Investigation of Effect of Nozzle Geometry on Spray Characteristics with a 3D Eulerian Spray Model Coupled with the Nozzle Cavitating Flow

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Abstract

It is well known that near-nozzle fuel liquid jet development dominated by internal nozzle flow and related fluid-dynamic instability governs the primary break-up process of the injected fuel. The fuel primary atomization controls the mixing of fuel with surrounding oxidant gas, which is significant to achieve highly-efficient and clean combustion for diesel engines. Different nozzle geometry at the same operative conditions can lead to dramatically different behaviors in combustion performance and emissions formation. While the relation between nozzle flow and spray development in the combustion chamber is still a challenging topic with a high improvement potential. Based on the third-generation synchrotrons of Shanghai synchrotron radiation facility (SSRF), the high-precision three-dimension structure of nozzle with detailed internal geometry information were obtained, which is the basis of the subsequent numerical simulation. A 3D-Eulerian Spray multiphase model coupled with the cavitating flow inside the nozzle was put forward to simulate the whole spray process, including the primary atomization and secondary break-up. The nozzle flow and near-field spray were simulated with the VOF multiphase model. At a certain downstream location, where the spray is diluted, this Eulerian spray approach was switched to conventional Lagrangian approach. In this model, the fuel volume fraction of the cell at the switch position determined the droplet size. This entire methodology was validated through the experimental data of liquid spray penetration under non-evaporating chamber conditions. The multi-scheme numerical simulations were carried out by this model to investigate effect of the nozzle geometry and configuration on inner cavitating flow and the subsequent spray characteristics.

Key Words: diesel engine; nozzle; X-rays; cavitating flow; primary atomization; spray model

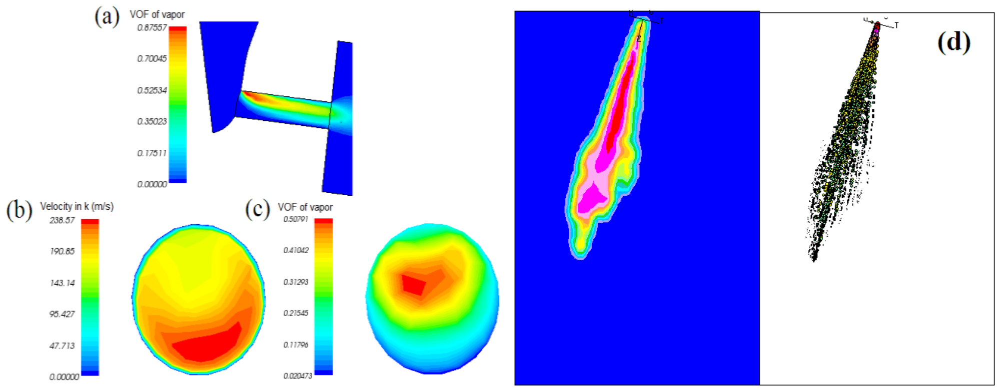

Figure Injectoin pressure 30MPa: (a) volume of fraction of fuel vapor (cross-section), (b) velocity in k direction (vertical direction of orifice outlet),(c) volume of fraction of fuel vapor (orifice outlet), (d) mass fraction of fuel and spray particle distribution.

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