FPIV study of density effect on air entrainment in gasoline dense sprays

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Due to necessary reduction of pollutants emission, automotive manufacturers have to product more efficient and cleaner engines. The injection conditions such as injection timing, injection pressure, aerodynamics, piston design and spray characteristics have to be optimized to control mixture formation and thereby combustion parameters leading to improve fuel saving for engines.

The aim of this experimental work is to study the air entrainment process induced by gasoline direct injection dense sprays and to estimate its impact on air / fuel mixture formation.

A new application of Particle Image Velocimetry (PIV) is developed in order to measure the air entrainment of dense two-phase flows. This method consists in replacing "classic PIV tracers with fluorescent ones. The dense two-phase flow well adapted technique relies on Fluorescent PIV one and permits to study gaseous phase in the close vicinity of the spray edge. Due to the simultaneous attendance of both tracers and droplets in PIV images, classical treatment methods turned out to be unsatisfying. This is the reason why a new algorithm of post-treatment has been developed. This method based on various tests combination permits to eradicate most of wrong persistent vectors inside and outside of the spray (figure 1) and validate the use of ensemble averaged method.

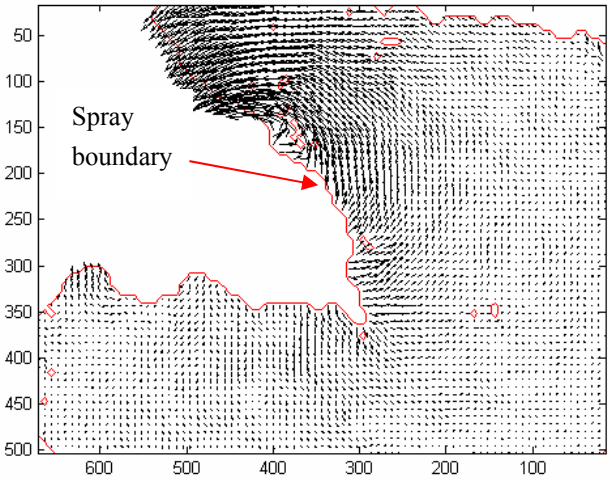

Fig. 1 Two-phase flow filtered instantaneous velocity flow field.

Measurements have been carried out in the vicinity of the spray edge and used to compute the axial evolution of the cumulative air entrained mass flow rate $\dot{m}_e$. Density effect has been studied and $\dot{m}_e$ is found to increase about 1200 % without saturation in the investigated range (ρ varying between 1.2 kg/m^3 and 18 kg/m^3). Good agreement is found with a one dimensional model that assumes a 3/2 and a 5/6 power law dependence of axial distance Z and density ρ, respectively, in the near field whereas a linear and a 1/2 power law of Z and ρ in the far field (like in variable density jet). The transition between the two regions depends on ambient density and appears more rapidly as ρ increase. Analyses of this result have been preformed in term of drop relaxation time (or length) and give interesting clue for the use of the model as a predictive one.

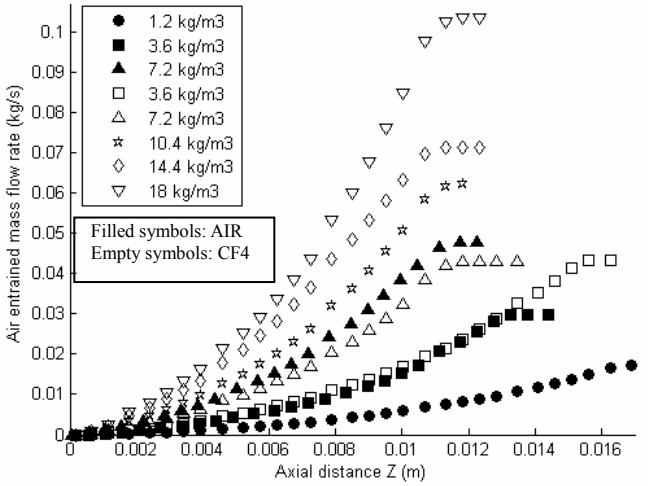

Fig . 2 Cumulative air entrainment mass flow rate at various ambient density.

As a conclusion, further work are still in progress concerning single injection and aim at providing data on air entrainment mechanism as well as vortex formation as a function of lift effect, injection pressure.

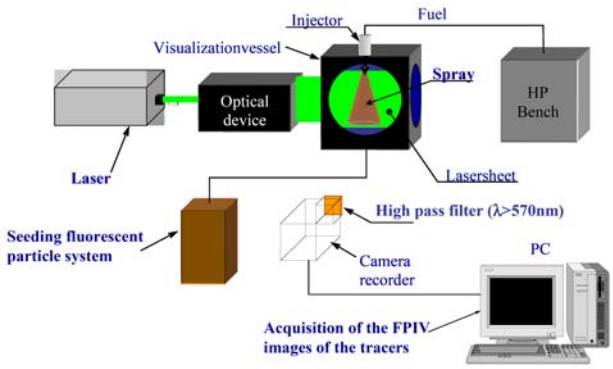

Fig. 3 Experimental set-up for FPIV