SPACE PROPULSION SYMPOSIUM (C4)
Interactive Presentations (IP)

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QUASI-DIRECT NUMERICAL SIMULATION ON ATOMIZATION AND MIXING CHARACTERISTICS OF A PAIR OF IMPINGING JETS

Abstract

Impinging jets injector elements,which make use of mutual impinging of fuel and oxidant to realize atomization and mixing process, are the preferred injector geometry for liquid rocket engines that use storable propellants. The quality of atomization determines subsequent evaporation and combustion process, and further affects combustion efficiency and stabilization of the engine. It will be of great importance for the design of the engine to make deep research on mechanism and characteristics of atomization. Quai-Direct Numerical Simulation was carried out to emulate the process of a single jet and a pair of impinging jets atomization. The computational domain was spacially discretized by cube elements organized as adaptive octree structure. The incompressible Navier-Stokes equations were directly solved by finite volume method. The interface between gas and liquid was reconstructed by VOF(Volume-of-Fluid) method. The combination of a balanced-force surface tension discretization and height function curvature estimation was used for accurate solution of surface tension. Dissipation of vortex at scales smaller than the mesh size was approximated by ILES(Implicit Large Eddy Simulation). Firstly, three dimentional numerical simulation of a single liquid jet ejected into high pressure gas atmosphere was carried out and we got the spray angle and breakup length of liquid core, which was validated by comparing with experimental data. Then the atomization of a pair of impinging water jets with various impinging angle and jet velocity was emulated. The simulation was validated by comparing numerical results with experimental data and the numerical precision was also given. The formation mechanism of impact wave was explored. Distribution characteristics of impinging jets was also obtained. Then the simulation of cold impinging atomization of NTO/MMH was carried out to investigate the mixing mechanism of unlike doublet impinging jets. The mixing ratio distribution of a certain plane downstream from impinging point was obtained. The adiabatic combustion temperature distribution of the plane was estimated by thermodynamical calculation based on mixing ratio distribution. The main conclusions we got are as following. The algorithm we used can realize numerical simulation of multi-phase, multi-scale atomization process. The formation mechanism of a pair of impinging jets is the result of uncomplete balance of inertia force when impinging happens. Diameter distribution of droplets is approximately obeyed Rosin-Rammler distribution. The adiabatic combustion temperature distribution can be obtained by simulation of cold impinging atomization of NTO/MMH.