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EXPERIMENTAL STUDIES ON THE WITHDRAWAL OF BUBBLE-FREE PROPELLANT BY USING PROPELLANT MANAGEMENT DEVICES (PMDS) UNDER COMPENSATED GRAVITY

Abstract

One of the main tasks in the field of astronautics is the gas- and vapor-free propellant supply of the engines. To fulfill the requests of the satellite customers, especially the exposure of the satellite at the desired orbit, a launcher must be more flexible. One possibility is to reignite the cryogenic upper stage of the rocket during the ballistic flight phase. For re-ignition during the ballistic flight phase so-called Propellant Management Devices (PMDs) are required. PMDs are refillable reservoirs which are located near the tank outlet. The PMD shall provide an adequate amount of liquid, especially during the ballistic, unpowered flight phase, until they get refilled, e.g. by capillary structures inside the tank.

This paper presents an experimental study of the refilling of a PMD during draining of a test fluid at the tank outlet under compensated gravity. The experiments were performed at the ZARM drop tower which permits an experimental time of 4.7 s of compensated gravity. During a test run the test liquid from the tank is drained out through the PMD via linear drives. Within the PMD are screens that will make it more difficult for gas bubbles to break through, because of the small bubble point of the screens. The most important boundary condition for the test series is the flow rate at the outlet, with which the test fluid is sucked through the PMD. The flow rate is fixed for every test run but was changed for every test run.

The aim of the experiments is to evaluate the refilling of the PMD for different fill levels and flow rates under compensated gravity. The more liquid is withdrawn; the lower is the level in the tank. Furthermore it will increase the probability of sucked-in gas through the openings of the PMD. A too high chosen flow rate at the outlet results in an insufficient refilling behavior of the PMD with liquid, because the refilling rate of the PMD is limited by the design. This test series is an attempt to validate the existing numerical models and to determine the critical flow rate, at which the PMD cannot be refilled.