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MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Microgravity Experiments from Sub-Orbital to Orbital Platforms (3)

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EXPERIMENTAL STUDIES ON THE PROCESSES OF PROPELLANT REORIENTATION IN SPACE BY USING DROP TOWER

Abstract

In space, the restart-up of the on-orbit upper stage of the rocket needs the safe propellant supply of the engines. One of main tasks is to control the location of the liquid propellant for engine by using an auxiliary thrusting system to provide acceleration which should be large enough to resettle the liquid. So, in order to ensure a successful engine restart sequence, it is necessary to determine effective thruster parameters such as the thrust and its acting time required to reorient the liquid propellant back to the desired location in microgravity environment.

This paper presents an experimental study of the two-phase liquid flow during the process of propellant reorientation in a scale-model propellant tank by using the Drop Tower with 3.6 second microgravity duration. The moving platform installed inside the drop capsule was constructed of the electromechanical drive system, which is capable to provide a variable low-level acceleration on the test tanks to meet the requirements of variable accelerations for the experiment. The test tanks on the moving platform have an additional acceleration during the free fall of the drop capsule in the drop tower. Two test liquids (FC-72 and ethanol) and two test tanks with different diameters 110 and 75 centimeters were used in the experimental investigations for different liquid filling percent in the tanks.

The process of liquid reorientation was observed clearly in drop tower runs and the experimental results show that, in most of the cases when thrust activated, the reorientation flow was in a sheet along the tank walls moving to the tank top and gradually formed a spike along the tank centerline. This spike then moved downward and grew in size until it impacted on the tank bottom. During the process, gas bubbles created inside the liquid. The thrust and time required to reorient the liquid propellant to its desired location were analyzed for different cases of the propellant reorientation. Due to the limited microgravity duration or the capsule dimension of the drop tower, the complete process of liquid reorientation in test tanks could not observed in some investigational cases.

The specific reorientation flow process of real-scale model and experimental scale model was simulated, respectively. The characteristic time of propellant reorientation flow was given by numerical simulation. The experiment results were compared with numerical results and a good agreement has been obtained.