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ANALYSIS OF CAVITATION CHARACTERISTICS OF PUMPS USED IN LIQUID ROCKET ENGINES BY USING MULTIHOLE ORIFICE PLATE

Abstract

One of the major subsystems of liquid rocket engines is propellant feed system which consists of booster turbopumps, main pumps turbines. The booster turbopumps are required to provide necessary safe inlet pressure to the main pumps for their cavitation free operation at the specified engine inlet conditions. In order to obtain the pump characteristics, the pumps are subjected to a series of developmental tests using water as working medium. Cavitation test is one of the most important tests in order to determine the cavitation characteristics. Cavitation test is done by reducing pump inlet pressure from nominal value to the pressure at which cavitation initiates. Experiments were carried out by using single hole and multihole orifices in the pump inlet. The multihole orifice is specially designed to shorten recovery length and to ensure full flow attachment sufficiently ahead of the pump suction. This design of multihole orifice ensured that Cavitation pressure of the Pump can be captured by using single orifice plate with shorter recovery length.

In the present paper, a comparative analysis was carried out between a single hole orifice and a multi-hole orifice plate for its behaviour, mainly discharge coefficient Cd, pressure loss, location of vena contracta and flow attachment when used for Cavitation analysis of pumps. Computational Fluid Dynamics (CFD) simulation has been used to predict the pressure loss across orifice and flow attachment for both single and multihole orifice at different equivalent diameter ratio (β). The κ-ϵ model with standard wall function was used to describe the turbulence and simulate the near-wall flow. The location of vena contracta and flow attachment by using single hole and multihole orifice was tracked with the help of CFD simulations for cavitation test of pumps. CFD simulations have been validated for discharge coefficient Cd, pressure loss and recovery length with experimental results by using water as working fluid. The experiments were carried out by decreasing the pump inlet pressure from 0.3 MPa to a pressure at which cavitation initiates

at a given flow rate and at a rated pump speed of 4900 rpm. It is concluded from the experimental results that the multihole orifice provides better flow attachment and less pressure loss across the orifice plate as compared to single hole orifice.