Influence of Signal Properties on ElectroHydroDynamic Primary Break-up of Thin Sheets of Dielectric Liquid

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Abstract

In industrial air blast atomizers, the fuel is injected at low pressure through an annular slot. This produces a tubular sheet of fuel which is disintegrated into droplets by two coflowing airstreams. Unfortunately, a high air velocity is needed in order to obtain a fine atomization. This is the main drawback of air blast atomizer. With an air velocity below $30 m.s^{-1}$ the atomization is too weak for fuel ignition. This problem could be encountered in relight ignition at high altitude, where the pressure and the temperature are very low. When the air velocity is below 10m/s the sheet of fuel is not sprayed anymore.

This paper is an experimental study of the primary break-up induced by an ElectroHydroDynamic actuator. Experiments have been performed on thin sheet of commercial diesel oil without active surface agent. The flow rate and the liquid sheet thickness are similar to the ones used in turbo engines. In the present work, the sheet of fuel is directly destabilized and disintegrated by an electrohydrodynamic actuator. Atomization is only due to electrical forces and the air velocity is equal to zero. As there is no coflowing airstreams and as the fuel is injected at low pressure, the liquid sheet is stable when the EHD actuator is turned off. Investigations on the primary break-up characteristics have been made with a high speed camera on the break-up length and on the spray cone angle, for various signal frequencies and amplitudes. The liquid velocity ranges from 0.6 to 2 $m.s^{-1}$

In industrial atomizers, the fuel is injected through an annular slit. Such device produces a thin turbular sheet of fuel. This shape is very efficient for atomization but difficult to investigate. More than a decade of studies in atomization process has proved that mechanism of disintegration are similar on cylindrical and planar thin sheet of liquid. Fig.1 shows a schematic diagram of the experimental setup. The fuel is pumped from a tank to the injector. The flow rate is controlled by the pump. Inside the injector a surge chamber smoothes out the turbulence of the fuel. Then the liquid is pushed through the planar slit.

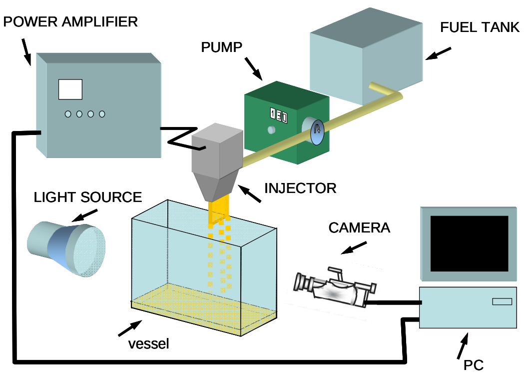
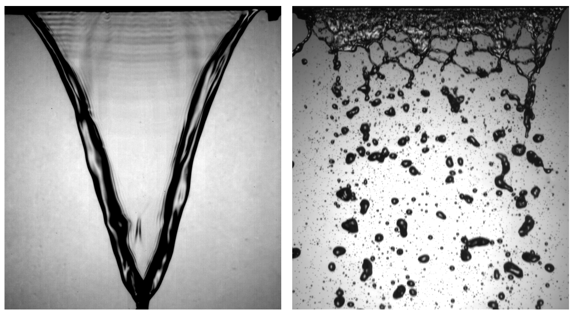


Figure 1: device



a) 0Hz b) 1kHz

Figure 2: front view of a sheet of diesel oil without electrical excitation (a) and with an AC signal frequencies (b)

The sheet is stable, when the EHD actuator is off (Photo a). When an AC signal is applied to the actuator, the sheet of fuel is shacked by electric forces. Four disintegrating modes depending on liquid velocity and on signal amplitude are analysed and described. In the flapping mode, the sheet waves as a function of both the liquid velocity and the signal frequency. The sheet wave amplitude can reach more than a 1cm. At relatively high liquid velocity, the sheet is greatly affected by charge injection. High frequency disturbances in the sheet become more predominant until perpendicular ligaments and then holes appear, giving rise to a perforated sheet. In the disintegrating mode, the sheet is fully atomized. The higher the frequency is, the more numerous the droplets, and the smaller the droplets size. A comparison between air blast and EHD atomization is made in order to underline similarities and differences of the two processes. It is demonstrated that the primary atomisation obtained with a 2kHz signal frequency is equivalent to the one observed with a $25 m.s^{-1}$ coflowing air stream, which is an important advance in EHD technology.