Large Eddy Simulation of Diesel like particle-laden flows

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In the automotive industry, computational fluid dynamics (CFD) tools are very useful in order to reduce experimental measurements and help understand many thermodynamic processes that take place inside internal combustion engines. These CFD codes solve the Navier-Stokes equations together with the energy equation using three different approaches to model the turbulence: Reynolds-Averaged Navier-Stokes (RANS), Large Eddy Simulation (LES), and Direct Numerical Simulation (DNS). Regarding Diesel spray injection, the most commonly used codes in the automotive industry, until very recently, are based on the RANS approach. These computational methods are very useful to study the averaged flow, but they do not provide any information neither about the turbulent fluctuations nor about the flow on the jet boundary. Nevertheless, they provide reasonably accurate results and have relatively lower computational cost.

On the contrary, direct numerical simulation (DNS) methods solve all the significative scales of the flow, and no modelling is required. Therefore, the DNS provides the highest level of description of the flow, but the computational resources required for most practical cases are above current computer hardware limitations (and will be in the next 20 years).

LES is a compromise between DNS and RANS. LES methods model only the smallest-scale fluid motions and directly represent the large-scale ones. While the use of LES increases the computational cost, LES has been a predictive tool able to consistently simulate the complex structures related with turbulent mixing, which is decisive in the injection and combustion processes and invisible for RANS solvers.

It is the aim of this paper the evaluation of numerical (LES) approach to simulate Diesel sprays by means of the open source CFD code OpenFoam. Previous works performed by these authors showed the potential of LES methodology for Diesel spray simulations, also with Euler-Euler approximations. However, since fuel-air mixing process is significantly influenced by fuel atomization, breakup and collision, the idea to approximate the spray evolution using gas injection cannot be completely valid for LES due to its degree of physical description. Therefore, Lagrangian-Eulerian particle-laden flow simulations have been carried out in order to accurately predict the mixing and entrainment processes that take place in a real Diesel spray. A parametric and sensibility study of the most significant parameters of the LES approximation has been also presented.

The modelling results are compared with the classical numerical RANS method with both Eulerian-Eulerian and Lagrangian-Eulerian approaches and are simultaneously validated with experimental data.