Experimental Study of Performance and Emission Characteristics of a Bio Dual Fuel Blends in Diesel Engine for Variation of Injection Pressures

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***Abstract*— In this study, by varying the injection pressures, the performance and emission characteristics were investigated for a dual bio fuel (Jetropha oil and Rubber seed oil) in a diesel engine. For this purpose a single cylinder four stroke Direct Injection (DI) constant speed diesel engine was used. The experiments were conducted for each of the injection pressures 200, 220 and 240 bar with the different proposition such as 20% and 60% of biodiesel blends with pure diesel fuel. While other parameters like injection timing and mass flow rate were constant, the injection pressure was changed during testing of the engine. The performance parameters were obtained for different load conditions from no load to full load at the rated power of 4.4 kW and a speed of 1500 rpm. From the results, it was observed that, CO_2, HC and CO emissions were reduced about 5% to 10%, when the fuel injection pressure is increased with less amount of biodiesel blends. However the smoke value and NOx is increased significantly when the injection pressure is reduced to 200 bar. The analysis revealed higher brake thermal efficiency for the biodiesel of B20 and a good reduction of carbon dioxide (CO_2), unburned hydrocarbon (HC) Nitric oxide (NOx) emissions when compared to the blend B60.**

***Index Terms*— Emission, Injection pressure, Performance, Injection timing, Bio-fuel.**

I. Introduction

The renewable liquid or gaseous transport fuels produced from plant or animal material have emerged as one of a number of possible alternatives to fossil fuels that might help meet our energy needs in an environmentally sustainable method. However, biofuels production, which mainly uses food crops, has been controversial because in some cases it has led to deforestation, and to disputes over rising food prices and land use. New types of biofuels, such as those using non-food crops and algae, are being developed with the aim of meeting our energy demands whilst avoiding the problems of the past. Forsonet al., [1], conducted a test in a single-cylinder DI with water cooled engine operating on diesel fuel and blends of Jetropha oil in different proportions of 97.4%/2.6%; 80%/20%; and 50%/50% by volume for a range of operating loads on the test engine. Carbon dioxide and carbon monoxide emissions were same for all fuels (Diesel and blended fuels); the 97.4% diesel/2.6% Jetropha fuel blend was observed to be the lower net contributor to the atmospheric level. CO, HC and smoke opacity decreased whereas NOx and brake specific fuel consumption were increased with different biodiesel fuel blends.

Ismet Çelikten al., [2] 100% diesel (SD), 50% rapeseed oil methyl ester and 50% diesel (B1), 50% hazelnut oil methyl ester and 50% diesel (B2), 25% rapeseed oil methyl ester, 25% rapeseed oil methyl ester and 50% diesel (B3) were used in a four-cylinder, four-stroke, 46 kW, direct injection diesel engine. As the rapeseed methyl ester rate increased in the blend, smoke and CO emissions were decreased, NOx and CO_2 emissions increased.

Jindal al., [3] investigated the change of design parameters such as compression ratio (CR) and fuel injection pressure (IP) on the performance with consider to fuel consumption (BSFC), brake thermal efficiency (BTHE) and emissions characteristics of CO, CO2, HC, NOx and Smoke opacity with Jatropha methyl ester as biofuel and its compared to the diesel. It is found that the increase of compression ratio and injection pressure increases the BTHE and reduces BSFC while lower emissions were occurs.

Sahoo et al [4], have analyzed jatropha karanja and polanga oil based methyl esters blended with conventional diesel having sulphur content less than 10 mg/kg. Ten fuel blends (Diesel, B20, B50 and B100) were tested for a water-cooled three cylinder tractor engine with speeds 1200, 1800 and 2200 rev/min. Brake specific fuel consumptions for all the biodiesel blends with diesel increases with blends and decreases with speed. There is a reduction in smoke for all the biodiesel and their blends when compared with diesel.

Frank Lujaji et al [5], have evaluated the effects of blends containing croton mogalocarpus oil (CRO)-Butanol (BU) alcohol-diesel (D2) on engine performance, combustion, and emission characteristics in a four cylinder turbocharged

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direct injection (TDI) diesel engine. Samples investigated were 15%CRO-5%BU-80%D2, 10%CRO-10%BU-80%D2, and diesel fuel (D2) as a baseline. The specific energy consumption (BSEC) of blends was found to be high when compared with that of D2 fuel. Carbon dioxide (CO2) and smoke emissions of the BU blends were lower in comparison to D2 fuel.

