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Effect of Biodiesel Blends on Diesel Engine

Akash Paul[1], Amiya Bhaumik[2], Kushal Burman[3]
[1]Lecturer, [2,3]Assistant Professor
Mechanical Engineering Department, Technoindia - Saltlake, Kolkata, West Bengal

ABSTRACT
The present research, utilised only renewable oil samples to reduce atmospheric pollution and also to decrease our reliance on fossil oil products and provide a direction towards alternative fuel usage in diesel engines. On a 1-cylinder, naturally aspirated, water-cooled, 4S, CI diesel engine, the tests have been conducted as to create comparative results of performance-emission characteristics in between the blends of conventional diesel, biodiesel thumba, biodiesel polanga and ethanol fuel. With the following blends, the diesel engine has been tested as such: diesel fuel (D100) (v/v), thumba biodiesel 100% (T100) (v/v), polanga biodiesel 30% with addition of diesel 70% (P30) (v/v), and ethanol 10% with addition of diesel 90% (E10) (v/v). The engine performance parameters: BTE of E10 and P30 blend was incremented than the diesel fuel, while the blends T100 was close enough to diesel fuel as well; whereas, BSFC data of E10 blend was the lowest in between the others samples and for T100 and P30 also it decreased. The emission values for CO, NOx and UHC of the blend samples was less than diesel fuel. The maximum CO2 emission was released by D100 and least by P30 fuel blend, whereas, the unused O2 released was the reverse. The effects of direct inhalation of biofuel blends in IC engine were analysed properly and in near future this alternative oil can be applied in our society.

Keyword: *Diesel engine, biodiesel polanga and thumba, ethanol, emissions, performance.*

I. INTRODUCTION

With the increasing population, industries, automobiles, infrastructure etc., in the developing and developed countries; the necessity for conventional diesel fuel is escalating day by day to fulfil our needs along with the depletion of oil from the reservoirs. Many nations in the world are importing petroleum products from different gulf nations in order to fulfil their demands with increasing price hike on daily basis. The use of diesel engine emits large amount of exhaust air pollutant gases such as CO, UHC, NO_x, PM, smoke, soot, CO_2, etc. although resulting higher BTE and performance. So, mostly all nations being governed by their authorities has imposed emission regulation on the diesel engine emissions. The CI engine emission has a negative effect on our environment which leads to greenhouse effect, global warming, etc. and directly or indirectly having an effect on our health [1]. So, in order to reduce our dependence for importing oil from other countries, and to reduce the emission level, reduce fuel cost, we have to search for an alternative fuel which can be grown, produce and extract from our own country, which will be renewable, biodegradable, easily available, non-toxic, environmental friendly and low cost. These days' biodiesel is very much effective and in demand as an alternative since it is eligible for the aforesaid and it can be directly applied in the diesel engine after blending with different fuels as well as diesel fuel. Biodiesel such as jatropha, karanja, cottonseed, sunflower, neem, thumba, polanga, etc. could be used to the CI engine without any change. Its usage will also reduce the greenhouse gas emission which is responsible for climate change, increase the farm income and also promote rural development and create global agricultural market [2].

Several investigation results reveal that, with the usage of neem biodiesel and polanga biodiesel on a one cylinder, CI engine, the emission was high for neat diesel fuel whereas the performance was moderate in case of diesel fuel w.r.t the other blends [3]. Also, another work with different biodiesel feedstock with low percentage of biodiesel with diesel blends provide increased engine performance along with reduced emission characteristics [4]. One research with the blends of jatropha biodiesel (25%, 50%, 75% and 100% (v/v)) and D100 were operated on 1-cylinder, CI engine and found that BTE of jatropha biodiesel fuel blends was differentiable w.r.t D100 at varying load equivalents, at peak load, NO_x emission blends of jatropha biodiesel blends was higher, smoke emission was lower and CO emission was also lower than diesel fuel [5]. Another report of diesel engine with compression ratio, injection timing and nozzle opening pressure had a substantial outcome on performance-emissions parameters of CI engine when inhaled with diesel-biodiesel blend [6]. One of the research, with jatropha biodiesel (5%, 10%, 15%, 20% and 100%) blended with diesel fuel at and operated in the IDI CI engine with addition of exhaust gas recirculation, resulted into as best fuel economy for 10% biodiesel blended diesel fuel, also, NO_x emissions incremented while smoke emission lowered at all speed ranges [7]. Another investigation, shown the effect of Linseed oil biodiesel as a fuel, with varying the fuel injection pressures on a constant speed, DI, diesel engine and it was observed that the performance and emissions at peak injection pressure got improved [8].

II. METHODOLOGY

In this present research, the fuel samples created for the work were diesel fuel, biodiesel thumba, biodiesel polanga and ethanol. The fuel samples were brought from the nearby market. The properties for the fuel samples were displayed in Table I. The research engine setup comprised of a 1cylinder, 4S, naturally aspirated, water-cooled, diesel engine, engine test bed, and exhaust gas analyser for metering the emission from diesel engine exhaust gas, and eddy current dynamometer for rendering load. The engine arrangement setup is showed in Fig. 1, and for CI engine specification, it is detailed in Table II. There was no requirement for engine modification for fuelling blended biodiesel, ethanol with diesel fuel, the fuel was directly inhaled along with diesel fuel in the engine.

