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INVESTIGATION OF POOL BOILING HEAT TRANSFER ON MODIFIED COPPER AND ALUMINUM SURFACES

by

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Abstract

This thesis presents an investigation of pool-boiling heat transfer using the surface-modification method. The studied boiling surfaces were smooth and rough pin-fins embedded on the copper and aluminum surfaces. This study visualizes bubble formation and departure diameter. Experimental testing aims to predict the heat transfer coefficients for different heat fluxes over smooth and rough pin-finned surfaces. The surface modification method allows changing the boiling surface characteristics, which can lead to enhanced heat transfer. Several factors were studied, including the heat-transfer coefficient, heat flux, bubble departure diameter, and formation time. Four surfaces were used for conducting the pool boiling experiment: a smooth copper surface, a pin-fin copper surface with a width and length of 1 mm and a height of 2 mm with a spacing of 2 mm, a smooth aluminum surface, and a rough aluminum pin-finned surface with 0.5×0.5×1 mm with and a spacing of 2 mm.

The experimental testing results compare the smooth and rough surfaces for each of the copper and aluminum materials, showing the differences between the bubble diameter sizes and the bubble formation and departure times at different heat fluxes (low, medium, and critical flux). It was found that the bubble diameter, bubble departure, and formation time increased as the heat flux on the smooth and rough pin fins increased. The study investigated the bubble diameter size and formation/departure times for different heat fluxes on smooth and pin-finned copper and aluminum surfaces. The results are as follows: The bubble diameter sizes (low, medium, and critical heat fluxes) on the smooth copper surface were 0.2803 cm, 0.437 cm, and 0.67 cm. While the bubble formation and departure time (low, medium, and critical heat fluxes) were 0.2859 s, 0.305 s, and 0.4025 s. As for the pin-finned copper surfaces, the bubble diameter sizes (low, medium, and critical heat fluxes) were 0.745 cm, 1.38 cm, and 1.95 cm and the bubble formation and departure times on the pin-finned copper were 0.184 s, 0.207 s, and 0.417 s. For the smooth aluminum surface, the bubble diameter size (low, medium, and critical heat fluxes) were 0.63 cm, 0.96 cm, and 1.27 cm, and the bubble formation and departure times (low, medium, and critical heat fluxes) were 0.27s,0.36s, and 0.40s. The bubble formation and departure times (low, medium, and critical heat fluxes) were 0.27s, 0.36s, and 0.40s. The pin-finned aluminum surface had bubble diameter sizes (low, medium, and critical heat fluxes) of 0.24 cm, 0.30 cm, and 0.83 cm. While the bubble formation and departure time (low, medium, and critical heat fluxes) were 0.11s, 0.13s, and 0.21s, respectively. It was concluded that the rough pin-finned copper surface showed an improved boiling heat transfer coefficient and higher heat flux at lower wall superheat temperatures than the smooth surface. In addition, a CFD simulation for boiling heat transfer was developed for comparison with the experimental results and to study the volume fraction of vapor, velocity, and temperature of the generated bubbles.

Keywords: Pool boiling, heat transfer, bubble dynamics, critical heat flux.