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Microgravity Experiments from Sub-Orbital to Orbital Platforms (3)

Author: Mr. André Pingel
University of Bremen - ZARM, Germany

Prof. Michael Dreyer
University of Bremen, Germany

PHASE SEPARATION OF HYDROGEN

Abstract

The phase separation of hydrogen is a current research theme in the field of space technology which is of special interest concerning two different applications in future cryogenic propulsion systems: On one side for the gas- or vapor-free delivery of the liquid propellant to the combustion chamber and on the other side for the liquid-free venting to condition the propellant. Phase separation can be realized using the retention capability of a screen or double screen against liquid.

Both applications are conceivable with autogenic pressurization in a one species two-phase system consisting of liquid hydrogen and hydrogen vapor as well as pressurization with a non-condensable gas in a two species two-phase system consisting of liquid hydrogen and gaseous helium.

First experimental and theoretical investigations with storable liquids have been conducted by Conrath and Dreyer [1] and Conrath et al. [2]. First ground experiments with cryogenic liquids have been performed by Behruzi et al. [3].

In this project a cryogenic test facility has been developed which allows to analyze the physical effects which are combined with the retention capability of a double screen against sloshing of liquid hydrogen in hydrogen vapor environment during ground and drop tests.

The development of the test facility required the provision of test determinations of the expected physical effects. Using a commercial computational fluid dynamics program, a first two dimensional, numerical, model could be produced. The model depicts the physical effects radial wicking, capillary rise with pressurization, bubble point and screen resistance in combination.

With the aid of the test determinations, the development and building of the cryogenic test facility could be accomplished. An experimental campaign consisting of 14 tests in earth gravity and three drop tests in microgravity using the drop tower at the University of Bremen has been conducted. During the experiments wall temperatures, saturation pressure and differential pressures have been measured. In order to track the liquid movement an endoscope with connection to a CCD camera has been used for video recording. The experimental results confirm the expected effects.

[1] M. Conrath, M. E. Dreyer, Gas breakthrough at a porous screen, Int. J. Multiphas. Flow, 42:29–41, 2012.

[2] M. Conrath, Y. Smiyukha, E. Fuhrmann, M. E. Dreyer, Double porous screen element for gas-liquid phase separation, Int. J. Multiphas. Flow, 50:1–15, 2013.

[3] P. Behruzi, J. Klatte, G. Netter, Passive Phase Separation in Cryogenic Upper Stage Tanks, AIAA 2013-3905, 2013.