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SPACE EXPERIMENTS OF EVAPORATION AND CONDENSATION PROCESS ONBOARD CHINESE TZ-1 CARGO SPACECRAFT

Abstract

In space, the phase change coupling with typical interfacial phenomena of heat and mass transfer will play main role in the process of evaporation and condensation, while which are still absent of comprehensive understanding in space where the influence of gravity (i.e. natural convection, buoyancy) can be minimized. In present paper, the space experimental investigation of evaporation and condensation in microgravity condition will be presented for recent space flight missions of Chinese 1st Cargo Spacecraft TZ-1 launched in April of 2017. The experiments were performed successfully during the total 234 hours' working time in orbit, which focuses to understand the influence of gravity effects on the heat and mass transfers of during phase change process. Specifically, both evaporation of FC-72 liquid layer and drop, and condensation of the FC-72 liquid vapor were observed experimentally in a closed combination chamber with controlling parameters (substrate temperature, volume of injecting working medium and inner pressure). Some key technologies, for development of the Two-Phase System Research Rack for future China Space Station,were performed also in this mission including thermal control techniques for the liquid-pump-drived two-phase fluid system, hot vapor generation from liquid storage, volatile liquid injection and the combined optical observations of Infra Camera and CCD Cameras in orbit. The experimental data, including typical temperature, heat flux and vapor pressure inside the test chamber were measured during the process of phase change. The feature evolution of evaporating liquid layer and drops, the formation of liquid film during the condensation process and the vapor-liquid interfacial temperature field were captured by a CCD camera and an infra camera, respectively. Quantitative investigations of evaporating evolution of liquid drops and liquid layers were achieved on a substrate and it was found that the gravity effect had distinct influence on the phase change heat and mass transfer, with obvious different convective cells in the thermal fields. The "Vapor Clouds" was observed during evaporation in space, which was helpful to study the pure diffusion progress at the liquid-gas interface in absent of buoyancy convection. The film-wise condensation evolution was observed and the onset of condensation was recognized by thermal measurements and optical observation system. It was found the heat transfer efficiency induced by condensation worsen than ground, owing to the condensate liquid film stabilized by surface tension in space. Acknowledgements: This research was financially supported by the China's Manned Space Program (TZ-1), the National Natural Science Foundation of China (Grants No. 11532015, U1738119) .