Enhancement of Nucleate Boiling Heat Flux on Macro/Micro-Structured Surfaces cooled by Multiple Impinging Jets

A thesis submitted in partial satisfaction of the requirements for the degree Master of Science in Mechanical Engineering

by

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ABSTRACT OF THE THESIS

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An experimental investigation of nucleate boiling heat transfer from modified surfaces cooled by multiple in-line impinging circular jets is reported and found to agree with single jet results. A copper block is heated from the back by two electrical arcs, and cooled on the opposite side by three identical liquid jets of distilled water at subcoolings of 25°C, 50°C, and 77°C and Freon 113 at 24°C subcooling. Liquid flow rates are held
constant at 5, 10, and 15 GPH for each of the three jets, with jet velocities ranging from 1.4 m/s to 11.2 m/s and jet diameters from 0.95 mm to 2.2 mm.

To increase the maximum heat flux (CHF) and heat removal rate, the boiling surface was modified by both macro and micro enhancements. Macro modification consists of machined radial grooves in the boiling surface arranged in an optimally designed pattern to allow better liquid distribution along the surface. These grooves also reduce splashing of liquid droplets, and provide "channels" to sweep away bubbles. Micro modification was achieved by flame spraying metal powder on the boiling surface, creating a porous, sintered surface.

With the addition of both micro and macro structured enhancements, maximum heat flux and nucleate boiling can be enhanced by more than 200%. Examination of each surface modification separately and together indicates that at lower superheats, the micro structure provides the enhanced heat transfer by providing more nucleation sites, while for higher superheats, the macro structure allows better liquid distribution and bubble removal. A correlation is presented to account for liquid subcoolings and surface enhancements, in addition to the geometrical and fluid properties previously reported in the literature.
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