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INVESTIGATION OF TWO-PHASE INTERFACIAL BEHAVIORS ON PROPELLANT REORIENTATION IN DROP TOWER

Abstract

In order to fit different transmission requirements, the main engine of launch vehicle must have the ability to restart more than two times in microgravity environment. During the engine-off time, the liquid propellant is expected to be held in the proper position of the tank for an engine restart on the vehicle. In space, where the effective gravity is small, the worst case of propellant reorientation is that the liquid phase locates at the top of the tank. Various methods have been proposed to control the location of the liquid for engine venting and restarting. In the present design of large propellant tanks, one way to accomplish both of these objectives is to use an auxiliary thrusting system to provide a linear acceleration large enough to settle the liquid. Its principles are similar to a tank on Earth exposed to gravity. So, the thrust and time required to reorient the liquid propellant back to its desired location must be known to ensure a successful engine restart sequence and to determine effective thruster parameters. In present study, numerical simulations of the process of propellant reorientation in orbit have been performed, the volume-of-fluid (VOF) method is used, and an axisymmetric model is adopted to simulate the unsteady, incompressible flows with deforming the gas-liquid interfaces. The process of the liquid propellant reorientation started from initially curved interfaces. The characteristic time of propellant reorientation flow in different reorientation impulse and settling Bond number was presented numerically. The numerical results show that the reorientation impulse and settling Bond number in each case have nearly a linear relation. The settling Bond number gets larger; the greater impulse for reorientation is needed to settle the liquid propellant. A series experimental investigation in a scale model of liquid propellant tank is conducted in the Drop Tower Facility of Beijing (China) with 3.6 seconds of free-fall time. A special facility installed inside the capsulate of drop tower is developed in order to change the Bond numbers of two-phase liquids in the experimental model of liquid propellant tank. A large variation of the Bond numbers is realized during the free falling of drop cabin in microgravity condition. The two phase flow in the model tank are observed for different reorientation cases and compared with the numerical simulation.