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Experimental Modeling and Simulation of Zero-Surface Temperature of Controlled Water Jet Impingement Cooling System for Hot-Rolled Steel Plates

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Abstract : Zero-surface temperature, which controlled the cooling profile, was modeled and used to investigate the effect of process parameters on the hot-rolled steel plates. The parameters include impingement gaps of 40mm to 70mm; pipe diameters of 20mm to 45mm feeding jet nozzle with 30 holes of 8mm diameters each; and flow rates within $2.896x10^{-6}m^3/s$ and $3.13x10^{-5}m^3/s$. The developed simulation model of the Zero-Surface Temperature, upon validation, showed 99% prediction accuracy with dimensional homogeneity established. The evaluated Zero-Surface temperature of Controlled Water Jet Impingement Steel plates showed a high cooling rate of 36.31 Celsius degree/sec at an optimal cooling nozzle diameter of 20mm, impingement gap of 70mm and a flow rate of $1.77x10^{-5}m^3/s$ resulting in Reynold's number 2758.586, in the turbulent regime was obtained. It was also deduced that as the nozzle diameter was increasing, the impingement gap was reducing. This achieved a faster rate of cooling to an optimum temperature of 300oC irrespective of the starting surface cooling temperature. The results additionally showed that with a tested-plate initial temperature of 550oC, a controlled cooling temperature of about 160oC produced a film and nucleated boiling heat extraction that was particularly beneficial at the end of controlled cooling and influenced the microstructural properties of the test plates.

Keywords : temperature, mechanistic-model, plates, impingements, dimensionless-numbers
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