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Author: Mr. Pu Shi
Science and Technology on Combustion, Internal Flow and Thermal-structure Laboratory, Northwestern Polytechnical University, China

Dr. Guoqiang ZHU
Northwestern Polytechnical UniversityNPU, China
Dr. Jiming CHENG
Science and Technology on Combustion, Internal Flow and Thermal-structure Laboratory, Northwestern Polytechnical University, China
Prof. Jinxian Li
Science and Technology on Combustion, Internal Flow and Thermal-structure Laboratory,Northwestern Polytechnical University, China

MULTI-SCALE NUMERICAL STUDY ON ATOMIZATION DYNAMICS OF GAS-LIQUID PINTLE INJECTOR

Abstract

Variable thrust liquid rocket engines have broad applications in VTVL(Vertical Takeoff and Vertical Landing) reusable launch vehicle and space propulsion. Due to the deep throttling ability and other excellent advantages, pintle injectors have been studied widely for variable thrust liquid rocket engine. During the working process of LRE, the propellant undergoes injection, atomization, evaporation, mixing reaction, expansion and acceleration to provide thrust. The atomization characteristic of injector affects the subsequent mixing combustion process, and then the LRE performance directly. In this work, the atomization dynamics process of a liquid-centered gas-liquid pintle injector is studied with a multi-scale VOF model and adaptive mesh refinement technique. The model validity and accuracy are verified by comparing the numerical results with the experimental results. And then breaking and spray morphology of the liquid jet are obtained. The influence of operating and geometrical parameters on atomization characteristics, such as atomization angle α and SMD is also studied parametrically. The results show that during atomization process, the liquid cylinder is broken into ligaments firstly and then into droplets under the interaction of aerodynamic force, surface tension, viscous force and so on. The atomization angle α is dominated by LMR mostly, and increases with it. SMD is mainly affected by gas-liquid mass flow ratio, and gets smaller with the increase of gas-liquid mass flow ratio.