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SELF-REWETTING CAPILLARY FLOW UNDER EVAPORATION AND CONDENSATION PROCESSES IN PARABOLIC FLIGHT CONDITIONS

Abstract

Self-rewetting fluids are dilute aqueous solutions of long chain alcohols with an unusual surface tension behavior. The presence of small proportions of alcohols in water changes both the wetting and surface tension properties of the mixture. Contrary to ordinary liquids, the surface tension becomes an increasing function with temperature that, in addition to the variation induced by the preferential evaporation of the more volatile component, provides a reverse Marangoni flow along the liquid-vapor interfaces driven towards the hotter regions. Such mixtures have been extensively investigated on ground as working fluids for two-phase heat transfer devices. One of the most interesting applications of the self-rewetting effect is a spontaneous liquid inflow towards hot spots or dry patches of evaporation-based heat transfer devices. As working fluids for heat pipe systems, self-rewetting fluids show better properties, i.e. lower thermal resistance, enhanced dry-out limit and more stable behavior.

An experiment investigating the heat transfer performances of both pure liquids and self-rewetting fluids in two-phase systems taking advantage of the favorable weightlessness conditions in space, is being planned on board the International Space Station. This article reports the results of precursor experiments carried out on board a 'zero-g' plane, during the 66th Parabolic Flight Campaign of the European Space Agency. The heat and mass transfer processes of self-rewetting fluids is investigated in a single groove heat pipe model mounted on an experimental payload aboard the zero-g plane. The experimental cell is a V-shaped groove channel equipped with thermal sensors and a top transparent window that allows the observation of the liquid distribution inside the groove channel thanks to a LED illumination technique. The experimental cell is heated with an electrical heater at the hot side and cooled with water loop at the opposite side. The groove channel is partially filled with the self-rewetting mixture before the flight and the capillary-driven flow investigated in presence of evaporation/condensation processes, under variable gravity conditions. The power level was gradually increased in steps of 10Watt up to 30Watt, according to the maximum operating limits. Results show that the liquid film distribution is affected from the gravity levels. During the parabolic maneuvers, the liquid remains confined inside the groove channel and increasing the power level the liquid film thickness gradually decreases. The results are explained with respect to the thermo-physical properties of the self-rewetting mixture and discussed in relation to the experiments carried out in normal gravity condition.