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Microgravity Experiments from Sub-Orbital to Orbital Platforms (3)

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RECENT DEVELOPMENTS ON HEAT PIPES FOR GROUND AND MICROGRAVITY CONDITIONS

Abstract

Two-phase flow and thermal physics are extensively investigated in microgravity environment with the continuous motivation of improving heat transfer devices in space as well as in terrestrial applications. For this purpose a dedicated hardware, called Thermal Platform (TP1), is under development by the European Space Agency to be implemented in the Fluid Science Laboratory (FSL) on board the International Space Station (ISS). Innovative heat pipes with enhanced performances and other heat transfer related phenomena, will be investigated in microgravity conditions by using advanced working fluids, i.e. special mixture called self rewetting fluids, materials and optimized geometries. Self Rewetting fluids means binary or multi-component mixtures having an unusual surface tension behavior. For these mixtures the reverse Marangoni effect along liquid-vapour interfaces is responsible for relatively strong surface tension-driven flows towards the hot region. One of the most interesting applications of this effect is spontaneous liquid inflow towards hot spot or dry patch on the heater surface of heat pipe or similar evaporation-based heat transfer devices.

This article focused on the experimental insert SELf rewetting fluids for thermal ENErgy management (SELENE) which is aimed to study the fundamental physics and the evaporative heat and mass transfer from the free surface of pure liquids and self rewetting fluids in a partially transparent V-shaped groove channel configuration. The paper discusses the different aspects of the experiment in microgravity conditions, where surface tension-driven phenomena dominate fluid behavior. The role of thermo-capillary effect on two phase heat transfer devices in pure liquids has been investigated on ground with a bread-boards apparatus based on a single V-groove. Transparent configuration allows flow visualization and optical diagnostic techniques to be used. The working fluids are an environmentally sustainable engineered liquid (Methoxy-nonafluorobutane, Novec 7100), whose low freezing point makes it ideal for use in space applications, and water. Special attention is focused on the role of wetting properties. The experimental results are explained on the basis of numerical models including evaporation, heat and mass transfer from the liquid/vapour interface and Marangoni effects.