

PIV Measurements in Diesel Sprays

SubTask: 1.2C

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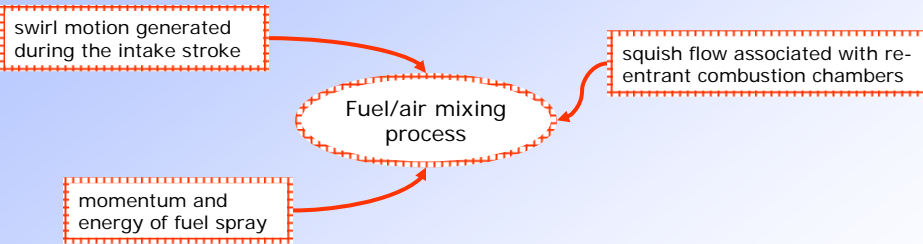
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The fuel-air mixing is the key process in the
engine combustion

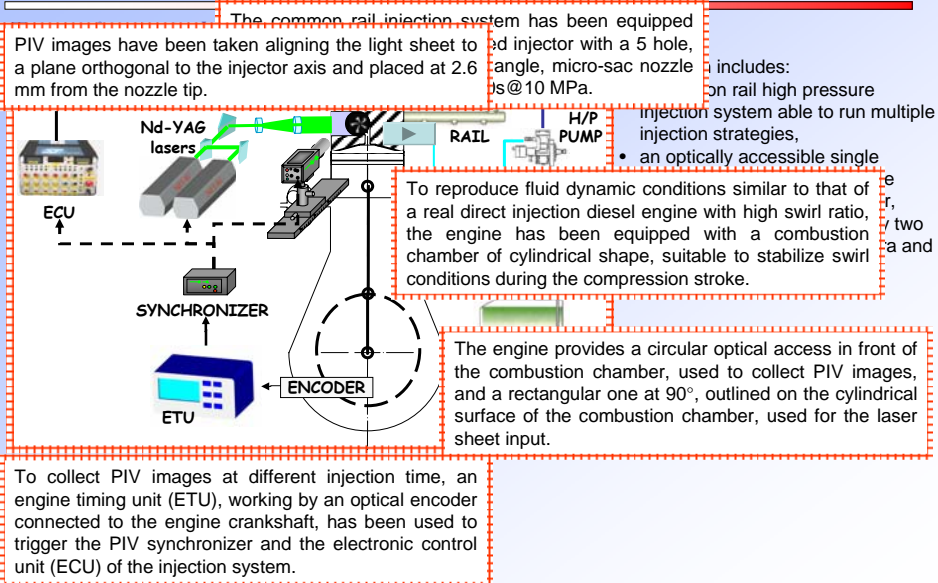


Description and targets of the problem

In light-duty engines the interaction of the fuel jet with the swirl flow may prevent the impact of liquid fuel on the combustion chamber wall with a reduction in smoke and HC emissions.

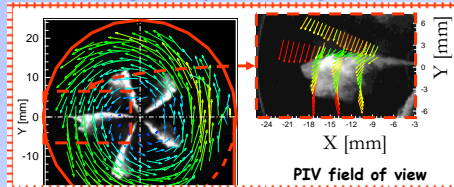


The aim of this work is to investigate the diesel air/fuel mixing process by PIV



Test conditions

The investigations have been focused on the influence of the swirl intensity on the fuel spray evolution and liquid fuel droplets velocity distribution. Tests have been carried out for a multiple injection strategy typical of low load running conditions of a current light duty diesel engine.

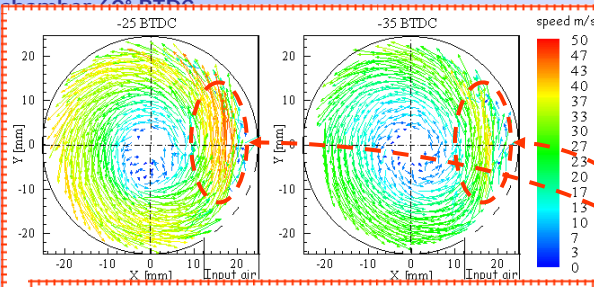


INJECTION STRATEGY							THERMO FLUID DYNAMIC CONDITIONS				
	Pilot	Pre	Main	dw_1 [μ s]	dw_2 [μ s]	Injection Pressure [MPa]		Air density [kg/m^3]	Air temperature [K]	Ω [rad/s]	
Low Load	Solenoid exciting time [μ s]	375	375	480	200	240	28.0	SOI 25° BTDC	8.6	620	1914
	Fuel injected [mg/str]	0.66	1.15	1.5				SOI 35° BTDC	5.6	531	1387

Figure 1: PIV field of view and operating conditions.

