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Numerical Investigation of Water Quenching of Large Forged Steel Blocks : Effect of Bath Design on Water Agitation

Hadil Messikh[1*], Mounir Baiteche[1], Jean-Benoit Morrin[2], Mohammad Jahazi[1*]
[1]École de technologie supérieure, 1100 Rue Notre-Dame Ouest, Montréal, QC H3C 1K3, Canada
[2]Finkl Steel-Sorel, 100 McCarthy Street, Saint-Joseph-de-Sorel, QC J3R 3M8, Canada
*mohammad.jahazi@etsmtl.ca
*hadil.messikh.1@ens.etsmtl.ca

ABSTRACT

A 3D transient mathematical model was developed to investigate the impact of water volume on agitation and cooling efficiency within a quench bath during the quenching of a large steel block. The computational fluid dynamics (CFD) model was developed using ANSYS-CFX® to predict the cooling process on an industrial scale. The model accounts for critical parameters related to the quench bath, the steel block, and the cooling agent (water). While the primary objective is to predict temperature profiles, examining cooling behavior across multiple regions of the block is also important to address challenges associated with non-uniform cooling in large-scale components. For this purpose, a series of factors that reflect the change in thermophysical properties for the steel block and phase change in water from liquid to vapor during quenching are taken into account. Following validation and calibration of the model for the original bath design, a modified design was proposed, increasing the bath height by 24 inches to introduce additional water volume. Without modifying the agitation system, a frequency analysis was conducted to evaluate the effects of this modification on water agitation level and cooling behavior,. The findings provide valuable insights into the relationship between bath design, water volume, and cooling performance, offering a predictive tool for enhancing industrial quenching processes.