Proceedings of the 6th International Conference on Fluid Flow and Thermal Science (ICFFTS 2025)
Barcelona, Spain - October 29 - 31, 2025
Paper No. 104
DOI: 10.11159/icffts25.104

Modeling Induction-Heated Feeder for Metal Casting Processes

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Extended Abstract

Metal casting [1] is a manufacturing process that involves melting metals and pouring them into molds to shape metals in the desired manner through solidification. During the solidification, the metal shrinks significantly, which may lead to pores, cavities, and suction-related deformations. Additional feed molten metal is supplied by a feeder [2] to ensure continuous melt flow to the solidifying front. Hence, the metal in the feeder shall remain melted until the whole part solidifies. Traditional feeders are designed in sheer size to ensure a slow solidification process in casting, which induces a considerable waste of energy when melting more material than that used for the cast product. Effee has developed a new design of an induction-heated feeder. Induction heating through electric coils is applied to keep the material inside the feeder melted during the casting process. With this new method, the feeder size can be smaller, requiring less molten metal. The heating power can be well controlled according to the solidifying process with better efficiency.

The performance of the induction-heated feeder can be affected by several operating parameters, including material properties, dimensions of the feeder and electric coils, level of molten metal, current intensity, and current frequency. It is essential to understand fundamentally how these parameters affect the operation of the induction feeder. A FEM (Finite Element Method) modeling approach is proposed to simulate the operation of an induction feeder and estimate the induction heating power to molten metal. The numerical model was created using the multiphysics software COMSOL. The variation of induction heating power to the molten metal inside the feeder is investigated by varying the temperature-dependent electrical conductivity, current intensity and frequency, and metal level inside the feeder. In addition, induction heating tests of solid billet are designed to precisely measure the heating power from the induction feeder to the billet. The test results are used to verify the accuracy of the numerical modeling method and the parameter inputs to the numerical model.

With the verified numerical model, a set of simulations systematically varying the input parameters of current density and frequency, metal level, and electric conductivity are conducted to create an operation database of the induction feeder. Then, a data-driven digital surrogate model, based on a multivariate regression algorithm [4], is designed to correlate the induction heating power to molten metal with the operating conditions of the induction feeder. This digital model runs much faster than the FEM model and can be used to optimize the operation of the induction feeder.

References

[1] J. Campbell, *Complete Casting Handbook: Metal Casting Processes, Techniques and Design*. Butterworth-Heinemann, 2011.
[2] H.-Y. Seo, P.-K. Seo and C.-G. Kang, "A study on the S/W application for a riser design process for fabricating axisymmetric large offshore structures by using a sand casting process," *Int. J. Naval Architecture and Ocean Engineering*, vol. 11, pp. 462-473, 2019.
[3] P. Garcia-Michelena, E. Ruiz-Reina, N. Herrero-Dorca and X. Chamorro, "Multiphysics modeling and experimental validation of heat and mass transfer for the vacuum induction melting process," *Applied Thermal Engineering*, vol. 243, 122562, 2024.
[4] X. Guo, Z. Shi and B. Li, "Multivariate polynomial regression by an explainable sigma-pi neural network," *Big Data and Information Analytics*, vol. 8, pp. 65-79, 2024.