Modeling of Spray Formation and Combustion

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Abstract

The break-up of the droplets in a fuel spray represents a very important process. Due to different nozzle shapes and injection pressures the break-up of Diesel and gasoline sprays differs. The high injection pressures in Diesel engines and hence high relative velocities between the fuel and the air cause a fast break-up of the liquid. The main break-up process can be described by secondary break-up. The relative velocity in gasoline sprays is much lower and in e.g. hollow cone sprays a liquid sheet is breaking up into droplets (atomization) and the droplets then break-up into smaller droplets (secondary break-up). In order to satisfactorily model the mixing of fuel with air, a good understanding of all the different processes occurring, such as spray break-up and evaporation, is required and these must be captured by the model. The VSB2 spray model, implemented in OpenFOAM®, is based on the idea of constructing a model that treats the spray and its break-up as one process, instead of summing individual, fragmenting droplets to a spray. The design criteria of the model were that it should be unconditionally robust, the number of tuning parameters should be minimal, and it should be possible to implement in any CFD software package. Spray simulations of both full cone Diesel sprays and hollow cone gasoline sprays were performed. Predicted Diesel spray liquid and vapor penetration are compared to experimental data from the Engine Combustion Network (ECN), Sandia National Laboratories. The gasoline spray simulations are compared with data acquired at Chalmers.

The modeling of turbulent combustion offers difficulties, since both the turbulent mixing of vapor fuel with air and the turbulence-chemistry interaction have to be described. There exist different approaches to modeling turbulent combustion. The Volume Reactor Fraction Model (VRFM) is based on the Eddy Dissipation Concept, introduced by Magnussen in 1981. The idea of the Volume Reactor Fraction Model is to define a reactor with a volume smaller than or equal to the computational cell volume. The reactor volume is depending on the state of unmixedness in mixture space and in chemical progress space. With this definition the problem of finding representative timescales of mixing and chemical reactions is removed. The simulated lift-off lengths of n-heptane sprays are compared to experimental data from the ECN.