Effervescent Spray Characterization of Jatropha Pure Plant Oil

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Abstract

Spray structure of Jatropha curcas vegetable oil from an effervescent atomizer has been studied at different gas-to-liquid ratios (GLR) using nitrogen as atomizing gas. Shadowgraphy technique has been used to study the spray structure. Results at low injection pressures indicate that significant improvement in atomization occurs with increase in GLR. This study, which is first of its kind concerning effervescent atomization of Jatropha oil, also includes detailed droplet size distributions obtained using the Interferometric Laser Imaging for Drop-Sizing (ILIDS) technique.

Introduction

Due to depleting fossil fuel reserves and the impact of emissions on the environment, the use of biofuels such as plant/vegetable oils has been increasing in recent times. Since the physical properties of these fuels are different from those of conventional fuels, existing injection systems may not be effective and efficient. Specifically, with respect to pure plant oils (PPOs), the higher viscosity and surface tension compared to those of conventional fuels, lead to poor atomization.

Effervescent atomization is one of the alternatives, and has been found to be an efficient way of atomization for high viscosity liquids [1]. It is a twin-fluid atomization technique in which a small amount of gas is injected into the liquid before the exit orifice to form a bubbly mixture of gas and liquid. On emerging from the nozzle, due to the pressure difference, gas bubbles rapidly expand and shatter the liquid into fine droplets. Hence, this method offers the advantage of smaller drop sizes at low injection pressures [2]. Due to these advantages, it has a potential application in gas turbines and internal combustion engines [3]. This is the first study to the best of our knowledge, wherein detailed characterisation of an effervescent spray of Jatropha oil is reported.

Materials and Methods

A schematic of the experimental setup utilised in the current study is shown in Fig. 1a. The liquid and the atomizing gas are supplied to the injector through two different lines. High pressure nitrogen gas from a gas bottle is metered using a pressure regulator and flow control valve. The volume of gas is measured using a thermal mass flow controller. The liquid fuel is pressurised in a chamber by high pressure gas. A pressure regulator in the liquid line is utilized to set the injection pressure. The quantity of liquid fuel injected is measured using a gear flow meter. The temperature and pressure upstream of the atomizer are measured in both the lines. The effervescent atomizer used in this study is of 'outside-in' type [3] in which the liquid flows through a centrally located tube and the gas is injected into the liquid through micron-sized holes in the tube. The atomizer used in the present study is similar to that used by Sher et al. [4]. In the present configuration, the central tube which acts as a mixing chamber, has a diameter of 4.5 mm. Atomizing gas is injected into the liquid through 20 gas-injection holes, 200-μm in diameter. The two-phase mixture formed in the mixing chamber exits through a 1-mm orifice.

Results and Discussion

Experiments were carried out for Jatropha curcas oil using nitrogen as an atomizing gas. The experimentally determined properties of the Jatropha oil sample used are shown in Table 1. Images of the spray were obtained using shadowgraphy as the imaging technique. A pulsed Nd:YAG laser was used as the light source, in conjunction with a fluorescent diffuser (Fig. 1b). A Imager Pro X 2M CCD camera with 1600 X 1200 pixel CCD resolution was used to capture images of the spray. Results are presented here for a liquid flow rate of 0.24 LPM with the GLR varying from 0 to 0.23. Figure 3 shows instantaneous images of the spray at different GLRs. As the GLR is increased, the quality of atomization improves significantly. The full paper will include:

- Shadowgraphy images of the effervescent Jatropha oil spray at high injection pressures
- Droplet size distributions and Sauter mean diameters (SMD) using the Interferometric Laser Imaging for Drop-Sizing (ILIDS) technique

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- Effect of GLR on spray structure and dropsizes

References

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Table 1. Properties of Jatropha curcas oil sample used in experiments

Property	*Values at 25°C*
Density	917 kg/m3
Viscosity	32 cP
Surface Tension	34 mN/m

