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Injection Pressure effect in C I Engine Performance with Karanja Oil Methyl Ester (KOME)-Diesel blends as a Fuel

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Abstract

To reduce the dependency on petroleum fuels and the environment pollution, biodiesel can be used as an alternative to diesel fuel. The biodiesel properties such as flash point, volatility and viscosity which affect the combustion process, there by the performance of engine. Biodiesel which is available at higher viscosity than diesel fuel can be injected into the engine cylinder at higher pressures for better atomization that leads complete combustion. Hence experiments were conducted on compression ignition (C I) engine for different injection pressures (IP) to find performance with diesel and diesel-biodiesel (Karanja oil methyl ester/KOME) blend as fuel (50% diesel and 50% biodiesel). The performance of blend fuel D50BD50 at different injection pressures are compared with diesel fuel at 200bar. The results indicate that the performance of engine is improved with D50BD50 at IP of 220bar compared to other injection pressures. It is observed that brake thermal efficiency is improved by 41.02% due to improved atomization and BSFC is lowered by 2.1%due to lower calorific value. In case of emissions hydrocarbons, carbon monoxide and smoke opacity are reduced by 45.4%, 33% and 33% respectively, where as NO_x emissions increased when compared with diesel fuel at IP of 200bar.

Keywords: Biodiesel, Engine, Injection pressure, Blend fuel, Performance, Karanja Oil, KOME.

Introduction

The discrepancy between demand and supply of energy has become an increasing problem due to fast depletion of fossil fuel[1]. Biodiesel is becoming a significant, future renewable, alternative fuel and also as an additive to the existing petroleum fuels recently[2,3]. Biodiesel is a biodegradable, non-toxic and mostly renewable and alternative fuel. It can be produced from various edible and non-edible oils, waste cooking oil or animal fats. The properties of biodiesel may change when different feed stocks are used. In comparison of biodiesel properties with diesel fuel, it has higher viscosity, density and cetane number. But the energy content in biodiesel is about 10-12% less than that of conventional diesel fuel on the basis of mass[4-6]. Biodiesel properties are similar to diesel fuel; hence the modification of diesel engine is not required to use directly biodiesel or blends with diesel fuel[7].

Compression ratio of the engine can be changed by raising the bore and the engine head in variable compression ratio diesel engine. As the bore and engine head is raised or lowered, the change in clearance volume occurs that results in change of compression ratio[8]. Experiments were conducted on engine with biofuel and blends with biofuel as an additive on high speed diesel engine at various compression ratios, timing of injection and load on engine. The conclusions were the reduced engine performance with the increase in biofuel additive percentage in the blend fuel more than 20% as compared with that of conventional fuel. With increasing in compression ratio and timing of injection the reduction in performance of the engine can be improved[9]. Increasing injection pressure in association with compression ratio improves engine performance like *BSFC*, thermal efficiency and reduces hydrocarbon emissions, smoke and NO_x. The conclusion is that to use biodiesel in the engine, it must be at high compression ratio and working with very high injection pressure[10]. The VCR engine when operating with fried oil methyl ester and blends with diesel fuel shows that the performance of engine is improved with reduction in emissions[11]. In this paper the effort is made to investigate injection pressure effect on the C I engine performance fuelled with biodiesel and blends of biodiesel as fuel.

Materials and Methods

Karanja seeds were collected directly from the trees which are available in the campus of KITS College situated in Warangal, Telangana state. Oil is extracted from the dried Karanja seeds. The transesterification process is used to make biodiesel from the extracted oil. Filtered pure oil is acid treated with methanol and sulfuric acid to remove some of the fats as glycerin.

In the base treatment methanol and NaOH (Sodium Hydroxide) are thoroughly mixed to form a clear solution called "*Sodium Methoxide*". This solution is added to the acid treated oil and stirred along with heating at 60^0C to neutralization sulfuric acid. When the solution turns into brown silky in colour, that shows the whole reaction is completed. After settlement of mixture the bottom part of the glycerin is separated from the biodiesel

(Figures-1 to 3). The obtained Karanja oil methyl ester (KOMEis bubble washed with distilled water to remove soaps. Washing is repeated til the KOME separated with clear water (Figures- 4, 5). Prepared KOME is heated to remove water and formed biodiesel is tested for properties as shown in Figure-6.

