Advanced Science and Technology Letters
Vol.33 (Bioscience and Medical Research 2013), pp.24-28
http://dx.doi.org/10.14257/astl.2013.33.06

Application of Biodiesel Fuels in Diesel Engine

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Abstract. This research was conducted on experimental analysis of spray and combustion characteristics of six different biodiesels in a constant chamber using a common-rail injection system. The processes of atomization and flame developments were visualized by using a high digital camera under different injection pressures. These quantitative and reliable date of biodiesel fuels which might be useful in supporting applicability and establishing emission reduction measure in future as well

Keywords: Biodiesel, Constant volume chamber (CVC), Spray, Common-rail direct injection(CDI), Ultra low surpher diesel(ULSD)

1 Introduction

Research on alternative energy resources and environmental pollution has been conducted actively to seek for solution for expensive oil price and global environmental problems which become important issues in international society. Particularly, it is necessary to reduce NO_x and PM simultaneously and effectively since the effects of NO_x and PM emitted from diesel engine are fatal to human body. On the other hand, bio-diesel fuel has been observed as a low emission alternative fuel in the aspect of harmful emission reduction and climate change agreements. However, biodiesel fuels have their unfavorable properties at a low temperature and cause problems in fueling system. Cold performance test of six different biodiesel blends in a passenger car and a light duty truck was made to investigate cold performance and cold filter plugging point (CFPP) in property characteristics of biodiesel fuel blends [1]. It is usually produced from animal fats or vegetable oils by trans-esterification reaction. Biodiesel fuel includes lower sulfur and higher oxygen content of diesel than conventional diesel fuel. The included oxygen may facilitate the combustion process and contribute to reduce pollutant emissions from diesel engine. Furthermore biodiesel fuel can be applied to current diesel engines without special engine modification. As an alternative fuels, biodiesel fuel has a great potential of reducing CO, CO_2, HC, PM, Sox and PAH emissions nevertheless there are slight increase of brake specific fuel consumption and NO_x emission [2, 3]. Flame development and soot formation processes of biodiesel fuel spray were studied [4]. 2. Experimental Apparatus and Method

2.1 Experimental Apparatus

ISSN: 2287-1233 ASTL

A constant volume chamber was applied for the visualization of spray and combustion characteristics of a compressed ignition type engine and its bore and with were 86.2mm and 39mm. A high speed digital camera was installed to photograph actual shapes of fuel spray and diffusion of flame. An intake valve, an exhaust valve, a pressure sensor and a spark plug and two visual windows of bore 120mm and thickness 25mm at both sides for photographing were installed as CVC peripheral equipment. Residue exhaust gases were removed using a vacuum pump and collected in a decompression tank (See Figure 1). The experimental conditions were shown in Table 1.

Table 1. Experimental conditions

Bore × Width (mm)	86.2 × 39
Displacement (cm^3)	228
Fuel Delivery	Direct Injection
Injection Pressure(MPa)	60, 100
Injection Duration(ms)	2.5
Ambient O_2 Concentration	2% vol.(spray) 21% vol. (combustion)
Ambient Pressure(MPa)	2
Nozzle dia. (mm)	0.134

2.2 Experimental Method

The experiments were conducted under the conditions of atmosphere pressure 2MPa and the injection pressures were fixed to 60Mpa and 100MPa. And injection period was fixed to 2.5ms during the whole process of the experiment.

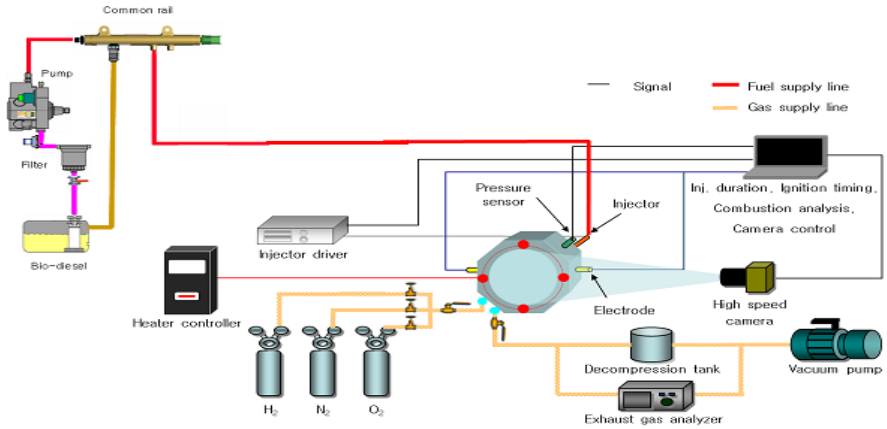

Fig. 1 Schematic diagram of experimental apparatus.

