LES of atomization: From the resolved liquid surface to the subgrid scale spray

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Abstract

Liquid injection takes an important part in many physical processes. For instance, in internal combustion engines (ICE) new direct injection strategies are used to control the flow inside the combustion chamber. It follows that injector manufacturers propose more and more performing injection systems. Parameters and geometries become numerous then to characterize. In order to evaluate and use these new generation of injectors, accurate numerical tools are expected. Up to know the RANS (Reynolds Averaged Navier-Stokes) approach has been widely used, both in Eulerian and Lagrangian frameworks. Several works[1, 2] have been developed in our team to represent, in a realistic manner, the dense part of the spray in order to capture the details of the flow at the exit of the injector. One of the advantages is the possibility to couple directly a simulation of the flow inside the injector to get the final spray. However, in one hand computations of injection process are often non stationary RANS while in the other hand LES simulations in single phase flows are known to be more accurate than RANS. Then naturally LES of atomization seems to be a necessarily step forward.

Characteristics of LES are there ability to treat realistic situations beyond those than can be computed directly with DNS (Direct Numerical Simulation). Inversely when the available mesh is fine enough, it is expected that LES tends to DNS results. Atomization or more generally liquid-gas flows are characterized by a special treatment of the interface where jumps of variable such density can occur. And this is also where the surface tension forces take place. In addition of the special care on the transport equations when dealing with LES formalism, a special attention is necessarily to represent the interface. Two limit cases may happen:

- The liquid surface can be well captured with the available mesh size (or filter size) and the LES formulation must recover the DNS methods used to track the interface (Level Set, VOF…)
- The liquid surface wrinkles are below the mesh size and the two-phase LES formulation must recover the LES used for spray flows where finally droplets are considered very small by comparison to the mesh size.

Previous LES simulations of atomization are only able to represent the first limit [3]. In this work we present a possible LES method for two phase flow that can reach dynamically these two limits. It is shown that the unresolved SGS (Sub Gris Scale) term that appears in the phase function equation plays an important role. Even if it is very small by comparison to the resolved contribution [4]. Application of this method to the atomization of a Diesel jet is presented. LES results are then compare to a DNS data base which has been obtained on the same configuration [2, 5].

Keywords: Large Eddy Simulation, atomization, turbulent liquid jet

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