Surface Geometry and Heat Flux Effect on Thin Wire Nucleate Pool Boiling of Subcooled Water in Microgravity

In the summer of 2010, undergraduates from the USU Get Away Special team flew a nucleate pool boiling experiment on NASA’s Weightless Wonder to study nucleate boiling heat transfer in microgravity. The motivation of this research was to understand the effects of surface geometry and heat flux applied to a thin wire heater for the design and development of efficient thermal management systems for space applications. The specific objectives were to observe and characterize behaviors of boiling onset, steady state heat transfer, and bubble dynamics with respect to nucleate boiling of subcooled water. Using three thin platinum wire geometries and five different constant power levels, free-floating boiling experiments were conducted for more than 30 parabolic flight trajectories to simulate microgravity. To represent the trends in bubbles behavior across hundreds of frames of video in a single graph, a new method for relative bubble area analysis was developed to analyze the recorded videos of the experiment. It was found that the efficiency of steady state heat transfer via nucleate boiling in microgravity was equal comparable to (and in some cases more efficient than) steady state heat transfer in terrestrial experiments. The three wire geometry reduced the heat flux necessary to initiate boiling. Bubble dynamics showed a transition from isolated bubbles to jets of small bubbles as heat flux increases, which was confirmed both visually and with the relative bubble area analysis. The implications of this research are that sustained convective heat transfer with subcooled water is possible in microgravity. There are surface geometries that enable boiling to be initiated at lower heat fluxes, which is beneficial because the high heat transfer rates associated with boiling can be achieved with minimal super heating of the surface.