

Spray Collision Modelling of Immiscible Droplets in Direct Water Injection

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Abstract

Droplet collision in a diesel spray is an important phenomenon affecting spray propagation and droplet evaporation. Researchers have been conducting numerous visual investigations on the dynamics of binary collision system with two equivalent droplets of the same liquid and classifying the collision outcomes on a Weber number and an alignment index of the impact. Collision modelling for diesel spray has been dealing with “inner-spray” collision between the droplets of the same kind, and the collision event has been a sidebar issue as far as diesel sprays is concerned. A few attempts, however, are introduced utilizing “inter-spray” collision to promote the drop breakup or to promote the entrainment of droplets of the different liquid from diesel fuel. DWI (Direct Water Injection) system recently introduced to reduce NO_x emission from marine diesels, however, could have considerable collisions between the droplets of the different liquid, that is, between water droplets and fuel droplets since it has near co-axial nozzle layout and water is usually injected under much lower pressure than fuel. In this study, the criteria of the collision outcomes between immiscible droplets were newly derived theoretically and implemented into KIVA3 code. In this collision model for immiscible droplets, the collision outcomes were divided into full four cases as observed by R. -H. Chen and C. -T. Chen, and the effects of drop size ratio and momentum distribution were theoretically taken into account. Concentric water-in-oil type droplet had to be newly introduced as an outcome of oil and water droplet coalescence. With different treatments in calculating its breakup and evaporation processes, the new collision model gave more enhanced fuel evaporation through the production of the concentric droplets and made more water droplets remaining around the spray tip. This would affect the subsequent ignition and combustion processes greatly, so that NO formation process in DWI system should be discussed carefully.

Key words: diesel sprays, modeling, droplet collision, immiscible droplets, water injection

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