

MeltFlow-ESR™

A Comprehensive Simulation Tool for the Electroslag Remelting (ESR) Process

The ESR Process for Ingot Production

Electroslag Remelting is a consumable electrode remelting process used for producing high-quality ingots of superalloys and steel through controlled solidification and chemical refining.

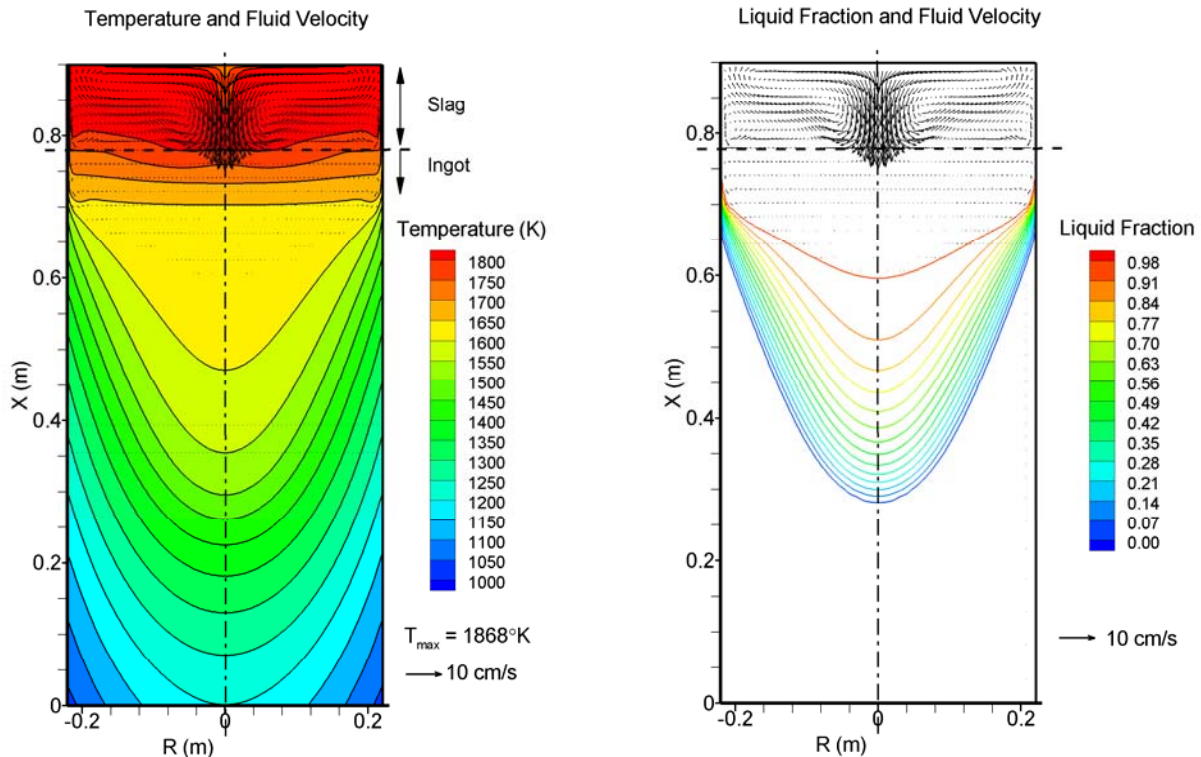
The quality of an ingot produced from the ESR process is governed by complex interactions among AC electromagnetics, flow, heat transfer, and phase change phenomena occurring in the slag and the metal. A trial-and-error approach is ineffective for process optimization because of the complexity of the process, high operating costs, and measurement difficulties.

A Powerful Predictive Capability

MeltFlow-ESR* offers a scientific and cost-effective approach for predicting the effects of process conditions on the quality of the ingot produced.

MeltFlow-ESR considers all the underlying phenomena in a comprehensive and efficient manner for a detailed prediction of the flow, temperature, and electromagnetic field variations in the slag and the growing ingot during the entire process, and the distributions of the concentrations of the alloying elements within the final ingot produced.

