Paper ID: 65895
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IAF SPACE PROPULSION SYMPOSIUM (C4)
Liquid Propulsion (2) (2)

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MULTI-SCALE NUMERICAL STUDY ON ATOMIZATION PROCESS OF GAS-LIQUID PINTLE INJECTOR FOR LIQUID ROCKET ENGINE

Abstract

Variable-area injectors are suitable choices for developing throttleable liquid rocket engines. Pintle injector is a kind of variable-area injector that can control the mass flow rate of propellants by its moving part. In this work, the atomization process of gas-liquid pintle injector is studied with adaptive grid technique and multi-scale model based on VOF method under different operating conditions. The correctness and effectiveness of the multi-scale model are verified by comparing the numerical results with the experimental results. Firstly, the breaking mode of liquid and atomization field structure characteristics are obtained. Then the influence of flow and structural parameters on atomization characteristic parameters such as atomization angle, droplet size is also investigated with the multi-scale model. Finally, the sensitivity of parameters is studied to determine the key parameters affecting atomization characteristics of the gas-liquid pintle injector. The simulation results show that the liquid jet is broken into liquid ligaments and further into droplets under the action of aerodynamic forces. Local momentum ratio dominates atomization angle and the atomization angle increases with local momentum ratio. Gas-liquid flow ratio is the key parameter affecting droplet size, in which droplet size decreases and droplet size uniformity index increases with gas-liquid flow ratio.