World Academy of Science, Engineering and Technology
International Journal of Computer and Systems Engineering
Vol:10, No:03, 2016

Bi-Liquid Free Surface Flow Simulation of Liquid Atomization for Bi-Propellant Thrusters

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Abstract : Bi-propellant thrusters use impinging jet atomization to atomize liquid fuel and oxidizer. Atomized propellants are mixed and combusted due to auto-ignitions. Therefore, it is important for a prediction of thruster's performance to simulate the primary atomization phenomenon; especially, the local mixture ratio can be used as indicator of thrust performance, so it is useful to evaluate it from numerical simulations. In this research, we propose a numerical method for considering bi-liquid and the mixture and install it to CIP-LSM which is a two-phase flow simulation solver with level-set and MARS method as an interfacial tracking method and can predict local mixture ratio distribution downstream from an impingement point. A new parameter, beta, which is defined as the volume fraction of one liquid in the mixed liquid within a cell is introduced and the solver calculates the advection of beta, inflow and outflow flux of beta to a cell. By validating this solver, we conducted a simple experiment and the same simulation by using the solver. From the result, the solver can predict the penetrating length of a liquid jet correctly and it is confirmed that the solver can simulate the mixing of liquids. Then we apply this solver to the numerical simulation of impinging jet atomization. From the result, the inclination angle of fan after the impingement in the bi-liquid condition reasonably agrees with the theoretical value. Also, it is seen that the mixture of liquids can be simulated in this result. Furthermore, simulation results clarify that the injecting condition affects the atomization process and local mixture ratio distribution downstream drastically.

Keywords : bi-propellant thrusters, CIP-LSM, free-surface flow simulation, impinging jet atomization
Conference Title : ICCFD 2016 : International Conference on Computational Fluid Dynamics
Conference Location : Prague, Czechia
Conference Dates : March 30-31, 2016