Pandian et al [6], investigated the effect of injection system parameters such as injection pressure, injection timing and nozzle tip protrusion on the performance and emission characteristics of a twin cylinder water cooled naturally aspirated CIDI engine fueled with pongamia oil, blended with diesel. The experiments were designed using a statistical tool known as Design of Experiments (DoE) based on response surface methodology (RSM). The results depicted that the BSEC, CO, HC and smoke opacity were lesser, and BTE and NOx were higher at 2.5 mm nozzle tip protrusion, 225 bar of injection pressure and at 30_ BTDC of injection timing. Optimization of injection system parameters was performed using the desirability approach of the response surface methodology

In this study, the esterified rubber seed oil and Jatropha oil blended with the pure diesel fuel was used with the different blends such as B20 and B60 to obtain the performance such as Brake Thermal Energy Consumption (BTEC) and emissions characteristics of CO, HC, NO_x of a single cylinder constant speed diesel engine running at 1500 rpm and different injection pressures (200, 220 and 240 bar) maintained constant injection timing of 24^0 . The diesel engine was performed change of rated power to measure the performance and emissions characteristics with some engine modification. Table1 gives the properties of the fuels considered for the study.

TABLE 1
PROPERTIES OF FUELS

Property	Diesel	Rubber Seed Oil (RSO)	Jetropha Oil (JO)	Biodiesel (RSO & JO)
Sp. Gravity	0.74	0.82	0.96	0.90
Viscosity at 40^0C (mm^2/s)	4.15	70.2	4.4	4.2
Calorific Value(KJ/kg)	42000	37000	38500	39500
Carbon residues%	0.12	0.19	0.61	0.26
Iodine value	0.067	133.46	120.5	133.32

II. EXPERIMENTAL SETUP AND TEST PROCEDURE

The single cylinder constant speed DI engine was used to evaluate the engine performance and emission characteristics with biodiesel. The diesel runs under different load conditions at a constant speed of 1500 rpm with the different biodiesel proportions. The diesel engine (Kirloskar made) was directly attached with an eddy current dynamometer for changing the different loads. The different type of measuring device was attached in the test engine such as orifice meter with U tube manometer for measuring air consumption, the one liter burette for fuel consumption and the Separate biofuel fuel tank An AVL415 smoke meter was provided for measuring the smoke opacity and exhaust temperatures. The test rig was installed with AVL software for obtain various curves and results during operation. A five gas analyzer was used measured the emission characteristics such as CO_2, CO, HC, NOx, and O_2 values from the exhaust gas. The performance and emission test was conducted for the compression ratio of 17.5 at different injection pressures like 200, 220, and 240 bar at rated power of 4.4 kW. The test was carried out at different proportions such as biodiesel 20% and 60% blended with the diesel fuel. The performance analysis of the engine at different rated power was evaluated in terms of brake specific fuel consumption (BSFC), brake thermal efficiency (BTE) and emissions characteristics such as carbon monoxide (CO), carbon dioxide (CO_2), un-burnt hydrocarbon (UHC) and Nitric oxide (NOx). The specifications of the test engine are described in table 2.

TABLE 2
THE TEST ENGINE SPECIFICATIONS

Bore	87.5 mm
Stroke	110.0 mm
Speed	1500 (constant speed)
Compression Ratio	17.5:1
Rated Power	4.4 KW
Number of Cylinders	1
Type of Cooling	Air cooled-Eddy current dynamometer
Injection Opening	24^0 BTDC
Pressure	220 bar
Number of Stroke	4 stroke

III. RESULTS AND DISCUSSIONS

A. *Brake Specific Fuel Consumption (BSFC)*

Fig 1.shows the variation of brake specific fuel consumption (BSFC) for different injection pressures such as 200 bar, 220 bar and 240 bar with the different proportions of B20 and B60. The BSFC was decreased at no load to full load condition.

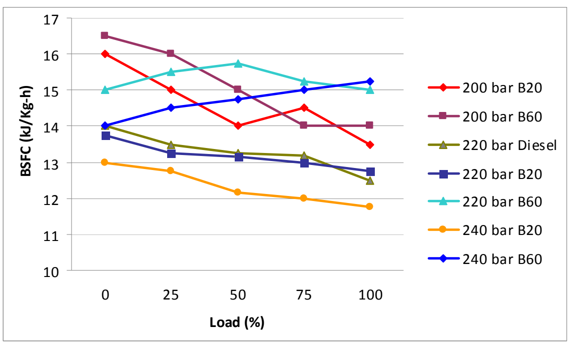

Fig.1 Variation of load and brake specific fuel consumption

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The rated power is 4.4 kW at 200 bar pressure always decreased at zero rated power then it was decreased from 5 kg/kW-h to 10kg/kW-h.For the injection pressure of 220 bar at B60 of BSFC gradually decreased at no load to full load. At 240 bar used in the test engine, the BSFC was reduced from 0.40 kg/kW-h to 0.24 kg/kW-h. From the result, at 240 bar and full rated power, the BFC always increased at different load condition. With increasing injection pressures in the C.I engine, ignition delay was reduced and the fuel may be completely burnt to produce the large amount of heat energy.

