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C1Po1B-07 [09]: Numerical Analysis of Fluid Transients Induced by Valve Operation in Cryogenic Feed lines

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Rapid change in fluid flow conditions, whether purposeful or accidental, may result in the generation of a pressure spike in the fluid flow system followed by oscillations of pressure which is known as the fluid transient/fluid hammer. The maximum amplitude of these oscillations may go beyond the safe operating limits of the system producing detrimental effects on pipelines, valves, pumps and other fluid network devices. Sometimes, the system pressure may also go below the vapor pressure of the fluid due to oscillating behavior of the wave which results in cavitation. Hence, it is essential to consider the effect of fluid transients for the correct design of the cryogenic propellant feed system of space launch vehicles which involves rapid closure and the opening of valves.

In the current work, a mathematical model is formulated using the Method of Characteristics to predict fluid transients occurring due to sudden closure and the opening of the valve in the cryogenic propellant feed system. Various unsteady friction models are incorporated in the mathematical model to study the effect of friction on dampening of the pressure wave. The applicability of the developed model is evaluated by comparing its predictions with the results available in the literature. It is observed from the current study that the first peak of the pressure oscillations can accurately be simulated with steady/quasi-steady friction, but the prediction of precise attenuation of pressure wave requires the inclusion of unsteady friction term.

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