

Numerical simulation of optical diagnostics and comparisons to experiments

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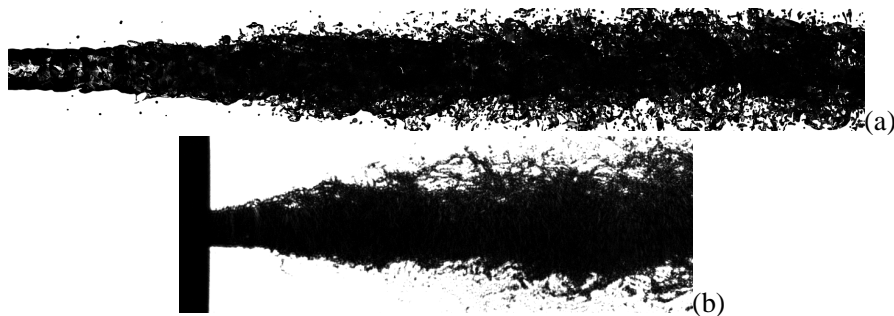
Liquid jet atomization is the key problem of efficiency improvement of liquid fuel combustion engines. Indeed, it governs the granulometry of the fuel droplets which generate the fuel/air gas mixing by evaporation. The near field of the injector nozzle is of primary importance : hydrodynamic instabilities occur in this region, and they play an important role in the development and break up of the liquid jet into liquid elements like ligaments and droplets. Experimental investigations in this zone are particularly difficult due to the very short elapsed time of the phenomenon (injection time is about 1 ms for a high pressure Diesel injector) and of the high liquid density (limitations of classical optical diagnostics).

Nevertheless, direct numerical simulations (DNS) of a high pressure liquid jet have been carried out [1, 2], by using a coupled LS/VOF/GF (Level Set/Volume of Fluid/Ghost Fluid) method with realistic physical parameters (pressure, velocity, surface tension, viscosity, liquid and gas density). On the other hand, high resolution experimental images of the liquid jet have been obtained, by using femtosecond laser beam. The present study tries to open the way of a direct comparison between DNS and experimental images.

Basic comparisons of experimental images and numerical simulations are presented, for a commercial Diesel injector [3] : the liquid is a Diesel substitute; the injection pressure is 400 bars; the nozzle has one hole, and its diameter is 200 μm . The images are obtained by a femtosecond laser beam illumination. The field may vary with the optical magnification and is about a few millimeters. The image resolution is about 8 μm . Several geometrical parameters of the experimental jet and the numerical simulations are compared: the penetration length of the jet versus time, the spray angle, the mushroom shape of the liquid in first injection times, the topology of the interface, etc...

Moreover different optical diagnostics can be simulated by using the results of DNS. A light propagation model is used to obtain simulated optical signals: it consists in a ray tracing program, using the basic laws of geometrical optics. Examples of such simulation will be presented and compared to experimental measurements.

They open the way of an improved analysis of optical signals that are obtained by interaction of a light beam with a liquid jet.



(a) Simulated image of a numerical spray using geometrical optics,
(b) Example of an experimental image.

References

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