Vaporization and Collision Modeling of Liquid Fuel Sprays in a Co-axial Fuel and Air Pre-mixer

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Abstract

Droplet collision occurs frequently in regions where the droplet number density is high. Even for lean premixed pre-vaporized (LPP) liquid sprays, the collision effects can be very high on the droplet size distributions, which will in turn affect the droplet vaporization process. Hence, in conjunction with vaporization modeling, collision modeling for such spray systems is also essential. The standard O'Rourke's collision model, usually implemented in CFD codes, tends to generate unphysical numerical artifact when simulations are performed on Cartesian grid and the results are not grid independent. Thus, a new collision modeling approach based on no-time-counter method (NTC) proposed by Schmidt and Rutland is implemented to replace O'Rourke's collision algorithm to solve a spray injection problem in a cylindrical coflow premixer. The so called "four-leaf clover" numerical artifacts are eliminated by the new collision algorithm. Next, the dispersion and vaporization processes for liquid fuel sprays are simulated in a coflow premixer. Two liquid fuels under investigation are jet-A and Rapeseed Methyl Esters (RME). Results show very good grid independence. At relatively low spray cone angle and injection velocity, we found that the collision effect on the average droplet size and the vaporization performance are very high due to relatively high coalescence rate induced by droplet collisions. We also found that the vaporization performance and the level of homogeneity of fuel-air mixture can be significantly improved when the dispersion level is high, which can be achieved by increasing the spray cone angle and injection velocity.

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