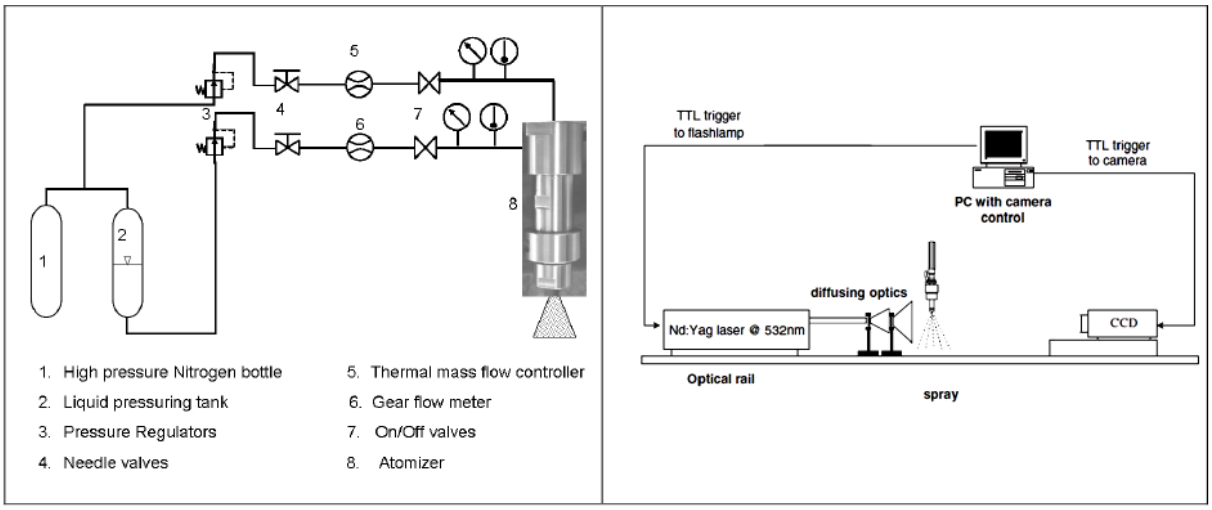

Figure 1. a) Schematic of the experimental setup b) Schematic of the setup used for shadowgraphy

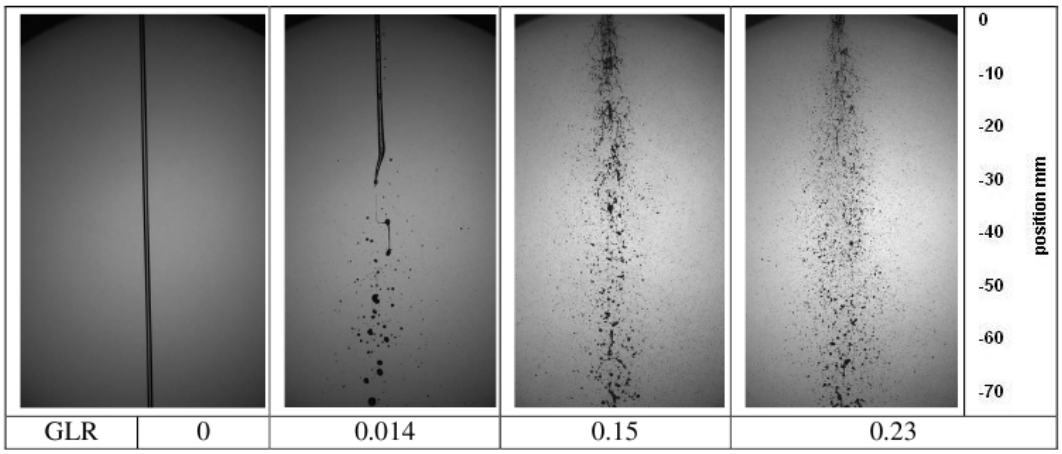

Figure 2. Structure of the Jatropha oil spray at different Gas to Liquid Ratios (GLR)