Experimental investigation of Multi Cylinder DI Diesel Engine Fuelled with Dual Bio - Fuels

S. Mahalingam[1], V. Ravikumar[2]

[1, 2] Associate Professors, Department of Mechanical Engineering, Sona College Technoogy, Salem - 636005
smahasona[at]gmail.com

Abstract: ***In this experimental study, the performance and emission characteristics were investigated for dual bio fuel (Jatropha oil and Rubber seed oil) in a Multi cylinder diesel engine by retarding the injection timing maintained at standard injection timing of 24º. The blends used in B20 (Biodiesel - 20%), B40 (Biodiesel - 40%), B60 (Biodiesel - 60%) with pure diesel fuel. This paper reveals about the influence of dual bio fuel blends with pure diesel fuel. The performance and emission parameters considered for the tests are SFC (Specific Fuel Consumption), CO (carbon monoxide), NO_X (nitrogen oxide) and UHC (unburned hydro carbon). These parameters were analyzed for different load conditions varying from zero to 100 % load. From the test results, it was observed that SFC is lower for B20 blend compared to that of pure diesel fuel whereas B40 and B60 blends have slightly higher values but are closer to B20 blend. It is also found that the emissions of CO, UHC were reduced with increase in blends of biodiesel in the fuel mixture but NO_x emission is increased with increase in blends of biodiesel in the fuel mixture.***

Keywords: Multi cylinder Engine, Bio Fuel, Injection Timing, Performance and Emission.

1. Introduction

In the transportation and agriculture sector, various renewable liquid bio - fuels derived from biological resources have proved to be good alternatives for fuels derived from crude oils. For the problems of environmental effects, energy safety, restricting imports, village people employment and agricultural wealth, these bio - fuels are gaining global acceptance as a solution. The most promising biofuel, and closest to being competitive in current markets without subsidy, are methanol, ethanol, vegetable oils and biodiesel. Cenk Sayin et al [1]. studied the influence of injection timing on the engine performance and exhaust emissions by using ethanol blended diesel fuel from 0% to 15%. The different injection timing was used are 21˚, 24˚, 27˚, 30˚ and 33˚, the experimental results showed that the BSFC and emissions of CO and NO_x increased as BTE and emissions of CO and HC decreased with increasing amount of ethanol in the fuel mixture. Hyung jun Kim et al [2] Investigated the bowl shape of the engine piston head was modified to apply the narrow spray angle and advanced injection timing. The injection timing ranging from BTDC 80° to BTDC 10° and two fuel masses were selected. NOx emissions at injection timing before BTDC 30° remarkably decreased, while hydrocarbon (HC) and carbon monoxide (CO) emissions at injection timing of BTDC 70° showed high levels. The IMEP and ISFC have decreasing and increasing patterns respectively as the injection timing was advanced. Z. Zhu et al [3]. Studied about a two - cylinder, DI diesel engine was retrofitted to run on diethyl ether (DME) fuel. Under different fuel delivery timing, UHC, CO, NO_x, smoke, DME and formaldehyde (CH_2O) emission characteristics of DME engine were investigated and compared with diesel engine. Compared with diesel engine, DME engine can achieve smoke - free and significant lower THC and NO_x emissions. The CO exhaust emission of DME engine is decreased at low and middle engine speed conditions as well. CH_2O emissions for both fuels are roughly equal. The injection timing retarded in DME, NO_x emission can be further reduced, while the increase of CO, THC, DME and CH_2O emission are observed. R. Chandra et al [4] The maximum brake power produced by the engine was found at ignition advance of 35˚ TDC for all the tested fuels. In comparison to diesel as original fuel, the power deteriorations of the engine was observed to be 31.8%, 35.6% and 46.3% on compressed natural gas, methane enriched biogas and raw biogas, respectively, due to its conversion from CI to SI mode. The methane enriched biogas showed almost similar engine performance as compared to compressed natural gas in terms of brake power output, specific gas consumption and thermal efficiency. Ruijun Zhu et al [5] studied the effects of DMM addition and fuel injection timing on combustion characteristics, fuel efficiency and emissions of a compression - ignition engine fueled with diesel - dimethoxymethane (DMM) blends. It was found that NO_x is slightly increased, when advancing fuel injection from 20 to 23 CA BTDC, the number of nanoparticles is reduced; the further advanced fuel injection timing from 23 to 26 CA BTDC produces more nanoparticles. In this study, the lowest nanoparticle number in exhaust gas was achieved by injecting diesel - DMM blends with 50% DMM addition at 23 CA BTDC. M. Mani et al [6] analyzed the influence of injection timing on performance, emission and combustion characteristics of a DI diesel engine running on waste plastic oil. Tests were performed at four injection timings (23˚, 20˚, 17˚ and 14˚ BTDC). When compared to the standard injection timing of 23_ BTDC the retarded injection timing of 14˚ BTDC resulted in decreased oxides of nitrogen, carbon monoxide and unburned hydrocarbon while the brake thermal efficiency, carbon dioxide and smoke increased under all the test conditions.