Results

The first step of the investigation has been the characterization of the flow field evolving inside the combustion chamber without fuel injection. PIV measurements have been taken using as tracer diesel droplets sprayed inside the combustion chamber (25° BTDC).



The velocity vector distribution has been estimated applying an ensemble averaging procedure over 30 instantaneous velocity

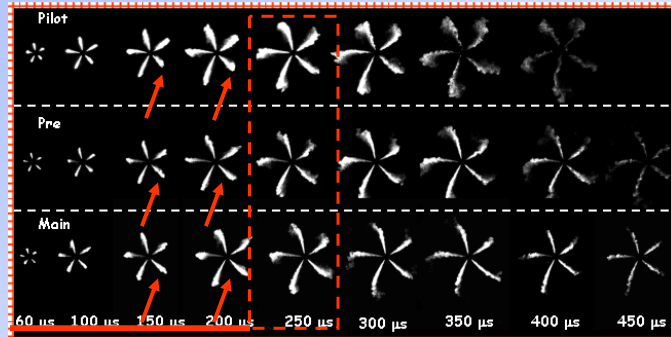
ve. The vector field depicts a counter-clockwise rotation, indicating a high kinetic energy field having a high

Moving away from the outlet zone, the velocity lightly decreases showing a relative maximum, at the combustion chamber periphery, of about 45 m/s and 35 m/s at 25° and 35° BTDC, respectively

close to the tangential duct, of about 50 and 40 m/s at the crank angle positions of 25° and 35° BTDC, respectively

Results

Image sequence of pilot, pre and main injection strategy relative to the SOI of 20° BTDC.



At early injection time, all jets proceed undisturbed along the nozzle holes axis due to the initial high momentum of the fuel droplets that travel into the low angular momentum region of the combustion chamber.

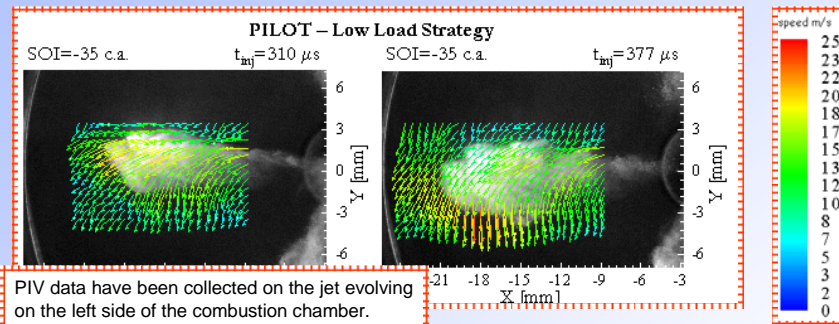
The fuel jet at the bottom right, of each frame, depicts the smallest elongation because of the higher drag effect of the air flow coming from the inlet tangential duct.

At 250 μs from the SOI, for each injection, the fuel spray begins to be distorted by the air motion because of the momentum exchange between the fuel radial momentum, and the air flow have momentum.

Later, cluster of fuel droplets are detached from the main jets and dragged into rotation by the swirl flow. This behavior is less evident on the main injection spray because of the enhanced evaporation conditions.

Results

Fuel droplets mean velocity distribution on the pilot injection at different injection time for a SOI 35° BTDC.



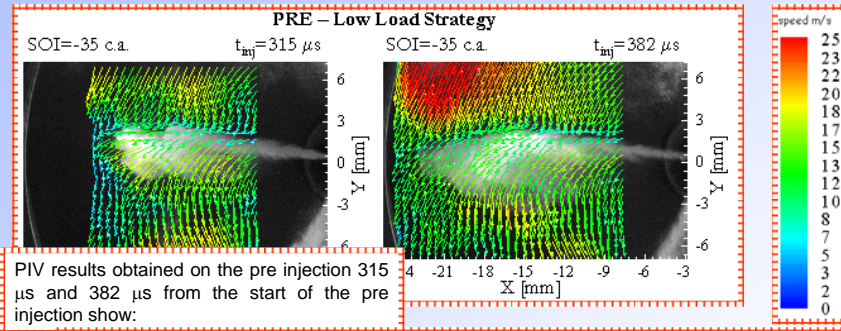
PIV data have been collected on the jet evolving on the left side of the combustion chamber.

