Theoretical and experimental study of aviation fuel sprays in an optical reciprocating engine, under Unmanned Aerial Vehicle like conditions and controlled atmospheres

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This work is focused on improving the knowledge of physical and morphological characteristics of aviation fuel injection sprays with application in unmanned aerial vehicles (UAV). This work is carried out by means of the combination of complex and singular experimental techniques such as an optical engine and Schlieren technique with modelling tools [1][b].

The work done is divided into two parts: 1) Experimental and modelling of fuel rates of injection with different jet fuels, fossil and renewable hydrogenated and 2) Experimental study of fuel sprays visualization with an optical reciprocating reproducing unmanned aerial vehicle like conditions, under both inert and reactive atmospheres at different simulated altitudes (between 0 and 3000 m above the sea mean level). The research group have a non-negligible background about the characterization of injection process with different alternative fuels (biodiesel, paraffinic hydrocarbons, alcohols, etc.) [2, 3]

The work is carried out by means of the jet fuel sprays experimental characterization and its modelling, using different techniques, among others, an optical reciprocating internal combustion engine. Related to characterization of fuel injection system, first results show the effect of different fuels on the rate of injection and the spray momentum flux.

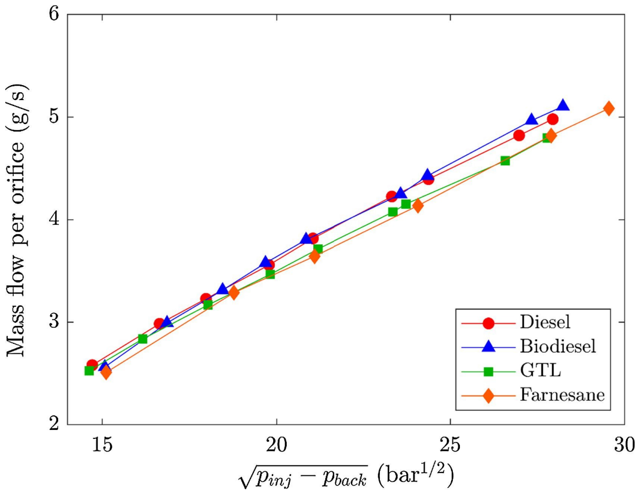

Figure 1: Mass flow rate per orifice under stabilized conditions, for all the fuels, obtained from momentum flux test rig.

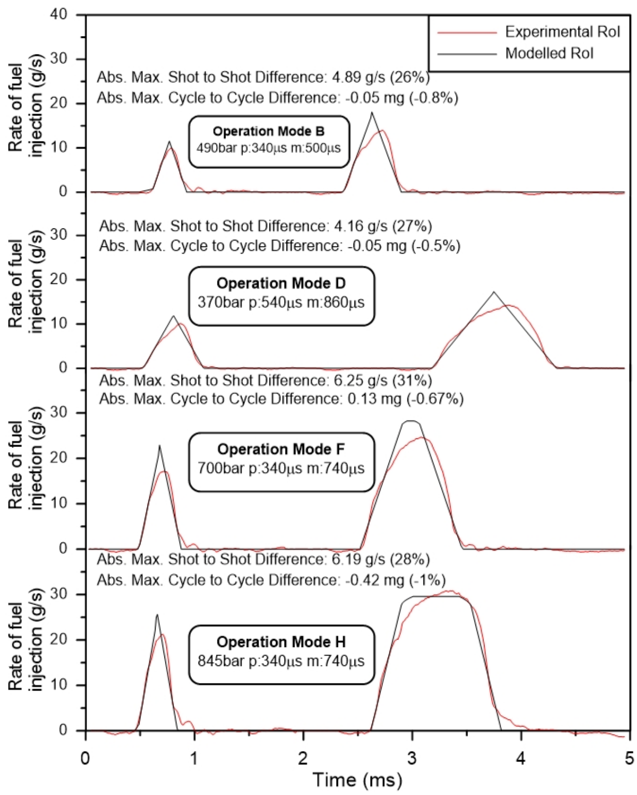

Figure 2: Fuel rates of injection experimental and modelled under different operating engines modes.

Results

As Figure 1 shows [4], evaluated methods (experimental and calculation) provide a valid rate of injection despite being a theoretical approach and relying only on momentum flux experiments and the total injected mass.

Regarding modelling the rate of injection with zero dimensional models, Figure 2 shows results obtained by means of the fuel injection rate indicator and zero-dimensional modelling [5] under different engine operating conditions.

Zero-dimensional model proposed in this part of the

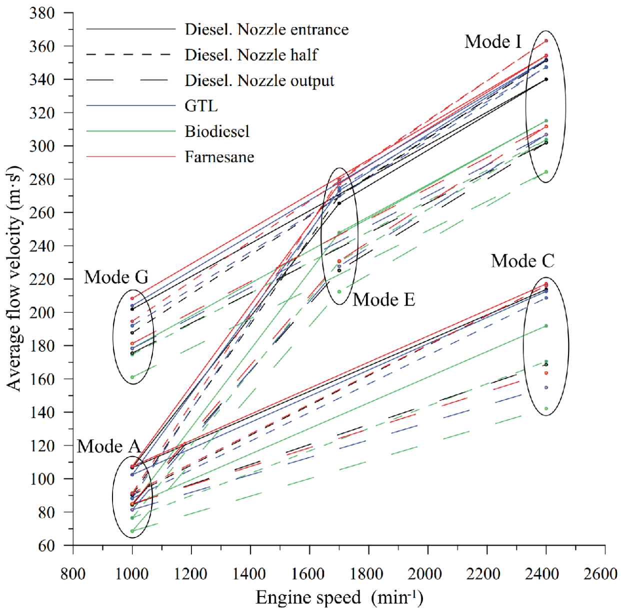

Figure 3: Fuel flow mean velocity from the five tested operating modes at the inlet, middle and outlet sections of the nozzle orifice with four fuels tested vs. engine speed.

study has demonstrated to be very useful for predictive and experimental thermodynamic models for calculation of the heat release along the combustion process within the engine cylinder.

Results of computational fluid dynamic modeling (Figure 3) show the effect of fuel origin on the internal flow along the nozzle orifice of the injector [6].

At medium engine load the effect of the needle lift on the cavitation generation is more significant than the fluid circulation velocity and fuel origin impacts as follows: Biodiesel > GTL > Farnesane > Diesel; while, at medium or high engine speed, an increase of engine load causes a decrease of cavitation generation and fuel origin impacts as follows: Diesel > Farnesane > GTL > Biodiesel.

Currently the work is going on with the experiments in the optical engine.

Conclusions

Main conclusions of this part of the work are the following: The tests of fuel rate of injection allow a good estimation of the spray momentum flux. The proposed zero-dimensional model for calculating the rate of fuel injection is simple but at the same time has precision enough to be used during thermodynamic diagnosis. Fuel origin has a non-negligible effect on the internal flow fluid-dynamic within the injector nozzle.

Notes

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b. The following researchers also participate in this work: MSc. Lis Corral-Gómez, Dr. José A. Soriano, Dr. Arantzazu Gómez and Dr. Luis Sánchez-Rodríguez from UCLM and researchers from University of Málaga.

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