Figure-1
Initial heating of oil

Figure-2
Base treatment

Figure-3
Separation of Glycerin

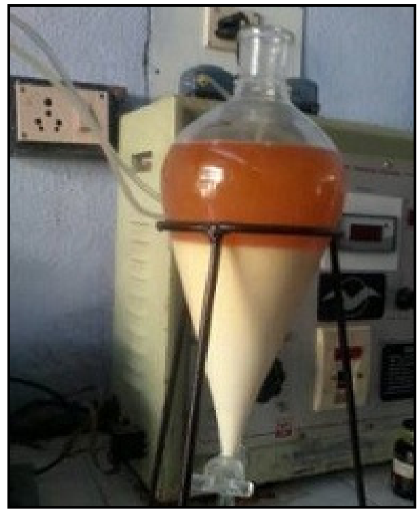

Figure-4
Soap water during washing

Figure-5
Clear water in washing

Figure-6
Biodiesel (KOME)

Experimentation: Single cylinder of four-stroke Kirloskar make DI diesel engine coupled with eddy current dynamometer is used for the experimental work. Experiments were conducted at varying loads of 0, 20, 40, 60, 80 and 100% for diesel at 200bar and blend fuel *D50BD50* at 200, 220 and 240bar of injection pressures under at constant rated speed of 1500 rpm. Exhaust gas temperatures and fuel consumption were measured by usual procedure. The parameters like brake thermal efficiency and *bsfc* are evaluated for all load conditions. The emission characteristics were measured at steady state condition of the engine with the help of AVL make smoke meter. Exhaust gas analyzer was used to measure the carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbon emission (HC) and nitrogen oxides (NO_x). The smoke intensity was measured with smoke meter and the obtained results were compared with diesel for the best injection pressure.

Results and Discussion

Brake Thermal Efficiency: The in Brake Thermal Efficiency (BTE) and *BSFC* with Load are shown in Figure-7. At higher injection pressure the BTE is increased due to improved atomization with reduced viscosity which leads to complete combustion. The BTE value maximum at 220bar; this may be due to fine spray of blend fuel during injection which improves atomization. Further increase in injection pressure the BTE tendency is to decrease; this may be due to lower momentum of fine droplets which reduces the penetration in combustion chamber. The maximum BTE occurs at full load and at IP of 220bar is 41.02% for blend fuel when compared with diesel at 200bar. The *BSFC* decreases when the load on the engine is increasing. The KOME consumption is higher than diesel; this may be due to the low calorific value of biodiesel. It is observed that with increase in IP up to 220bar the BSFC is decreased. At higher IP the length of penetration and spray cone angle of injected fuel increases. The *BSFC* for blend fuel at 220bar IP is 2.1% less, when compared with diesel for full load condition at 200bar.

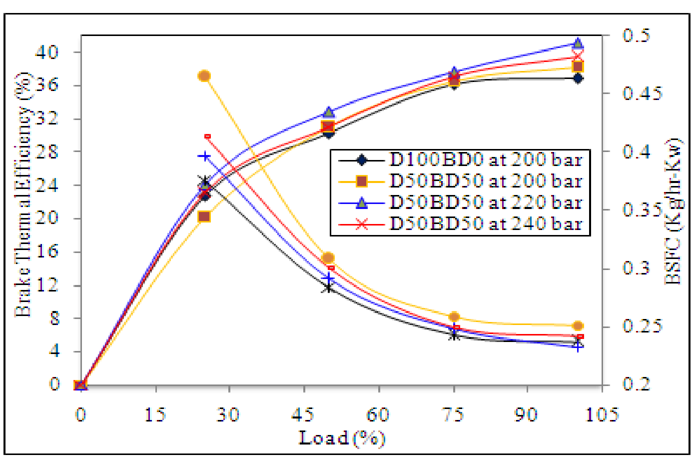

Figure-7
Brake Thermal Efficiency and *BSFC* variation with Load

Peak cylinder pressure: The Figure-8 shows that at 220bar heat release rate increases during premixed combustion due to improved atomization and mixing of air with blend fuel results in increasing the rate of combustion. The peak pressure obtained for blend fuel is 63.35, 65.83 and 64.15bar at injection pressures of 200, 220 and 240bar, whereas for diesel the peak pressure is 63.95bar at 200bar. Results indicate that the peak pressure with blend fuel ***(D50BD50)*** varies very marginally by changing in injection pressure and it is comparable with diesel fuel.

Exhaust temperature: Figure-9 shows the variation in exhaust gas temperature with load for all injection pressures. The increase in injection pressure makes better mixing of fuel with air which leads complete combustion results in increase of temperature at higher loads. Blend fuel exhaust temperature is lower for all loads at injection pressure 220bar compared to diesel.

