PhD Thesis Position
Rouen, Normandy, France.

Development of a joint meshless / Eulerian approach to model spray atomization

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Context :

Injection and atomization of liquid is widely used in many industrial and domestic applications such as, fuel injection in engines or burners, spray-painting, medical sprays, spray drying among others.
Various approaches exist to simulate two-phase flows. Usually, interface tracking methods (ITM) are used to simulate the primary atomization while a discrete method such as the Lagrangian particle-tracking approach may be used to model the final spray. Despite progresses in numerical methods and computer performances, complete simulation of atomization and spray remains inaccessible for many applications.

Modeling main difficulties arise from the disparity of length and time scales present in a turbulent two-phase flow in the presence of an interface and very large injection rates. If we want to capture all these phenomena, we must use an exceptionally fine mesh to capture all the gradients and smaller drops while maintaining a large enough computational domain to resolve the most energetic scales of the order of the inlet diameter of the injector. It is the objective of the direct numerical simulation or DNS that proposes to capture all the scales of the flow thanks to an Eulerian description. However, the prohibitive cost of DNS excludes simulations extending beyond a few tens of diameters of the injector. Large Eddy Simulations allows extending this limit but not far enough since the mesh extension is limited by the high injection rate.

Objectives :

The objective of the PhD is to couple a meshless method (Smoothed Particle Hydrodynamics - SPH) and a usual Eulerian description. The SPH-Euler hybrid method will capture the physical properties of the spray near the injection area without mesh limitation and then, switch to a conventional Eulerian method (finite volumes description) - further into the chamber. This innovative approach in the area of the injection will greatly reduce the computational cost that prevents high fidelity simulation in the field of liquid fuel atomization. This work involves a close collaboration with a post-doctoral fellow that will work specifically on the SPH methods optimization. The OpenFoam library for CFD will be used and the candidate will develop a specific solver.
The flow in and out of the injector will be modeled by SPH, freeing the simulation of the stress of the fine and costly mesh. The coupling of SPH with the finite volumes Eulerian description will be developed to integrate the atomization model ELSA (Eulerian / Lagrangian dispersed phase coupling). This work will also open the door to many other configurations in the field of hydrodynamics.

Further reading from the team :

- B. Duret, J. Reveillon, T. Menard, and F.X. Demoulin, 'Improving primary atomization modeling through DNS of two-phase flows', 2013, International Journal of Multiphase Flow, Volume 55.
- B. Duret, G. Luret, J. Reveillon, T. Menard, A. Berlemont and F.X. Demoulin, 'DNS Analysis of

turbulent mixing in two-phase flows', 2012, International Journal of Multiphase Flow, Volume 40.

- Chesnel J., Reveillon J., Menard T., Demoulin F.X., 'Large Eddy simulation of liquid jet atomization', 2011, Atomization and spray, Volume 21 / Issue 9.
- Chesnel J., Reveillon J., Menard T., Demoulin F.X., 'Subgrid analysis of liquid jet atomization', 2011, Atomization and spray, Volume 21, Number 1, Pages 41-67.

Profile :

- Applied Mathematics or Fluids Mechanics Master 2nd year or Engineering school.
- Emphasis in Computer science (C++, Fortran, programming, linux..).
- Scientific attitude
- High motivation for computational simulation and research.
- Some experience in OpenFoam would be an advantage but is not mandatory…programming skills and experiences are mandatory.