Modelling of Heat Transfer during Controlled Cooling of Thermo-Mechanically Treated Rebars Using Computational Fluid Dynamics Approach

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Abstract : Thermo-mechanical treatment (TMT) of rebars is a critical process to impart sufficient strength and ductility to rebar. TMT rebars are produced by the Tempcore process, involves an 'in-line' heat treatment in which hot rolled bar (temperature is around 1080°C) is passed through water boxes where it is quenched under high pressure water jets (temperature is around 25°C). The quenching rate dictates composite structure consisting (four non-homogenously distributed phases of rebar microstructure) pearlite-ferrite, bainite, and tempered martensite (from core to rim). The ferrite and pearlite phases present at core induce ductility to rebar while martensitic rim induces appropriate strength. The TMT process is difficult to model as it brings multitude of complex physics such as heat transfer, highly turbulent fluid flow, multicomponent and multiphase flow present in the control volume. Additionally the presence of film boiling regime (above Leidenfrost point) due to steam formation adds complexity to domain. A coupled heat transfer and fluid flow model based on computational fluid dynamics (CFD) has been developed at product technology division of Tata Steel, India which efficiently predicts temperature profile and percentage martensite rim thickness of rebar during quenching process. The model has been validated with 16 mm rolling of New Bar mill (NBM) plant of Tata Steel Limited, India. Furthermore, based on the scenario analyses, optimal configuration of nozzles was found which helped in subsequent increase in rolling speed.

Keywords : boiling, critical heat flux, nozzles, thermo-mechanical treatment
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