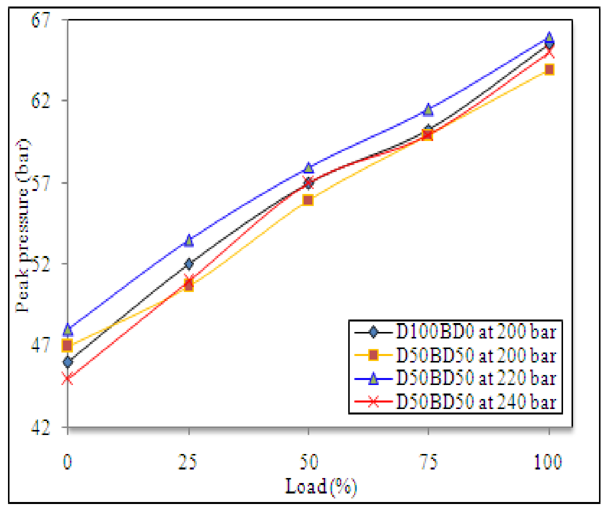

Figure-8
Peak pressure variation with Load

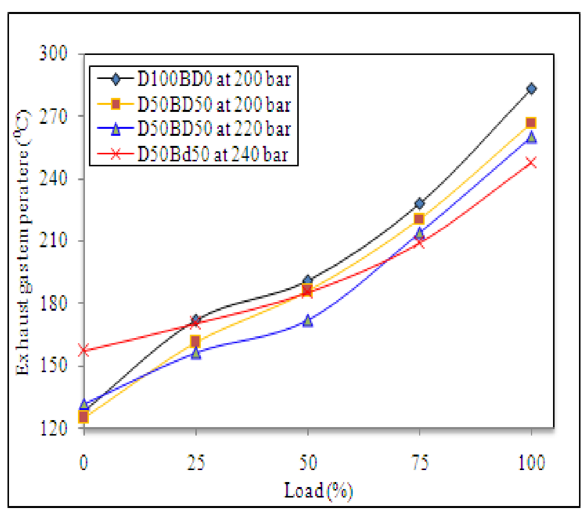

Figure-9
Exhaust Temperature variation with Load

Hydrocarbon emissions: The HC emissions are increased with increase in load for diesel and KOME-Diesel blend fuel at all injection pressures. The observation from Figure-10 shows that the HC emissions for all blend fuels are less than that of diesel, which indicates that the heavy particles of hydrocarbon present in diesel fuel increases HC. In addition the availability excess oxygen in biodiesel promotes combustion which leads to lower in emissions of HC. At IP of 220bar the HC emissions for blend fuel are 45.4% lower than diesel at 200bar for full load.

Carbon monoxide: The CO emission variation with load is shown in Figure-11. Biodiesel contains 11 percentage of oxygen that helps in complete combustion of blend fuel causes reduction in CO emissions than diesel. From the Figure-11 it is found that CO emission increases gradually with increase in load due to decrease in air-fuel ratio but decreases at higher loads. The emission of CO for blend fuel used at full load and 220bar IP is nearly 33% lower than diesel at 200bar.

