Quenching Heat Transfer Characteristics of Copper Rod in Saturated and Various Subcooled Condition

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Abstract This study investigated the quenching performance of a copper rod with 50 mm length and diameter of 20 mm. The specimen was heated to 600 °C as the initial temperature and immersed in a quenching pool of pure water (distilled water) followed with a subsequent quench seven times. Under atmospheric pressure, the experiments are conducted in saturated and various subcooled conditions (90, 80 and 60 °C). The cooling curves (temperature vs time) and the cooling rate curves (°C/s) of the copper cylinder are obtained from the experiment. Results show that the cooling performance for 1st quench and the subsequent quench for saturated and 90 °C subcooled condition shows a different performance related to the formation of the oxide layer at the copper surface that changes the surface characteristic. Vice versa, the cooling performance in 80 °C and 60 °C subcooled conditions has consistent performance for all quench, which is believed to be the domination of the subcooling effect, even though the physical surface appearance shows the same. Overall, the cooling curve of the copper rod was enhanced with the increase of subcooled temperature, especially for 60 °C subcooled conditions. The cooling curves for the subcooled of 90 and 80 °C still maintain the slope with the three-section shape, which is similar for the saturated case, but for the 60 °C subcooled conditions, the cooling curve slope suddenly increased and shifted to the left, showing the drastic decrease of centre temperature and the impact on the highly subcooled condition. The cooling rate curve shows the increasing peak value of cooling rate with increasing the subcooled temperature, which is the highest value during quench in 60 °C conditions. The minimum heat flux (MHF) point temperature rises and occurs faster, and the Critical Heat Flux (CHF) point is achieved early with the increasing subcooled temperature. The highly subcooled condition 60 °C shows no film boiling regime formation and the MHF point location is not visible.

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