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Spray and Combustion Characteristics of Biodiesel Blends in CI Engine

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ABSTRACT

This experimental evaluation of spray and combustion characteristics of six different biodiesels in a constant chamber using a not unusualrail injection device. The strategies of atomization and flame traits have been visualized by the use of a excessive digital camera under two distinctive injection pressures. The stress modifications have been measured by means of a piezometer strain sensor, and combustion procedures have been analyzed via computing warmness release fees. From those outcomes, it turned into concluded that exceedingly pressurized injection expanded atomization of fuels and prompted to shorten ignition put off period and for that reason stepped forward average combustion characteristics. in particular, the oxygen contents protected in biodiesel expanded combustion situations. Moreover, these quantitative and reliable information of biodiesel fuels which might be beneficial in supporting their applicability and setting up emission reduction degree in destiny as nicely.

Keywords : Biodiesel, Compressed ignition, Ignition delay, Constant volume Chamber (CVC), Common-rail direct injection, Ultra low sulfur diesel (ULSD).

I. INTRODUCTION

On alternative energy sources and environmental pollutants has been carried out actively to seek for solution for steeply-priced oil rate and worldwide environmental troubles which come to be vital troubles in international society. Specifically, it is vital to lessen NOx and PM simultaneously and efficiently because the effects of NOx and PM emitted from diesel engine are deadly to human body. Alternatively, bio-diesel fuel has been found as a low emission alternative gas within the aspect of dangerous emission reduction and climate alternate agreements. However, biodiesel fuels have their detrimental properties at a low temperature and motive problems in fueling gadget. Bloodless performance check of six distinct biodiesel blends in a passenger car and a light obligation truck turned into made to investigate bloodless overall performance and cold filter plugging point (CFPP) in assets traits of biodiesel fuel blends [1]. it is also comprised of animal fats or vegetable oils by means of trans-esterification reaction. Biodiesel gas includes lower sulfur and higher oxygen content than traditional diesel gasoline. The protected oxygen may facilitate the combustion technique and make contributions in lowering pollutant emissions from diesel engine. moreover biodiesel gasoline can be carried out to cutting-edge diesel engines without unique engine modification. As an alternative fuel, biodiesel gasoline has a superb potential of decreasing CO, CO2, HC, PM, SOx and PAH emissions although there are slight boom of brake unique gasoline intake and NOx emission [2, 3]. Flame development and soot formation processes of biodiesel gas spray were studied [4]. The impact of biodiesel and its blends (BD10~BD80) had been investigated on the engine overall performance, emission and combustion characteristics with the aid of making use of waste cooking oil methyl ester (WCO-ME) [5]. Biodiesel (fatty and methyl ester) changed into used to analyze the traits of engine performance and emissions traits [6]. Meanwhile, a combustion take a look at on an engine became carried out through applying 11 unique varieties of vegetable oils [7]. Biodiesel gasoline was applied to small and full sized automobiles and studied the power and emissions [8]. Research at the behavior and atomization traits of biodiesel gasoline turned into carried out [9-15]. This take a look at turned into conducted on combustion and emission characteristics in order to analyze its feasibility as an opportunity fuel. The experiment become carried out in a consistent quantity chamber by way of conventional diesel fuel with six exclusive of biodiesel fuels and the consequences of emissions and combustion characteristics had been compared and analyzed with every other blends.

II. Experimental Apparatus and Method

2.1 Experimental apparatus

A constant volume chamber was applied for the visualization of spray and combustion characteristics of a compressed ignition type engine and its bore and width 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, a spark plug and two visual windows of bore 120mm and thickness 25mm at both sides for photographing were installed as CVC peripheral equipment. Residual exhaust gases were removed using a vacuum pump and collected in a decompression tank (See Figure 1). A high speed digital camera was used to photograph the spray and flame development of biodiesel fuel and the corresponding photographing speed was set up to 4000 fps. Also, the pressure change was measured by a piezometer pressure sensor and combustion processes were analyzed by computing the heat release rates. The data of combustion pressure were secured using DAQ (Data Acquisition: DAQ Card-6024E) and all the signals of ignition and photographing timings were controlled by Code vision AVR C language. After the completion of combustion process Horiba potable gas analyzer (MEXA-554JK) was applied. The experimental conditions were shown in Table 1.

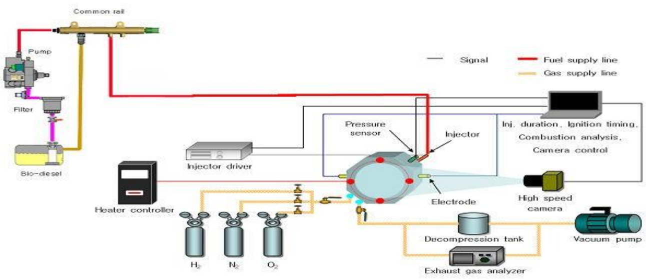

Figure 1. Schematic diagram of experimental apparatus

Table 1. Experimental conditions

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

Table 2. Properties of biodiesel (BD20) blends for test *HBD: Hydro-Treated Biodiesel, WCO:Waste Cooking Oil