In this study, the esterified rubber seed oil and jatropha oil blended with pure diesel fuel was used with different blends such as B20, B40 and B60 to obtain the performance such as brake specific fuel consumption (BSFC) and emission characteristics of CO, UHC and NO_x of a Multi cylinder constant speed direct injection diesel engine running at 2000 rpm and maintained at injection timing 24˚ constant injection pressure and mass flow rate. The diesel engine was performed change of rated power to measure the performance and emission characteristics without any engine modification. Table 1 gives the properties of the fuels considered for the study.

Table 1: Properties of Fuels

Property	Diesel	Rubber seed oil (RSO)	Jatropha oil (JO)	Bio – diesel (RSO & JO)
Sp. Gravity	0.74	0.82	0.96	0.90
Viscosity at 40˚C [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

2. Experimental Setup and Procedure

The Multi cylinder diesel 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 2000 rpm with the different biodiesel proportions. The diesel engine (TOYATA made) was directly attached with an eddy current dynamometer for changing the different loads. The test rig was installed in thermal engineering laboratory with software for obtain various curves and results during operation. A five exhaust gas analyzer was used measured the exhaust emission characteristics such as UHC, CO and NO_x values from exhaust gas. The performance and emission test was conducted for the compression ratio of 17.5 at maintained constant injection timing and pressure at rated power of 4.4 KW. The test was carried out at different proportions such as biodiesel 20%, 40% and 60% blended with diesel fuel. The performance analysis of the diesel engine at different rated power was evaluated in terms of brake specific fuel consumption (BSFC) and emission characteristics such as carbon monoxide (CO), un - burnt hydrocarbon (UHC) and Nitric oxide (NO_x).

