Large Eddy Simulation of Fuel Sprays using the Eulerian Mesoscopic Approach. Validations in realistic engine conditions

L. Martinez[*,1], A. Vié, S. Jay[1], A. Benkenida[1] and B. Cuenot[2]
[1]IFP, 1&4 av. de Bois-Préau, 92852 Rueil-Malmaison Cedex - FRANCE
[2]CERFACS, 42 av. G. Coriolis, 31057 Toulouse Cedex 1 - FRANCE

Abstract

The main objective of this work is to assess the accuracy of the Large Eddy Simulation (LES) of fuel sprays in realistic engine conditions, using an Eulerian-Eulerian approach. For this purpose, numerical results of spray penetration are compared to experimental results in high pressure cells.

The liquid and the gas phases are solved using conservation equations, and interact through source terms for mass, momentum and energy exchanges. The gas phase, composed of air and fuel vapour, is solved by compressible Navier-Stokes equations, whereas the liquid phase, *i.e.* the fuel injected, is solved using the Mesoscopic Eulerian Formalism (MEF) developed by Février et al. [J. Fluid Mechanics 2005]. Initially developed for dilute sprays, this formalism was then extended to dense sprays by Martinez et al. [ILASS 2007], taking into account collisions between droplets. These developments were introduced in AVBP, a parallel CFD code co-developed by IFP and CERFACS, and specially dedicated to LES.

In order to simulate a Diesel spray, the methodology proposed by Martinez et al. [submitted to FUEL 2008] is used. An injector model is combined to conservation equations to obtain inflow turbulent boundary conditions, called DITurBc, at a given distance downstream from the nozzle exit. This strategy allows to perform LES calculations with reasonable CPU times because it avoids the simulation of complex phenomena, especially cavitation and primary break-up of the liquid core, that occur very close to the nozzle exit.

Diesel spray simulations are performed and compared to experimental data in a high pressure vessel. The gas contained in the vessel is pressurised at 1,5 or 3 MPa with temperatures respectively of 800 and 400 K. Three injection pressures are tested : 40, 80 and 150 MPa. The LES calculations reproduce very accurately the evolution of the liquid fuel penetration for all cases. Comparisons between experimental shadowgraphs and 3D visualizations, show that the spray angle and volume are also well estimated by the LES. Evaporating sprays are then considered and results are again in good agreement with measurements for both liquid and vapour penetrations. Furthermore, it is verified that the numerical results are grid independent, which is a great benefit of the two-fluid model and confirms the quality of the LES.

Key words : Diesel Sprays, Large Eddy Simulation, Eulerian Mesoscopic, Atomization

[*]Corresponding author: lionel.martinez@ifp.fr