Blends	**PourP**	**Flash point**	**CFPP (**	**CN**
ULSD	**-12**	**59**	**-8**	**55**
Soybean	**-10**	**64**	**-8**	**50**
Jatropha	**-10**	**63**	**-8**	**54**
Palm	**-8**	**63**	**-8**	**54**
WCO	**-10**	**64**	**-8**	**56**
HBD	**-15**	**62**	**-10**	**56**
Rapesee	**-10**	**63**	**-8**	**54**

2.2 Experimental method

Biodiesel fuel was sprayed within a very short period of time, which was much faster as the injected pressure increased. Spray visualization was made in order to photo graph instantly high resolution pictures in a darkroom. For the visualization of combustion processes hydrogen fuel was supplied to a constant volume chamber just before biodiesel fuel was injected in order to provide high atmosphere temperature and pressure inside the chamber (Figure 2). The experiments were conducted under the conditions of atmosphere pressure 2MPa and the injection pressures were fixed to 60MPa and 100MPa. And also injection period was fixed to 2.5ms during the whole processes of the experiment.

2.3 Applied biodiesel blends

Six kinds of biodiesel fuel blended by 5 and 20% ratios were used. The biodiesel blends were kept at 300K for 30 days and as the result of inspection, there was no separation of liquid phase except for some sediment in jatropha, palm and rapeseed oils. Table 2 represents the properties of biodiesel fuels. The index of their CFPP and pour point represent properties quantitatively at cold weather.

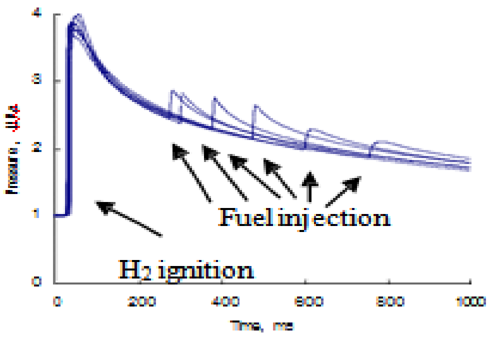

Figure 2. Pre-ignition of hydrogen and injection

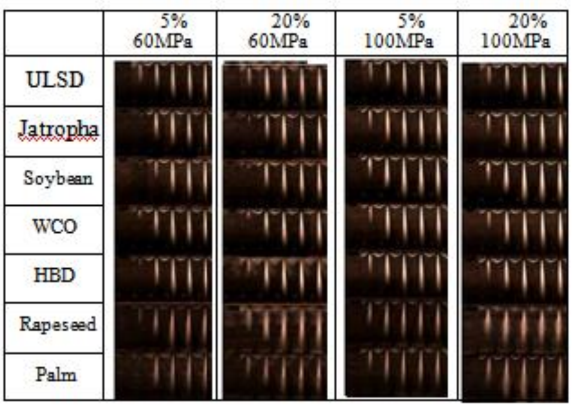

Figure 3. Spray tip penetration of biodiesel blends at injection pressures

III. Results and Discussion

3.1 Spray visualization

The liquid spray images are shown in Figure 3 for BD5 and BD20 at two injection pressures to illustrate the effects of biodiesel on spray development or tip penetration distances. More fuel impingements are found for BD20 than BD5. The stronger fuel impingement for BD20 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 (or BD0). And when injection pressure increases, the spray reaches faster to the bottom of a combustion chamber in all the cases. This is mostly due to the more liquid penetration which accelerates the fuel droplets to move faster.

3.2 Combustion visualization

The combustion images for BD0 and BD20 are proven in figure 4 and five under unique 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 interior a combustion cylinder. The variations among BD0 and BD20 are ignition timing and luminosity. The preliminary flame takes place later for BD20. The luminosity of BD20 is decrease than that of BD0 and the flame of BD20 isn't always as dispensed as that of BD0. The neighborhood flame luminosity for BD20 is especially because of the gradual evaporation fee of BD20. The cetane range for BD20 is less than BD0 and it contributes to the ignition timing notably. BD0 has the best soot luminosity within the combustion flame, that is due to no oxygen inside the natural gasoline as compared with biodiesel blends. For biodiesel blends, the soot luminosity is attributed to the change-off between gas volatility and oxygen. From late flames, there are a few neighborhood flames at the chamber wall for BD20. For the BD20, there are some local early flame close to the spray tip location in the CVC. That is attributed that BD20 gasoline has longer ignition put off as compared with BD0. And additionally the flame of last level is burnt-out a good deal faster for BD20 than BD0 due to its oxygen content. When injection pressure will increase to 100MPa, the ignition commenced earlier because of the stronger fuel impingement. The variations between BD0 and BD20 are ignition and luminosity. Preliminary flame for BD0 happens later for BD20. The luminosity of BD20 is an awful lot lower than that of BD0. The combustion stress and heat launch rates as the characteristic of time for BD0 and BD20 are shown Figures 6~nine. The diagram of stress and warmth launch prices have been exclusive because of the numerous ignition timings on account that longer ignition put off allows plenty more mixtures of fuel and air and induces stronger jet impingement at some stage in the combustion strategies. HBD and WCO have shorter ignition delays compared to others. And HBD emitted much less CO, HC and NOx as compared to others. That is because of the characteristics of HBD fuel which become manufactured with the aid of the procedure wherein oxygen changed into removed and hydrogen was delivered rather.