3 Results and Discussions

3.1 Spray Visualization

The liquid spray images are shown in Figure 3 for BD 5 and BD 20 at two injection pressures to illustrate the effects of biodiesel on spray development or tip penetration distances. More fuel impingement is found for BD 20 than BD 5. The stronger fuel impingement for BD 20 is attributed to the longer penetration since biodiesel has a higher boiling point with a low evaporation and the density of biodiesel is slightly higher than ULSD. And when injection pressure increases, the spray reaches faster to the bottom of a combustion chamber in all the cases. This is attributed to the more liquid penetration which accelerates the fuel droplets to move faster.

3.2 Combustion Visualization

The combustion images for BD 0 and BD 20 are shown in Figure 4 and 5 under two different injection pressures. The injection timings are varied from 0.1ms to 2.5ms. The flames are developed in the direction of spray and then collided at a cylinder wall and diffused to inside a whole combustion cylinder. The differences between BD 0 and BD 20 are ignition timing and luminosity. The initial flame occurs later for BD 20. The luminosity of BD 20 is lower than that of BD 0 and the flame of BD 20 is not as distributed as that of BD 0. The local flame luminosity for BD 20 is mainly due to the slow evaporation rate of BD 20. The cetane number for BD 20 is less than BD 0 and it contributes to the ignition timing. BD 0 has the highest soot luminosity in the combustion flame, which is due to no oxygen in the pure fuel compared with biodiesel blends. For biodiesel blends, the soot luminosity is attributed to the trade-off between fuel volatility and oxygen.

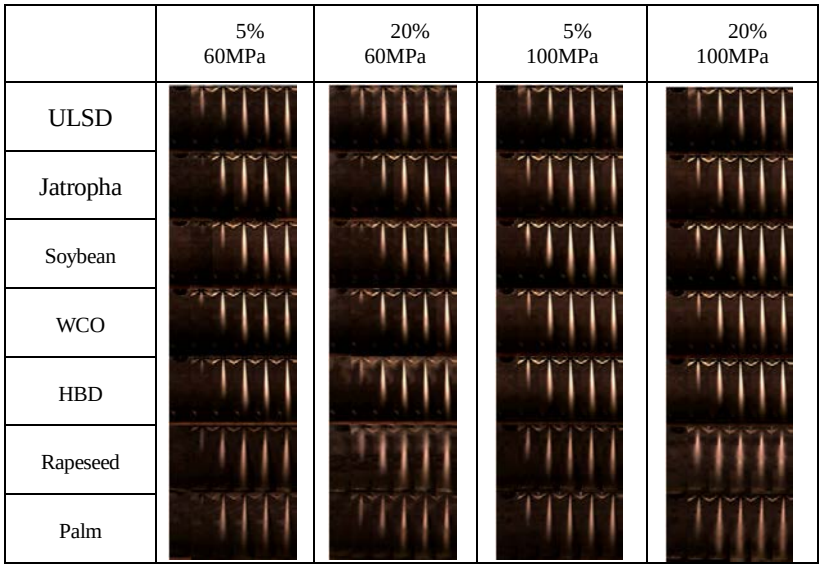

Fig. 3 Spray tip penetration of biodiesel blends at injection pressures

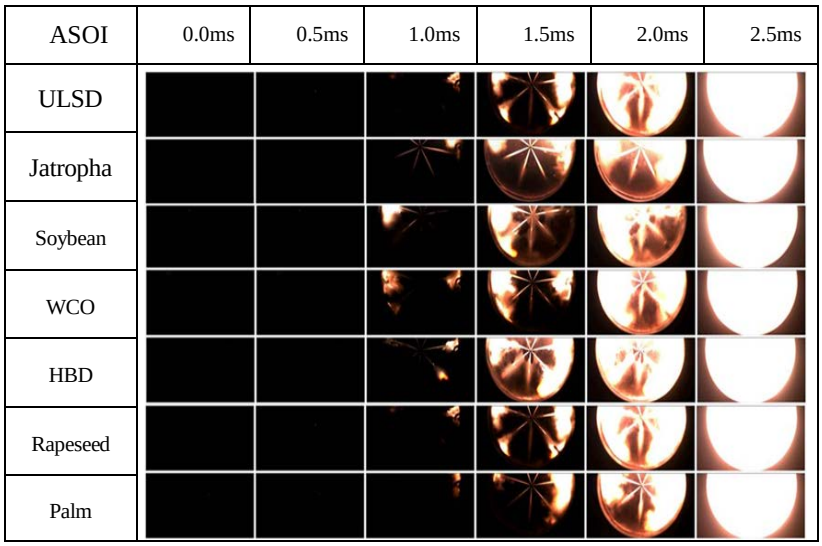

Fig. 4 Flame visualization of BD20 (P_{inj} = 60Mpa)

4 Conclusions

Jet spray, combustion images were important parameters in determining the characteristics of biodiesel blends and some important. Biodiesel has a higher boiling point and causes longer penetration and stronger fuel impingement with the increase of biodiesel content.

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