NUMERICAL AND EXPERIMETAL INVESTIGATION OF THE WATER HAMMER IN FEED LINES OF SATELLITE ROCKET ENGINES

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Operation of spacecraft propulsion systems is adversely faced with fluid hammering effects and several multiphase phenomena. From the moment an isolation valve is opened, the quick filling of the vacuum pumped lines produces a pressure surge that is hard to predict due to a lack of understanding of the physical multiphase processes taking place. Indeed, the priming operations in space satellites can be critical for the payload if the corresponding over pressures are not correctly taken into account.

Therefore, the main goal of the present work is the correct understanding of the water hammer phenomenon and the related multiphase phenomena by means of performing an experimental and numerical analysis. The numerical study is done with the numerical code EcosimPro/ESPSS, while the experimental study has been done in a setup that reproduces a simplified satellite propellant circuit (Figure 1). Water has been used as a working fluid.

The experimental campaign was carried out in order to reproduce the water hammer phenomenon under different initial pressure conditions both in the reservoir and in the test element. The evolution of the pressure at the end of the test element has been measured with a piezoelectric pressure transducer. The trapped air that remains in lateral branches has been revealed as a critical factor for the first peak amplitude and the time delay from peak to peak.

This facility has been modeled with EcosimPro/ESPSS. A good agreement has been found when comparing the numerical simulations with the experimental results. Moreover the nature of the flow within the first instants after the opening of the valve has been studied in X-t maps, which provide more information than the classical time graphs found in the literature. The existence of three different layers with different vapor content before the arrival of the liquid front has been observed in the numerical simulations. Therefore, is has been proved the existence of a complex flow that must be further validated for real satellite conditions.

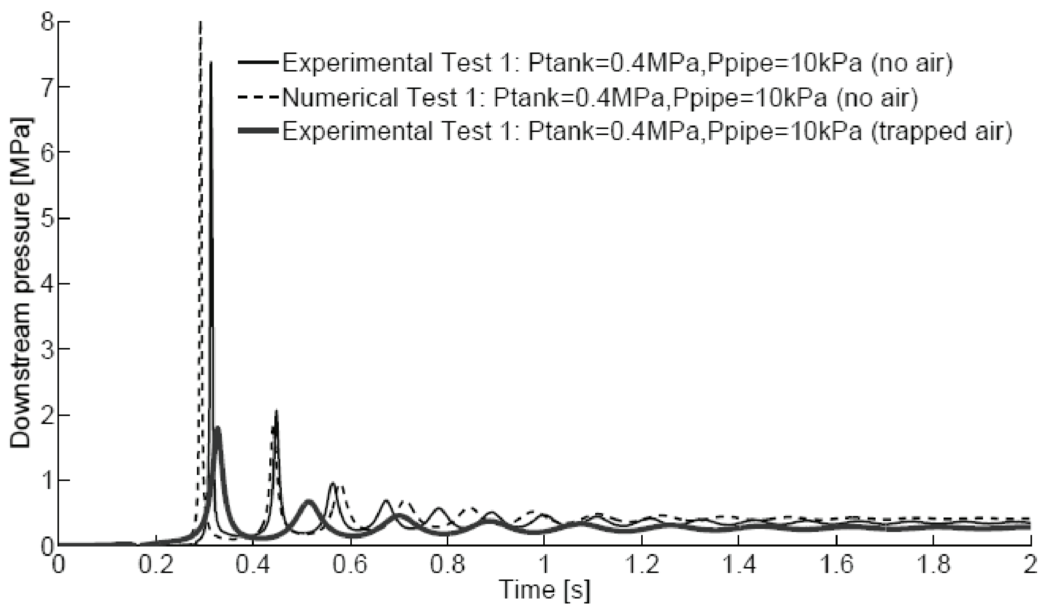

Figure 1: Evolution of the downstream pressure surge with and without trapped air in the lateral branches