*MeltFlow-ESR was formerly called COMPACT-ESR



Velocity and Temperature Fields, and Pool Region During an ESR Process for a Nickel Superalloy

Comprehensive Treatment of Process Physics

MeltFlow-ESR performs a rigorous analysis of the process by considering the following phenomena:

- Electromagnetic Phenomena with AC Power
- Turbulent Flow in the Slag and the Molten Pool
- Heat Transfer in the Pool and the Solid
- Formation of Slag Skin on Mold and Ingot
- Effect of Ingot Shrinkage on Mold Heat Loss
- Macrosegregation of Alloying Elements
- Motion and Dissolution of Inclusions

Efficient Computational Solution

The control volume computational method incorporates algorithms that address specific aspects of the ESR process. These include:

- AC Electromagnetics with Periodic Steady State
- Nonlinear Mold Heat Transfer with Slag Skin
- Growth of the Ingot in a Fixed Grid
- Automatic Determination of the Time Step

Thus, MeltFlow-ESR provides a robust and efficient calculation of the transient process behavior.

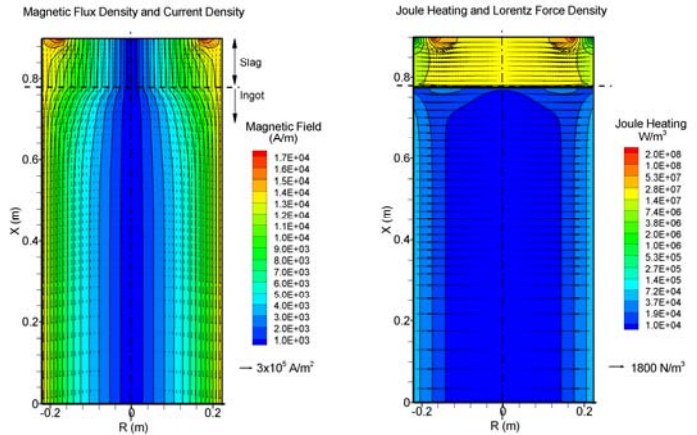
Powerful, Yet Easy-to-Use

MeltFlow-ESR allows easy creation of a process model by specifying ingot geometry, temperature-dependent slag and alloy properties, and melt schedule through a user-friendly graphical interface. Results of analysis are conveniently examined using powerful visualization software.

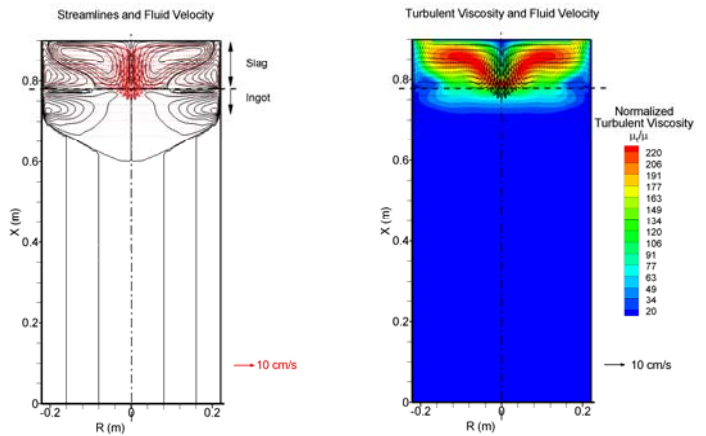
Engineering Benefits

MeltFlow-ESR has been shown to accurately predict the observed pool profiles. It is being used in the following manner by leading alloy producers to obtain substantial cost-savings in process design:

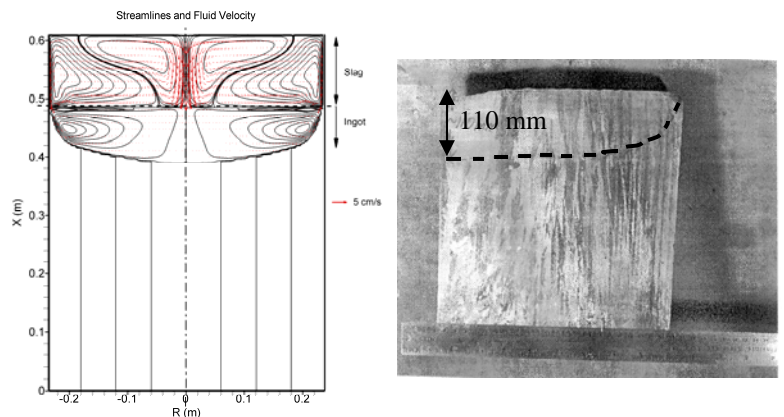
- Optimization of Melt Schedule
- Investigation of Process Anomalies
- Design of Process Variants
- Processing of Superalloys and Steel



Electromagnetic Fields in the Slag and the Ingot



Streamlines and Turbulent Viscosity in the Slag and the Ingot



Predicted and Measured Pool Shapes in a Superalloy Ingot