR process. This model facilitates the computation of heat flows on the crucible walls through thermo-fluidic coupling, providing a detailed representation of the thermal behavior within the cooling system and therefore in the crucible and the ingot.

To assess the impact of asymmetric cooling in critical cases, one of the four outlets of the cooling system is selectively closed, enabling a focused study on the resultant effects on the cooling process. Through systematic investigation, the article aims to predict the temperature distributions and heat transfer patterns caused by this modification to the cooling system.

The derived heat flows from the 3D simulation serve as a crucial tool to explore the effects of asymmetric cooling on the VAR process. To study those effects, the heat flows are extracted from the 3D model and integrated as boundary conditions into a 2D axisymmetric thermo-mechanical model of the ingot. The results presented in this article contribute to the fundamental understanding of VAR process but also provide actionable insights for the security of the furnace and the practical enhancement of alloy production and quality control.

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