Boiling Visualization, Enhancement through Porosity Modification and Anodization

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Abstract

Boiling heat transfer is used in the cooling of power plants, rocket engines, server farms, and even the cell phones in our pockets. A fluid can absorb a lot of energy while it is boiling. For example, boiling water into steam requires the same amount of energy as heating steam to 1200°C. And yet, most space missions do not leverage boiling heat transfer because of the design complexity of two-phase systems.

The purpose of this study is to advance the material knowledge of boiling on porous and anodized surfaces, partly through visualization of bubble shapes and comparison to hydrodynamic models. This will facilitate the study of porous evaporators for cooling on space missions, such as the work being carried out today at NASA Jet Propulsion Lab.

A pool boiler has been built for measurement of boiling performance and bubble visualization. A suitable measure of boiling performance is the boiling curve, which is the relationship between heat flux and surface superheat temperature. The temperature profile of a heated copper post with constant cross-section is monitored by thermocouples embedded along its length. Heat flux is obtained from the slope of the temperature-distance relationship, while superheat temperature is obtained by extrapolation of this relationship to the boiling surface. The apparatus has been tested with untreated copper up to a boiling heat flux of 60 W/cm^2 thus far. Nucleate pool boiling is also captured with a high-speed camera. Bubble contours are captured using image processing techniques. Bubble contour evolution over time will be compared to bubble hydrodynamic models.