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HEAT EXCHANGE AND PRESSURE DROP INDUCED BY SLOSHING

Abstract

The occasion to handle liquids under low gravity conditions is now growing with the progress of human activities in space. On the launch vehicles with liquid propulsion system, the dynamic acceleration during its powered ascent or ballistic flight makes it very difficult to control the position of propellants in the tanks. To establish the technology for the propellant management, it is essential to accumulate technical knowledge and experiences for the appropriate assessment of the fluid systems. However, in the atmosphere, there are not so many opportunities to realize the low-gravity state or the dynamic conditions of acceleration with airplanes or drop towers. Investigative methods based on Computational Fluid Dynamics, CFD, are therefore strongly desired.

For the prediction of heat transfer coupled with sloshing phenomena in the propellant tanks of reusable launch vehicle, the pressure drop induced by heat transfer and the dynamic motion of liquid in sub-scale vessels were experimentally observed and numerically investigated. The magnitude of heat flux between two phases in sloshing was found to have strong correlation with the appearance of droplets and wavy surface. The mechanisms enhancing heat transfer were discussed based on the computation. In both of the experimental data and numerical results, the similar correlation between the enhancement of heat transfer and appearance of droplets was obtained. It was suggested that, in order to prevent immediate pressure drop induced by sloshing, some device equipped in the tank were desired to damp the liquid motion and suppress the splash.