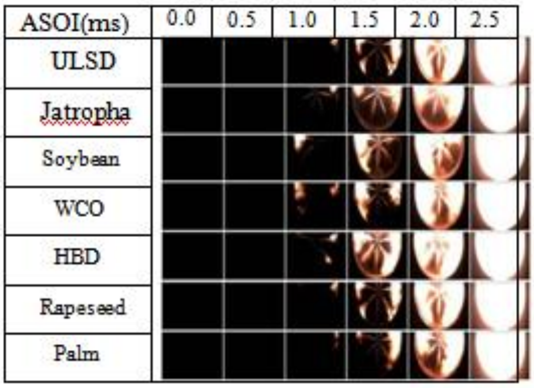

Figure 4. Flame visualization at 60Mpa

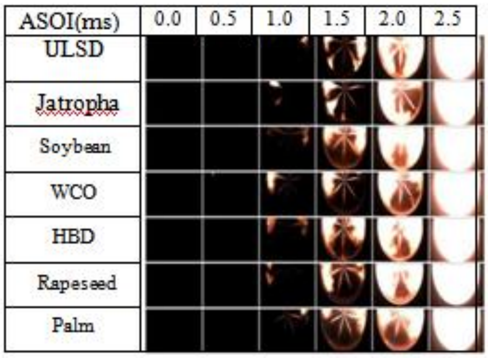

Figure 5. Flame visualization at 100MPa

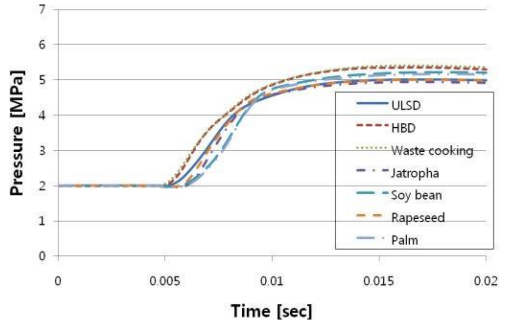

Figure 6. Pressure diagram of BD20 (Pinj=60Mpa)

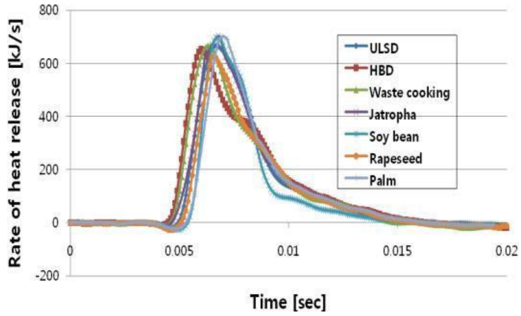

Figure 7. Heat release rates of BD20 (Pinj=60MPa)

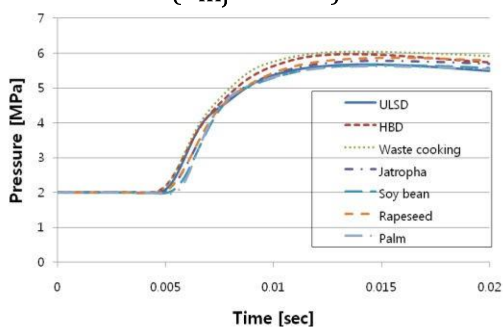

Figure 8. Pressure diagram of BD20 (Pinj=100MPa)

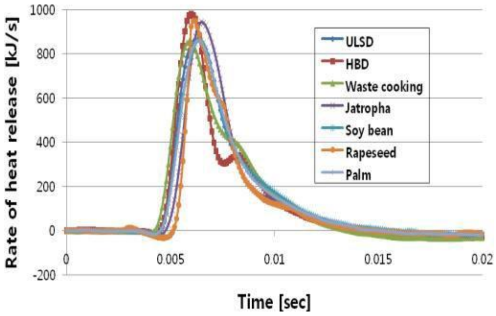

Figure 9. Heat release rates of BD20 (Pinj=100MPa)

IV. CONCLUSION

In precis, this study aims to analyze the characteristics on spray and combustions of six types of biodiesel blends (BD20) via making use of commonplace-rail machine in a regular quantity chamber. Jet spray, combustion photographs, combustion manner and heat launch quotes have been critical parameter in determining the characteristics of biodiesel blends and a few vital are made. Biodiesel has a better boiling point and reasons longer penetration and more potent fuel impingement with the growth of biodiesel content. The cetane numbers for biodiesel blends play an important role for the combustion performance of six biodiesel blends (BD20) and particularly cetane range in HBD and WCO are better than different blends. NOx emission increases with the increase of biodiesel contents because of it oxygen content and retarded injection timing. However, an early injection strategy may additionally make a contribution to lessen NOx emission drastically whilst biodiesel blends had been used to standard diesel engines.

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