LARGE EDDY SIMULATION OF EVAPORATING SPRAYS UNDER DIESEL-LIKE CONDITIONS

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Given that there are no black boxes and no limitations for detailed user-defined model development in the open source software OpenFOAM in contrast to other commercial computational fluid dynamics (CFD) codes, the long-term goal of this study is to establish an efficient 3-D evaporative spray model coupled with the Large-eddy Simulations (LES) over a wide range of diesel-like conditions through user-definition in OpenFOAM. This model coupled with LES not only minimizes the penalties in computational efficiency compared with Direct Numerical Simulations (DNS), but also has an insight into the vortex dynamics of the spray in contrast to Reynolds-averaged Navier-Stokes Simulations (RANS). The emphasis of this study is placed on the assessment of the predictive capability of vaporizing spray simulation under a specified high-temperature, high-pressure condition with experimental verifications.

The precise modelling of the spray is divided into three parts, which are the gas phase, vapor-liquid interface and the spray sub-models. Reasonable simplifications such as the quasi-steady state in gas phase, homogeneous distribution of temperature in the liquid phase as well as the vapor liquid equilibrium (VLE) are utilized in the numerical approach. The physicochemical properties of n-Dodecane, which acts as a substitute for the diesel fuel is employed in this model.

Experiments of diesel spray are conducted under the conditions of 3.96Mpa ambient pressure, 900K ambient temperature and 15kg/m^3 density (inertia gas N_2) in the constant-volume pre-combustion vessel (CVPV) equipped with the Z-type high-speed shadowgraph arrangement. Comparisons between experiments and simulations exhibit the feasibility of the model in predicting the temporal histories of both the liquid and vapor-phase spray penetrations.

The results reveal that with the lapse of time, the liquid penetration length elevates drastically attributed to the 120 MPa injection pressure and gradually shows a propensity to a constant value within 0.4 ms time after start-of-injection (ASI). The latter quasi-steady period is dominated by the exchange of momentum with the ambient inertia gas N_2 under the entrainment effect, which leads to the irregular periphery of the spray. In this study, the velocity field as well as the pressure field of the spray are also visualized by the post-processing ParaView. In addition, the effects of both the ambient temperature as well as the ambient pressure on the morphology and flow field of sprays are investigated respectively by means of extensive computational tests. Despite small discrepancies between the estimated and measured transient liquid penetration appear at the initial stage, the simulation of vaporizing spray gives a satisfactory agreement with experiments. The verification and universality of the spray model will be further examined over a wide range of diesel-like operating conditions using the multi-components fuels in the near future.