3. Results and Discussions

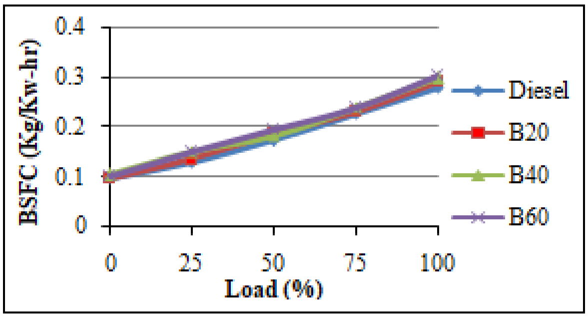

Figure 1: Variation of load and BSFC

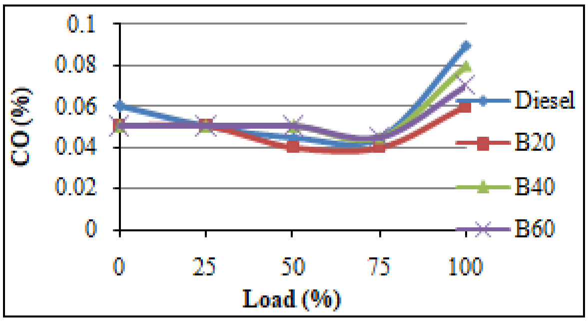

Figure 2: Variation of load and CO emission

3.1 Brake Specific Fuel Consumption (BSFC)

Fig 1. Shows that the variation of brake specific fuel consumption for dual fuel with standard timing and different biofuel proportions. The BSFC was increased at 0% load to 100% load condition. It indicates that the blends B20, B40 and B60 were increased from 0.1 Kg/KW - hr at no load to 0.28, 0.29 and 0.3 Kg/KW - hr respectively. The Diesel gave better result when compared to other 3 blends that is the fuel consumption of diesel is less due to higher calorific value. This also may be due to increase of ignition delay and the fuel may take longer time to burn completely to produce large amount of heat energy as a result there is an increase of fuel consumption. This BSFC graph reported that by changing the biofuel blends with maintained standard timing of this Jatropha oil and Rubber seed oil bio dual fuel blends with diesel results in higher brake specific fuel consumption.

3.2 Carbon Monoxide (CO) Emissions

CO emissions are mainly due to incomplete combustion of fuel and it is produced most readily from petroleum oils, which contain no oxygen in their molecular structure. Generally Co emissions are affected by start of injection timing, injection pressure, engine load, speed and improper air fuel mixing. Fig 2. shows the variation of carbon monoxide with changing the load conditions. In Multi cylinder constant speed engine with maintained standard timing the CO was analyzed using the exhaust gas analyzer and smoke meter. The CO emission of diesel is increased from 0.06% at no load to 0.09% at full load. The B40 is increased from 0.05% at no load to 0.08% of full load. The B60 is increased from 0.05% at no load to 0.07% at full load and B20 increased from 0.05% at 0% load to 0.06 at 100% load thus gives an optimum value and better result when compared to diesel. The CO emission of diesel is increased by 0.03% and B20 is increased by 0.01%.

3.3 Un - Burned Hydrocarbon Emissions (UHC)

UHC emission is mainly due to incomplete combustion and partially burning of fuel this may be due to improper air fuel ratio, higher density and viscosity of fuel. Fig 3. shows the variation of hydrocarbons at different loads with respect to injection timing, the Diesel is increased from 18 ppm at no load to 18.5 ppm at full load, B40 is increased from 12 ppm at no load to 18.5 ppm at full load, B20 increases from 18 ppm at no load to 18.5 ppm at full load and B60 increases from 156 ppm at no load to 17 ppm at full load thus giving a better result when compare to diesel. It is reported that the retardation injection timing is not suitable parameter for diesel fuel for reducing HC emission by using this dual bio fuel and the lower cetane number of biodiesel increases the combustion delay, by reducing the injection timing.