B. Brake Thermal Efficiency (BTE)

Using the biodiesel in constant speed engine the thermal efficiency is slowly increased for the biofuel as compared to diesel. The maximum thermal efficiency with dual fuel oil is about 31.5% whereas that of the diesel is 30.5% at maximum rated power output. The viscosity and density of biodiesel were reduced while the thermal efficiency increased from 5% to 10% as compared to the pure diesel fuel. From the result shown in Fig.2, for the injection pressure of 220 bar with blend B60, BTE increased up to 32% as compared to the diesel fuel. At 240 bar, for B20 the thermal efficiency reduced from no load to full load conditions.

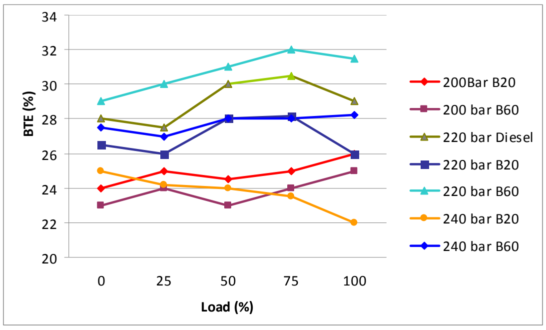

Fig 2.Variation of Brake thermal efficiency with different load

C. Carbon Monoxide (CO)

Fig 3 shows the variation of carbon monoxide with the changing load conditions. In single cylinder constant speed engine with the modification of inlet spring at the different pressures like 200 bar, 220 bar, and 240 bar the CO was analyzed using the exhaust gas analyzer and smoke meter. The CO emission of diesel engine decreases from zero loads to the full load. For the diesel fuel at 220 bar the emission increased up to 14%. Using dual fuel of rubber seed and Jetropha oil, the CO amount was decreased. The result obtained from the graph at 240 bar and B20 given the best with compared to the other biodiesel.

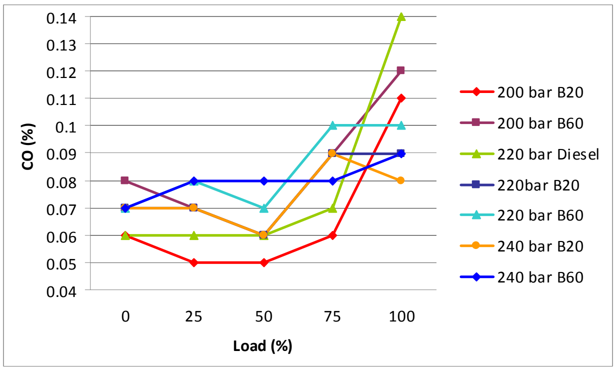

Fig 3.Variation of CO emission with different load

D. Hydro Carbon (HC)

The unburned hydro carbon of tested engine with the different injection pressures of two different bio mixing such as B20, B60 are shown in Fig. 4.When load increases, the HC emission is reduced in pure diesel and biodiesel fuels. At 220 bar the HC increased at low load as 23% and 26% at higher load. At 240 bar and various different proportions like B20 and B60 due to the complete combustion of biodiesel the HC was gradually decreased at the rate of 13 % of low load and 12% of full load conditions. This emission reduction was comparatively lower than the pure diesel fuel. When the HC was reduced the oxygen content increased in the biodiesel fuels leads to increased complete combustion and the higher cetane number of biodiesel reduces the combustion delay, by increasing the injection timing.

E. Nitric Oxide (NO_x) Emissions

Fig. 5 shows the NOx emission characteristics for the engine which formed inside the combustion chamber during the combustion process due to the effect of atomic oxygen and nitrogen. When the exhaust temperature increased, the NOx also continuously increased. The NOx emissions of the two fuels continuously increased with the various engine load conditions using the different injection pressures.

