EXPERIMENTAL INVESTIGATION OF A DUAL PRESSURE SWIRL INJECTOR FOR LIQUID BIOFUELS

Roger Apaza Vásquez
roger@lcp.inpe.br
Fernando de Souza Costa
fernando@lcp.inpe.br

Instituto Nacional de Pesquisas Espaciais, Laboratório Associado de Combustão e Propulsão
Rodovia Presidente Dutra, km 40, Cachoeira Paulista, SP, 12630-000, Brasil

This work presents results of an experimental investigation of a dual pressure swirl injector for atomization of biofuels. An injector prototype was built for comparative testing with distillate water, hydrated ethanol and B100 soy biodiesel. The atomization characteristics of the injector were obtained in a test bench specially developed for this research. The discharge coefficients, the average droplet diameters, the distribution of droplet sizes, the spray cone angles, the spray mass distributions, and the effects of operating pressures and mass flow rates of biofuels on the performance of the injector were determined using different experimental techniques.

Introduction

The continuous rise in oil prices and the growth in environmental concerns have raised the interest for the use of biofuels, especially ethanol and biodiesel. Pure biofuels and blends of them with gasoline and diesel have been used primarily in internal combustion engines for vehicles. On the other hand, environmental legislation has become more stringent, establishing limits for pollutant emissions in engines, turbines, furnaces, boilers and industrial combustion processes. Therefore, it is of interest to the country and companies to investigate the use of biofuels in industrial applications, aiming to reduce costs, increase efficiency of operations and reduce the emission of pollutants.

The transformation of liquids into *sprays* has various applications from industry to medicine. Many devices for atomization of liquids have been developed, named atomizers, nebulizers, injectors or nozzles. Combustion of liquid fuels in diesel engines, spark-ignition engines, turbines, rocket chambers, industrial burners and other equipments depend on the efficient atomization to increase the surface area of the fuel in order to attain high mixture and evaporation rates. In most combustion systems, the reduction of the average droplet diameter increases the heat release rates, facilitates ignition, provides larger burning range and reduces the pollutant emissions.

Biofuels are a renewable energy source and can be used directly in combustion chambers or mixed to fossil fuels. A main advantage of using biofuels is the reduction of pollutant emissions, due to the absortion of the atmospheric CO2 through the photosyntesis of the plants used for biofuel production.

Injector prototype

Figure 1 shows a computer view and a photo of the dual pressure swirl injector designed and built to atomize biofuels. Figure 2 shows a picture of a test of the injector with a laser beam crossing the spray for measuring droplet size distribution.

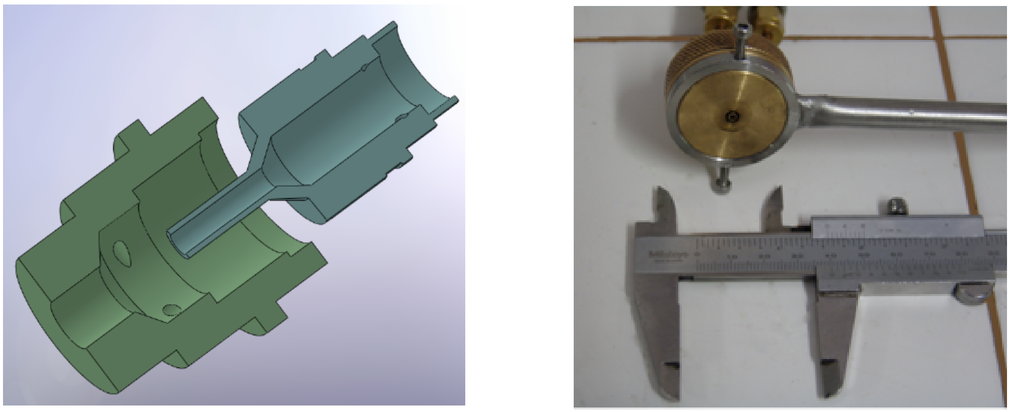


Figure 1 – Computer view and photo of the dual pressure swirl injector for biofuels.

Figure 2. View of the injector with the laser beam emitted from a laser difraction system (Spraytec).

Results

Figures 3 and 4 show discharge coefficients of the injector with destilate water, hydrated ethanol and soy biodiesel B100 in the primary and secondary chambers, respectively. Figure 5 shows average droplet diameters (SMD) for the injection of ethanol in the primary chamber and biodiesel in the secondary chamber, with the same injection pressure in both chambers.

Figure 6 shows frequency curves and average volume droplet diameters for the mixture of hydrated ethanol and soy biodiesel with different injection pressures.

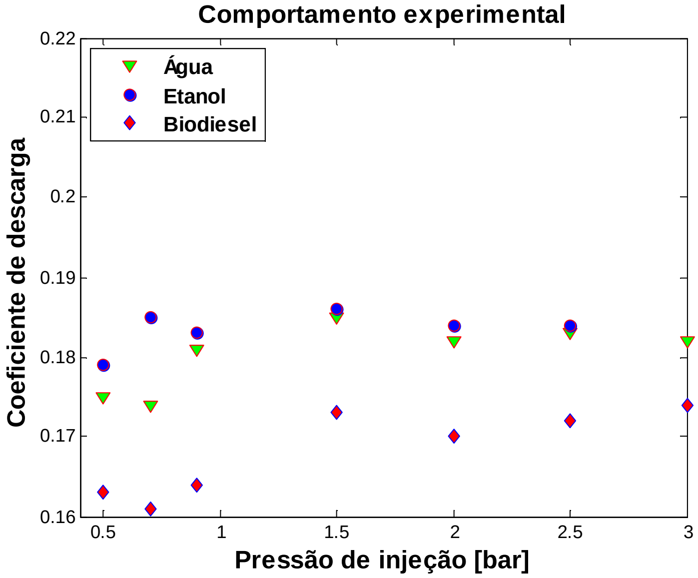


Figure 3 – Comparison of discharge coefficients of destilate water, hydrated ethanol and soy biodiesel B100 versus injection pressure in the primary chamber.

