High Pressure Spray Characterization of Vegetable Oils

D. Deshmukh*, A. Madan Mohan, T. N. C. Anand and R. V. Ravikrishna
Department of Mechanical Engineering
Indian Institute of Science Bangalore
India

Abstract

This paper reports data on high pressure spray characterization of Jatropha and Pongamia pure plant oils. Shadowgraphy technique is used to visualize the spray structure and measure cone angle and tip penetration, whereas Interferometric Laser Imaging for Droplet Sizing (ILIDS) technique is used to measure droplet sizes. A common rail injection system with a 7-hole injector having a 180-µm hole size is used. From measurements on spray from an individual orifice, Sauter Mean Diameter (SMD) is found to be 40µm at an injection pressure of 700 bar at 70mm from the nozzle tip.

Introduction

This work is motivated by the need to utilize pure plant oil or Straight Vegetable Oil (SVO) as a diesel subtitute in automotive engines. Jatropha and Pongamia oils are considered to be most suitable diesel substitutes in Asia and other parts of the world. However, there is no data in the literature on spray characteristics at high injection pressures typical of those found in common rail injection systems for these oils. SVOs and their derivatives are being used in diesel engines both as complete replacement and as blends with diesel. The advantages of SVO include renewability, heat content close to that of diesel fuel (about 80% of diesel fuel) and local availability [1].

Spray atomization is an important process governing diesel engine performance. High surface tension and viscosity of SVO have adverse effect on spray atomization as it increases the SMD compared to diesel under similar conditions [2, 3]. To adapt the various SVOs and their blends in diesel engines, it is necessary to study their spray characteristics. This is the first reported study to the best of our knowledge on spray structure measurements of Jatropha and Pongamia oils.

Materials and Methods

A high pressure spray injection facility is developed which utilizes a common rail diesel injection system. A high pressure pump is externally driven by an induction motor. Rail pressure is controlled using both a needle valve and the motor. Injection pressure can be varied from 200 bar to 1700 bar. The optical setup consists of an Nd:YAG laser, sheet optics, collecting lens and CCD camera with resolution 1600 X 1200 pixels. To get the maximum fringe contrast, camera was kept at 70o to laser sheet. Since the spray is dense, a rectangular aperture of 20 mm width and 5 mm hight was used to compress the interference image. Field of view for the given setup was 11mm X 8 mm. SMD was calculated based on 7000 droplets measured from 300 images.

Results and Discussion

Spray characterization is done for Jatropha oil at injection pressures of 500 bar and 700 bar, oil temperature 50 °C and injection duration of 800µs. Figure 1 shows the spray tip penetration for diesel and Jatropha oil at two different injection pressures. Injection delay for Jatropha is high compared to that of diesel, and decreases with increase in injection pressure. From the shadowgraphy image shown in Fig. 2, it is observed that the Jatropha spray structure is very different from that of conventional diesel spray.

Preliminary results on droplet sizing are presented. Figure 3 shows the interference image obtained using the rectangular aperture. Figure 4 shows the corresponding droplet distribution data. The uneven nature of the distribution is attributed to interference from sprays issuing from the neighboring orifices. This issue is being resolved by conducting experiments from a single hole injector, the results of which will be presented in the full paper. SMD values for Jatropha are observed to be higher than that of diesel. Detailed results on the spray characterization of Jatropha and Karanja will also be included in the full paper.

* Corresponding author: deven@mecheng.iisc.ernet.in

References

[1] Ramadhas, A.S., Jayaraj, S., Muraleedharan, C.,. Use of vegetable oils as i.c. engine fuels - a review. *Renewable Energy*, 29:727–742, 2004.

[2] Ryan, T.W., Dodge L.G. , Callahn T.J.,. The effects of vegetable oil properties on injection and combustion in two different diesel engines. *Journal of the American Oil Chemists Society*, 61(10), 1984.

[3] Lee, C.S, Park, S.W.,Kwon, S., . An experimental study on the atomization and combustion characteristics of biodiesel-blended fuels. *Energy Fuels*, 19:2201, 2005.

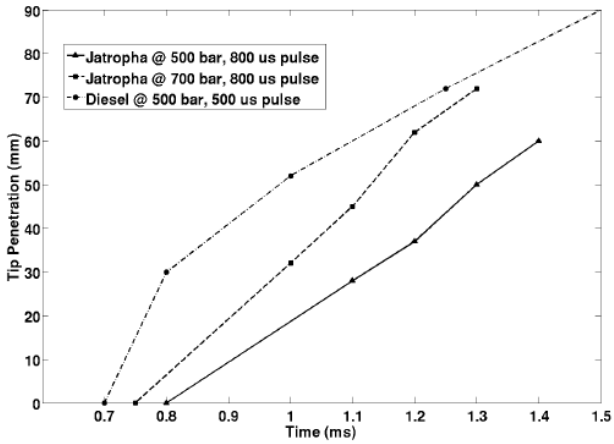

Figure 1. Spray tip penetration comparison for Jatropha and diesel

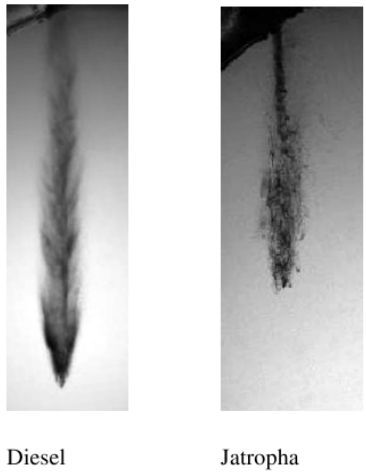

Figure 2. Shadowgraphy images (Pinj = 500 bar) 1 ms from start of injection

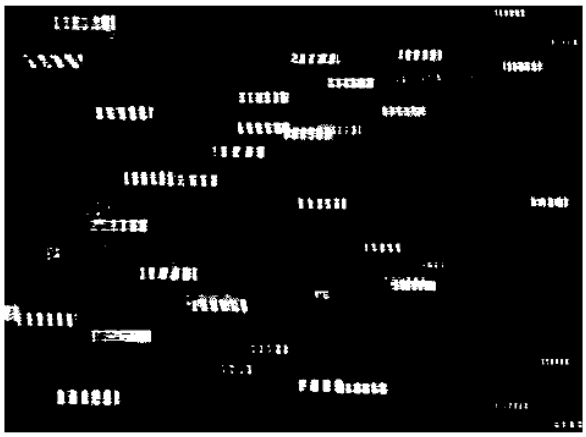

Figure 3. ILIDS image for Jatropha (Pinj = 700 bar)

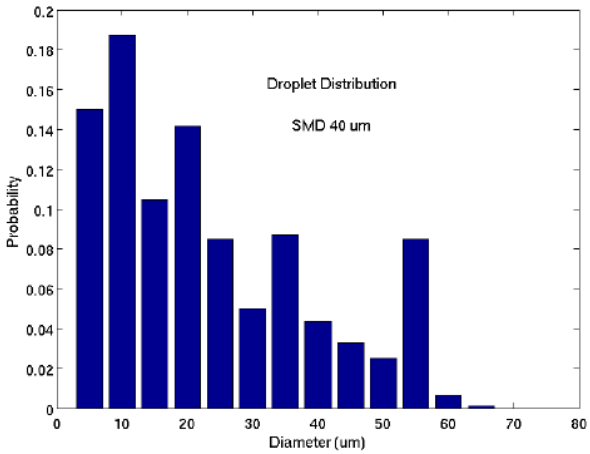

Figure 4. Droplet Distribution for Jatropha spray