Paper ID: SR221124211020 DOI: 10.21275/SR221124211020

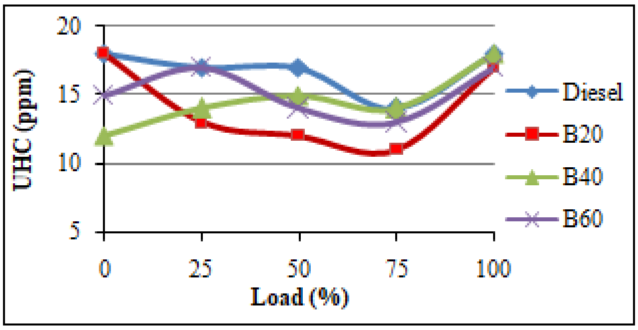

Figure 4: Variation of load and UHC

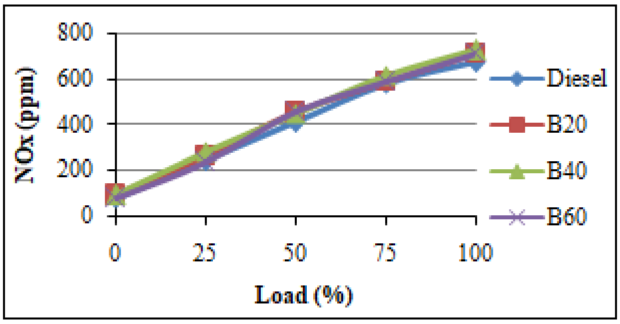

Figure 4: Variation of load and NO_x

3.4 Nitric Oxide (NO_x) Emissions

Variation of NOx with engine load was shows in fig 4. When the exhaust temperatures increase the NO_x emissions is also simultaneously increased. By injected dual fuel blends with diesel at maintained constant pressure and injection timing the NO_x emission of the two fuels continuously increased with the various engine load conditions. At bio blends B20, B40 and B60 gradually increased from 0% load to 100% load. In the blend B40 gave the higher value of nitric oxide emission from 99 ppm to 700 ppm at no load to full load and diesel fuel slightly increases the NO_x emission from 95 ppm to 660 ppm at no load to full load and giving the optimum value this may be due to higher calorific value. At variation of different loads the exhaust temperature increases gradually and this causes NO_x emission. This graph indicates clearly that the Nitric Oxide emission increases in bio diesels Dual fuel, Jatropha oil and Rubber seed oil blends with diesel.

4. Conclusions

The multi cylinder engine was run with dual fuel mode at the speed of 2000 rpm. From the result brake specific fuel consumption of diesel is optimally increased when compared to other bio diesel blends which increases higher than that of diesel. The CO emission of diesel is gradually increasing from 0.06% at no load to 0.09% at full load by without modified the test engine. The B20 gave the better result which increases 0.05% to 0.06% at 0% load to 100% of full load condition. This dual bio fuel, the unburned hydrocarbon emission (UHC) of B60 is from 15 ppm to 17 ppm while the UHC emission of diesel fuel is from 18 ppm to 18.5 ppm. Thus B20 gives the better result. The increase of diesel fuel may be due to change in density of fuel at different stages. The NO_x emission is seems to be increased for all the three blends B20, B40 and B60 and also with diesel fuel this mainly due to increase of exhaust gas temperatures from 0% load to 100 % load. The B40 gave the higher value of 710 ppm at 100% load while the diesel fuel gave 660 ppm at full load which is optimum for this dual bio fuel and lower than that of the B40 blend. On comparing dual fuel performance and emission characteristics from the graphs of B20, B40 and B60 with diesel, it observed that SFC of B40 and B60 is high compared to that of pure diesel. Thus the dual blend of B20 will be more effective compared to other blends fuel.

References

[1] Cenk Sayain, Mustafa Canakci, " Effect of Injection Timing on the engine performance and exhaust emissions of a dual - fuel diesel engine". Energy Conversion and Mangament 50 (2009) 203 - 213.

[2] Hyung Jun Kim, Kwan Soo Lee, Chang Sik Lee, "A Study on the reduction of exhaust emissions through HCCI combustion by using a narrow spray angle and advanced injection timing in a DME engine", Fuel Processing Technology 92 (2011) 1756 - 1763.

[3] Z. Zhu, D. K. Li, J. Liu, Y. J. Wei, S. H. Liu, " Investigation on the regulated and unregulated emissions of a DME engine under different injection timing", Applied Thermal Engineering 35 (2012) 9 - 14.

[4] R. Chandra, V. K. Vijay, P. M. V. Subbarao, T. K. Khura, " Performance evaluation of a constant speed IC engine on CNG, methane enriched biogas and biogas". Applied Energy 88 (2011) 3969 - 3977.

[5] Ruijun Zhu, Haiyan Miao, Xibin Wang, Zuohua Huang, " Effects of fuel constituents and injection timing on combustion and emission characteristics of a compression–ignition engine fueled with diesel –DMM blends". Proc of Combustion Institute, SciVerse Science Direct 34 (2013) 3013 - 3020.

[6] Biplab K. Debnath, Niranjan Sahoo, Ujjwal K. Saha, " Thermodynamics analysis of a variable compression ratio diesel engine running with palm oil methyl ester". Energy Conversion and Mangament 65 (2013) 147 - 154.