Velocity distribution, estimated at 310 μs from the SOI for the pilot injection shows a fuel jet deflected from the path alongside the nozzle hole axis to follow a curve trajectory because of the high angular momentum transferred to the fuel droplets from the air flow.

At 377 μs from the SOI, the velocity distribution depicts a fuel droplets flow field that tend to assume a motion tangential to the combustion chamber wall with maximum velocity values of about 20 m/s located on the low edge of the jet.

Results

Fuel droplets mean velocity distribution on the **pre injection** at different injection time for a **SOI 35° BTDC**.



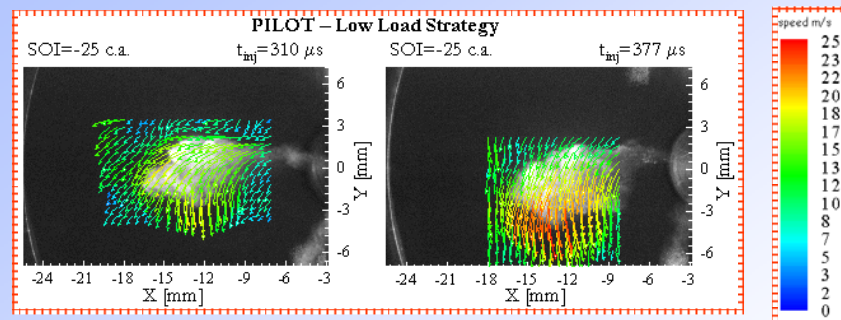
Valid PIV data have been collected on a larger region with respect to that set to calculate the velocity distribution during the pilot injection.

The velocity distribution confined within the fuel jet highlights a motion field related to clusters of fuel droplets that, exchanging momentum with the air flow, travel tilted with respect to the radial direction.

Vectors located around the spray depict a rotational flow field at high intensity connected to the fuel droplets that, delivered during the pilot injection, are still not evaporated and are dragged in rotation by the swirl flow.

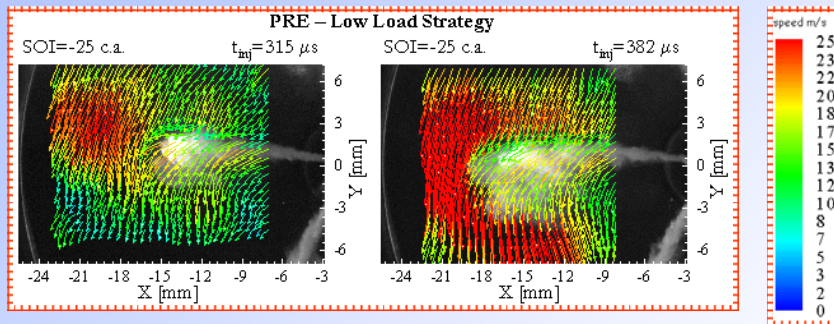
Results

Fuel droplets mean velocity distribution on the **pilot injection** at different injection time for a **SOI 25° BTDC**.



Results

Fuel droplets mean velocity distribution on the **pre injection** at different injection time for a **SOI 25° BTDC**.



PIV data collected at 315 and 382 μs after the start of the pre injection confirm the behavior of the spray showing a lower radial penetration of the fuel jet and a higher fuel droplets dispersion in a wide region of the combustion chamber.

The flow field located around the spray depicts a well structured rotational flow field with maximum velocity values of 35 m/s close to chamber periphery.

Summary and Conclusions

- ▶ In the first stage of injection, all fuel jets proceed undisturbed along the nozzle holes axis due to the initial high momentum of the fuel droplets that travel into the low angular momentum region of the combustion chamber.
- ▶ Then, the fuel spray reaches the periphery of the combustion chamber and begins to be distorted by the air motion because of the momentum exchange between the fuel droplets, source of radial momentum, and the air flow having, on the contrary, a high angular momentum.
- ▶ PIV data collected during the second step of the air/fuel mixture formation process have shown a strong distortion of the jet velocity vectors.
- ▶ Finally, it has been highlighted that a higher swirl ratio reduces significantly the radial dispersion of the fuel droplets. As a result, more fuel is confined within the central region of the combustion chamber with an increase of area with richer concentration of fuel droplets and more droplet dispersions in the periphery that leads to a more dilute spray with an effect on the flow liquid aerodynamics interaction.

High Swirl Engine Head

