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Optimization of Tundish Geometry for Minimizing Dead Volume Using OpenFOAM

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Abstract : Growing demand for high-quality steel products has inspired researchers to investigate the unit operations involved in the manufacturing of these products (slabs, rods, sheets, etc.). One such operation is tundish operation, in which a vessel (tundish) acts as a buffer of molten steel for the solidification operation in mold. It is observed that tundish also plays a crucial role in the quality and cleanliness of the steel produced, besides merely acting as a reservoir for the mold. It facilitates removal of dissolved oxygen (inclusions) from the molten steel thus improving its cleanliness. Inclusion removal can be enhanced by increasing the residence time of molten steel in the tundish by incorporation of flow modifiers like dams, weirs, turbo-pad, etc. These flow modifiers also help in reducing the dead or short circuit zones within the tundish which is significant for maintaining thermal and chemical homogeneity of molten steel. Thus, it becomes important to analyze the flow of molten steel in the tundish for different configuration of flow modifiers. In the present work, effect of varying positions and heights/depths of dam and weir on the dead volume in tundish is studied. Steady state thermal and flow profiles of molten steel within the tundish are obtained using OpenFOAM. Subsequently, Residence Time Distribution analysis is performed to obtain the percentage of dead volume in the tundish. Design of Experiment method is then used to configure different tundish geometries for varying positions and heights/depths of dam and weir, and dead volume for each tundish design is obtained. A second-degree polynomial with two-term interactions of independent variables to predict the dead volume in the tundish with positions and heights/depths of dam and weir as variables are computed using Multiple Linear Regression model. This polynomial is then used in an optimization framework to obtain the optimal tundish geometry for minimizing dead volume using Sequential Quadratic Programming optimization.

Keywords : design of experiments, multiple linear regression, OpenFOAM, residence time distribution, sequential quadratic programming optimization, steel, tundish
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