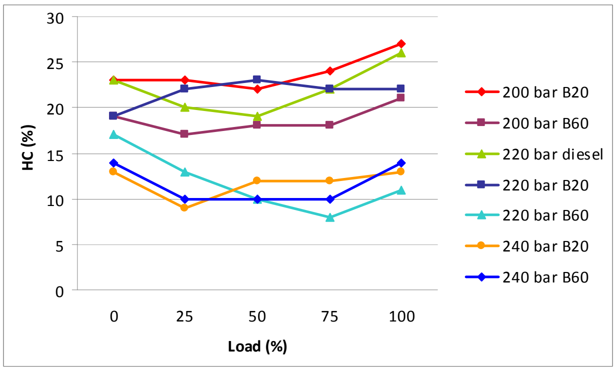

Fig 4.Variation of HC emission with different load

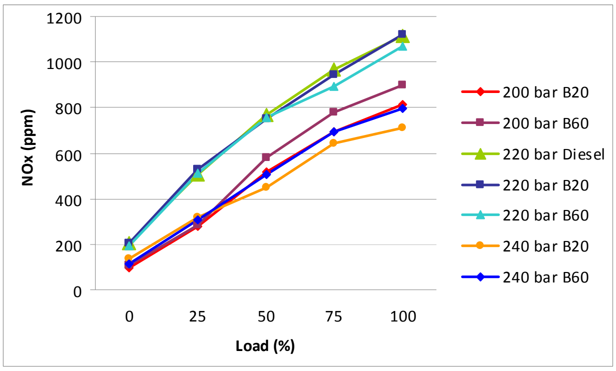

Fig 5.Variation of NO_x emission with different load

For the designed pressure of 220 bar and with B20 and B60, the NOx emission gradually increased comparatively low as 204 ppm at no load condition and 1120 ppm at full load condition. From the result at 240 bar, the blend B20 gives the better result compared to the other biodiesel fuel and pure diesel fuel. The reduced NOx at low load is 16 ppm to full load condition as 712ppm. It shows that the biodiesel blend ratios have more effect on the NO/NOx ratio at middle and high engine loads. The NO/NOx ratio increases with different engine load, and this illustrates, for an increased temperature in the cylinder, NO was formed.

IV. CONCLUSIONS

The rubber seed oil and Jetropha oil blended with the pure diesel in a single cylinder four stroke diesel engine maintained at a speed of 1500 rpm. The engine injection pressures were changed such as 200, 220 and 240 bar with the two proportions B20 and B60. The following conclusions were made from the experimental study.

At 220 bar and B60, the BSFC gradually decreased at no load to full load and at 240 bar BSFC was also reduced from 0.40 kg/kW-h to 0.24 kg/kW-h. It was found that at 240 bar with different proportions gives the better performance.

In Brake thermal efficiency the injection pressure at 220 bar with blend B60 increased up to 32% as compared to the diesel fuel. While the injection pressure was increased the BTE also increased with the different blends.

From the tested engine using diesel fuel at 220 bar the CO was increased up to 14%. Using dual fuel of rubber seed and Jetropha oil with diesel fuel the CO and HC decreased up to 12% and 13 ppm respectively. It is concluded that at 240 bar, the blend B20 given the best result as compared to the other biodiesel.

If exhaust temperatures increases, the NOx also increased. At the injection pressure of 240 bar the same proportions as B20 and B60 with different load conditions gives the better result compare to the other biodiesel fuel and pure diesel fuel. The reduced NOx at low load is 16 ppm to full load condition is 712 ppm which is lower than that of the diesel fuel.

(1)

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REFERENCES

[1] Forso F.K, Oduro E.K, 2004," Performance of Jetropha oil blends in a diesel engine", Renewable Energy, 29, pp.1135-1145.

[2] Cenk Sayin, Ismet Celikten, 2010, Variation of Performance and emission characteristics of a diesel engine fueled with diesel, rapeseed oil and hazelnut oil methyl ester blends, Fuel, pp.1407-1414.

[3] Jindal S, 2010 , Experimental investigation of the effect of compression ratio and injection pressure in a direct injection diesel engine running on Jatropha methyl ester. Applied Thermal Engineering, 30, pp.422-448.

[4] Sahoo P.K. LM. Das, MKG Babu, P. Arora, V.P. Singh, NR Kumar, T.S. Varyani, 2009, Comparative evaluation of Performance and emission characteristics of jatropha, Karanja and Polanga based biodiesel as fuel in a tractor engine, Fuel, 88, pp.698-1707.

[5] Frank Lujaji, Lukas Kristof, Akos Bereczky, Makame Mbarawa, 2011, Experimental investigation of Fuel Properties, Engine Performance, Combustion and emissions of blends containing croton oil, butanol and diesel on a CI engine, fuel 90, pp.505-510.

[6] Pandian M. , Sivapirakasam S.P, Udayakumar M., 2011 Investigation on the effect of injection system parameters on performance and emission characteristics of a twin cylinder compression ignition direct injection engine fuelled with Pongamia, bio-diesel-diesel blend using response surface methodology, Applied Energy, 88, pp.2663-2676.

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