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ANALYSIS OF THE PRESSURE SURGE DURING FAST TRANSIENT IN EVACUATED SPACECRAFT FEEDLINES

Abstract

During the start-up of the propulsion system of a satellite or spacecraft, the opening of the tank isolation valve will cause the propellant to flow into an evacuated feedline and slam against a closed thruster valve. This filling process, called priming, can cause severe pressure peaks as high as 250 bar, which could lead to structural failure or even to adiabatic compression detonation in the case of monopropellants such as hydrazine. At DLR Lampoldshausen an experimental campaign has been conducted in a dedicated test facility which allows fluid transient experiments in the same conditions as the operating space system. Results of the tests are used to validate numerical tools developed for designing space propulsion systems. In particular the objective of this campaign is to provide an extensive database to be compared against the numerical simulations of the transient flow in the feedline subsystem of a spacecraft. Tests are performed with water and ethanol at different operating conditions (tank pressure, vacuum level, pressurizing gas helium vs nitrogen, etc...). The pressure wave characteristics such as peak, frequency and damping behavior are found to be strongly affected by the pressurizing conditions. In fact, during the storage in the tank, the pressurizing gas dissolves in the liquid. When the fluid enters the evacuated pipe, this dissolved gas will desorb mixing with the fluid vapor coming from the flash evaporation. This makes the flow not only two-phase but also two-component, a severe benchmark for the numerical simulations. Particular attention is therefore given on the modeling of the desorption process, which has a major effect in case of fluid with a high amount of dissolved gas, such as ethanol.