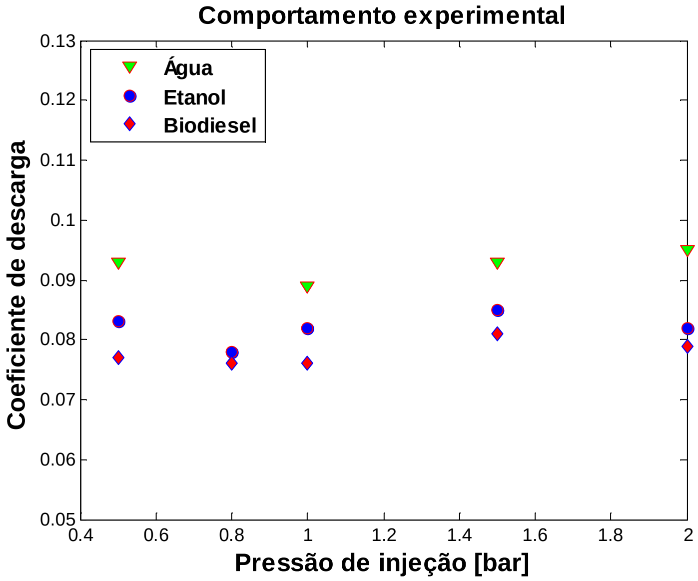


Figure 4 – Experimental discharge coefficients of destilate water, hydrated ethanol and soy biodiesel B100 versus injection pressure in the secondary chamber.

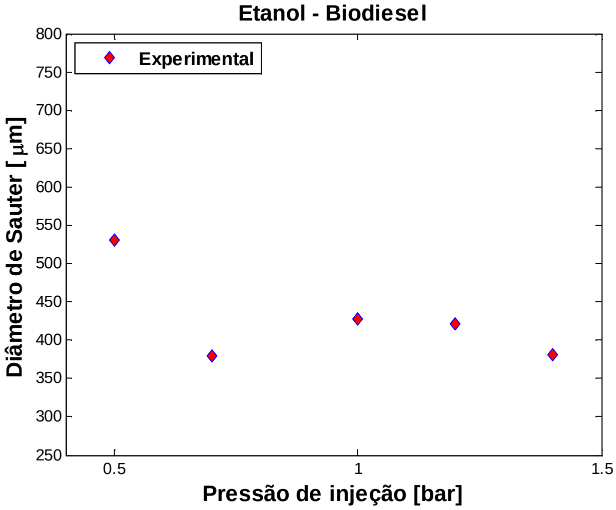
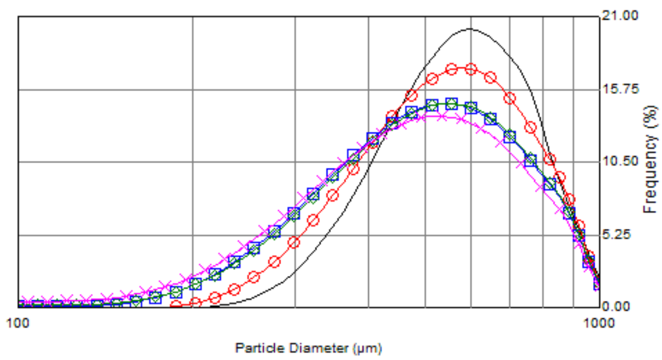


Figure 5 - SMD of the mixture of hydrated ethanol and B100 soy biodiesel at different pressures applied to the dual pressure swirl injector.



	File	Dx(10)	Dx(50)	Dx(90)	Transmission
[V]	Biodiesel - etanol 05bar	380.54	573.25	802.64	87.88
[V]	Biodiesel - etanol 07bar	336.95	543.10	804.57	88.36
[V]	Biodiesel - etanol 1bar	278.66	497.56	786.66	86.88
[V]	Biodiesel - etanol 1.2bar	276.56	500.25	789.14	79.29
[V]	Biodiesel - etanol 1.4bar	245.60	474.64	771.81	78.70

[V]=Volume [N]=Number

Figure 6 - Frequency curves and average volume droplet diameters for the mixture of hydrated ethanol and soy biodiesel with different injection pressures.

Conclusions

The characteristics of sprays of biofuels injected through a dual pressure swirl injector were described. Mass distributions, discharge coefficients, mass flow rates, Sauter and volume average droplet diameters, cumulative distributions and curves of diameter frequencies were obtained for injection of hydrated ethanol and B100 soy biodiesel at different injection pressures.

Acknowledgments

The authors acknowledge CAPES agency from Brazil for providing a scholarship to the first author through the Pró-Engenharia program.

Author publications

Vasquez, R.A., Maia, F.F., Costa, F.S., **Droplet Size Distributions of Biofuel Sprays**, 21st Brazilian Congress of Mechanical Engineering, October 24-28, Natal, RN, Brazil, 2011.
Azevedo, C.G., Couto, H.S., Costa, F.S., **Characterization of a Blurry Injector for Biofuels**, 21st Brazilian Congress of Mechanical Engineering, October 24-28, Natal, RN, Brazil, 2011.
Costa, F.S.; Vieira, R., **Preliminary Analysis of Hybrid Propulsion Systems for Launching Nanosats**, Journal of the Brazilian Society of Mechanical Sciences and Engineering, v.32, n.4, p.1-9, 2010.