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Abstract of PhD Dissertation

"Selection of ladle shroud construction applied in CSC process"

The new solution of the CSC (Continuous Steel Casting) tundish working conditions optimization was proposed in this work by the author. The main way of the improvement the tundish working conditions is to interfere with the liquid steel flow hydrodynamic structure. Subflux turbulence controller, dam, gas-curtain etc. are known as the FCDs (Flow Control Devices) which are installed inside the tundish space. The mentioned devices are exposed to the continuous erosion process caused by the liquid steel, which in the case of the FCD failure requires the tundish replacement. The ladle shroud as a new FCD was proposed by the author. So far, the ladle shroud is known as device which protects the liquid steel stream against atmospheric air, which flows from the ladle to the tundish without slag disruptions. The mentioned tasks have been extended by the possibility of hydrodynamic structure activation in the tundish space. Therefore, the ladle shroud can be identified as an FCD and as an effective substitute.

The continuous slab casting process was simulated in the range of this work using a one-strand wedge-type tundish. The ladle shroud modification relied on the change of the ladle shroud diameter, as well as the compression and decompression of the tundish liquid steel feeding stream. In total, five ladle shroud modifications were proposed by the author. Furthermore, four ladle shroud immersion depths in the liquid steel, the comparison with the conventional ladle shroud, and the cooperation with the subflux turbulence controller were tested. Thus, 56 tundish variants were checked in the range of this work.

The CFD (Computational Fluid Dynamics) technique was used in order to simulate the liquid steel flow hydrodynamic structure in the considered tundish. The mathematical model and boundary conditions used in the computer calculations were verified by laboratory experiments (using a water modeling technique) and the industrial trials (performed in the ISD Częstochowa Steelwork). The verification process relied on the liquid steel RTD (Residence Time Distribution) analysis. Seven turbulence models in the numerical calculations were tested in the range of the verification process. Eventually, the BSL

(Baseline) k-ω was chosen as the best correlating turbulence model with the results from laboratory experiments and industrial trials.

After utilizing a verified mathematical model, the numerical simulations of the liquid steel flow in the tundish were performed. The liquid steel flow, temperature, turbulence intensity fields, and behavior of the feeding stream were analyzed. Furthermore, the RTD of the liquid steel in the tundish space was checked. The results conclude as follows: the proposed ladle shroud modifications can activate the liquid steel hydrodynamic structure, decrease the transition zone during sequential casting process, and reduce the liquid steel turbulence intensity in the tundish.

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