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MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures I - Development and Verification (Space Vehicles and Components) (1)

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VERIFICATION OF DIAPHRAGM ANALYSIS

Abstract

This paper reports on numerical and experimental investigations into the membrane behavior of positive expulsion device (PED) satellite tanks. The work described herein focused on the development and the validation of suitable multi-physics analysis approaches to capture the fluid-structure interaction phenomena inside a PED tank and is motivated by the striving of MT Aerospace as a PED tank manufacturer to continuously improve the design and robustness of tank membranes. Especially the effects that eventually govern a tank's characteristic qualities related to conditions during filling and draining operations, as well the impact on its transient performance in harmonically excited sloshing conditions are examined. The investigated numerical simulation approaches and modelling strategies are put into comparison to results from experiment data that has been collected in dedicated sub-scale tests. This paper first describes the basic design of positive expulsion device tank and briefly introduces the particular configuration of the tank and the membrane that has been used for the numerical and experimental investigations that were performed. Then, the investigations into the PED tank filling and draining are discussed. The simulation results of the membrane inversion and the influence of membrane wall thickness distribution on the developing of folding patterns are presented. Test activities related to the membrane inversion during filling and draining are described, including results from stereoscopic digital image correlation (DIC) system, which allows a virtual 3d reconstruction of the evolving membrane surface. The following section then deals with the simulation and experimental investigation of the PED tank sloshing behavior for harmonically excited lateral accelerations. Fluid-structure interaction simulation outcomes are shown in comparison to sloshing test measurements, again including transient membrane movements from DIC surface scanning, to shed light on PED tank Eigenfrequency and damping. The paper finally evaluates the results gained from computation and test and concludes on the reliability and accuracy of the utilized simulation methods. Based on the gathered findings, an outlook is given on further investigations that appear advisable to consolidate the obtained experience.