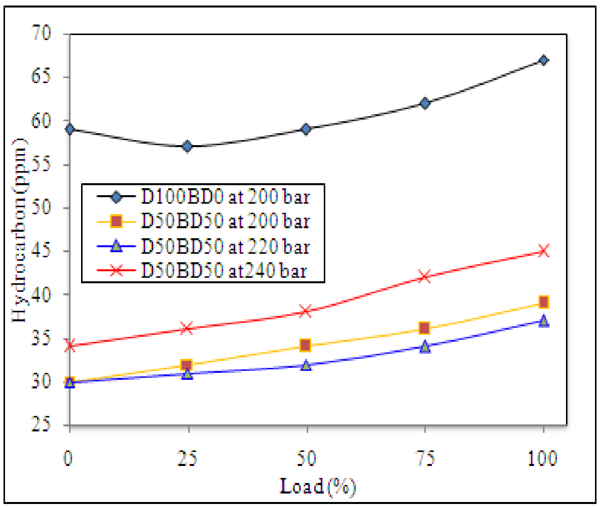

Figure-10
Hydrocarbon variation with Load

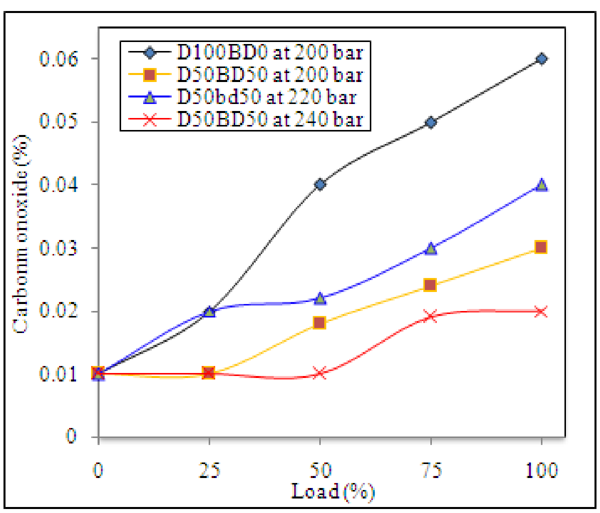

Figure-11
Carbon monoxide variation with Load

Smoke emissions: Figure-12 shows that the variation of smoke opacity with load. It is observed that the opacity is decreased with increase in load at all injection pressures for all fuels. Increase in IP from 200 to 240bar for all fuels at full load, the smoke is reduced. It is observed that the smoke opacity at 220bar is lowered by 33% at full load condition.

Oxides of nitrogen: The NO_X variation with load is shown in Figure-13. This emission is increased with increase in load for all fuels at all injection pressures; this is due to increase in temperature of gases in combustion chamber. The average NO_X emission in case of blend fuel is higher by 200ppm at 220bar than diesel at 200bar. NO_X emissions were lower at 200bar IP indicating that effective combustion is taking place in the early part of expansion stroke.

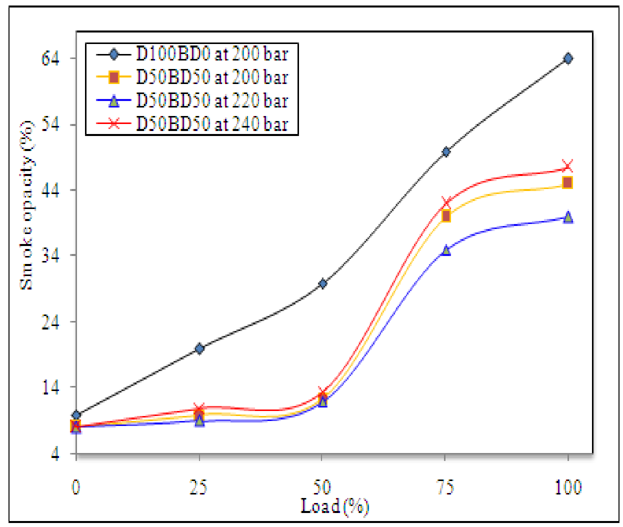

Figure-12
Smoke variations with Load

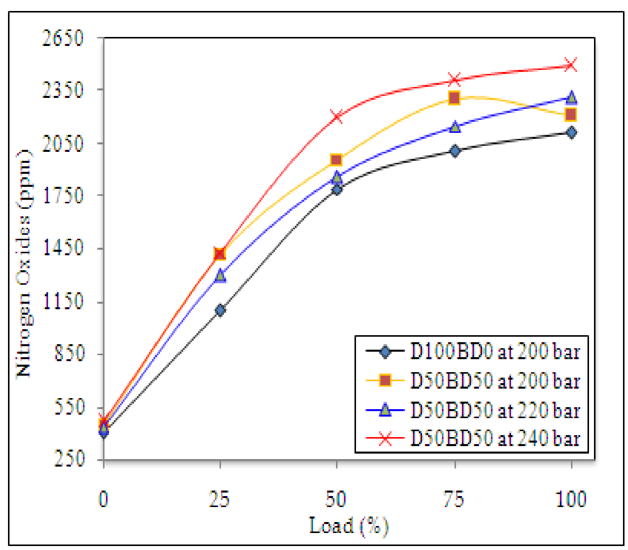

Figure-13
Nitrogen oxides variation with Load

Conclusion

For the operation of engine with KOME and diesel blends as fuel at different injection pressures, performance parameters were computed and the conclusions drawn are: i. Brake thermal efficiency is maximum for 220bar IP at minimum BSFC due to improved atomization of fuel. ii. Carbon monoxide and NO_x emissions levels are lower with biodiesel blends but at 220bar IP the CO_2 emission is less and NO_X is more than diesel. iii. Hydrocarbons and Smoke emissions are lower with biodiesel blends and the minimum values were at 220bar IP.

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