TABLE I PROPERTIES OF FUEL SAMPLES

Properties	Diesel	Thumba Biodiesel	Polanga Biodiesel	Ethanol
Density, kg/m^3 at 20°C	842.4	891	889	788
Calorific Value, KJ/kg	42510	42500	38550	26800
Cetane Number	50	52	57.3	8
Kinematic viscosity, x10^{-2} m^2/s at 20°C	2.8	5.3	5.2	1.2
Latent heat of evaporation, (kJ/kg)	252	232	200	840
Flash point ($^\circ$C)	79	174	151	13.5
Auto-ignition temperature, ($^\circ$C)	251	238	363	420
Oxygen content (wt%)	0	12	10	34.8

The fuel samples prepared for this research work are: D100 - diesel fuel 100% (v/v), T100 - thumba biodiesel 100% (v/v), P30 - polanga biodiesel 30% with addition of diesel 70% (v/v), and E10 - ethanol 10% with addition of diesel 90% (v/v). At the beginning, the engine was operated with conventional diesel oil and was tested at various loads as such: 0%, 25%, 50%, 75% and 100%, to get the reference data and to create an comparative study between the performance-emission data of various blend samples. Before any investigation with any new blend, the engine was operated for ample amount of time until the last drop left in the fuel tank to wipe out the remaining fuel during the ongoing work. The engine speed was maintained near about to i.e., 1500rpm of the engine for which proper care was taken and also, the repetition of the data for an individual blend was taken for four consecutive readings and finally averaged to get the net data.

TABLE II EXPERIMENTAL ENGINE DETAILS

Parameters	Values
Make-Model	Kirloskar-Varsha
No. of Cylinder	Single
Bore X stroke	80 X 90 mm^2
Max. power	3.12 kW
Compression Ratio	20:1
Engine speed	1500 rpm
CC Position	Vertical
Ignition method	Compression Ignition

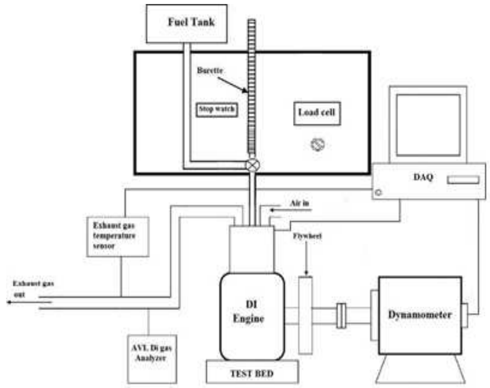

Fig. 1: Experimental Engine Arrangement

The entire investigation was conducted at an isolated space with a temperature of 25-27 ^{0}C. The performance parameters such as BTE, BSFC data were observed on the DAQ system, whereas, for measurement of exhaust emission gas parameters such as CO, UHC, CO_2, NO_X, and O_2 was displayed by AVL 5 gas analyzer.

III. RESULT & DISCUSSIONS

The present work details the performance and emission characteristics which are being detailed as follows.

A. Brake Thermal Efficiency

Fig. 2 shows the deviation of Brake thermal efficiency against Load for different fuel blends. The BTE for all the fuel samples including D100 was found to rise along with the increase in the load. It was observed for neat diesel D100, T100 fuel, the BTE to decrease throughout the operation in comparison to other blend samples, which might be due to the increase in the viscosity of thumba biodiesel; because of which, the fuel particles could not mix properly with the air molecules to develop homogeneous mixture in order to beget higher BTE. In the entire operation, the BTE for E10 blend showed an increasing trend during the whole scenario w.r.t other fuel samples. It might be due tthe high auto-ignition temperature, less

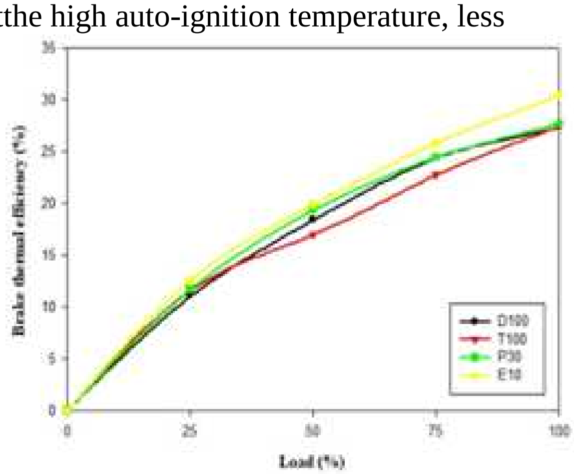

Fig. 2: Brake thermal efficiency variation with Load

viscosity and less density of the E10 blend. Also, the BTE of P30 blend was quite close enough to E10 blend.

B. Brake Specific Fuel Consumption

Fig. 3 displays the deviation of brake specific fuel consumption against the Load for all the fuel samples. The BSFC for all the blends showed a decreasing course throughout. The BSFC of T100 fuel was maximum throughout w.r.t the different oil. For E10 blend, the BSFC showed the least throughout the procedure w.r.t the various fuels, which might be due to the ethanol rich O_2 content. Whereas, the BSFC for D100 lowered during the final two loads. Also, the P30 blend BSFC got higher during the peak load condition.

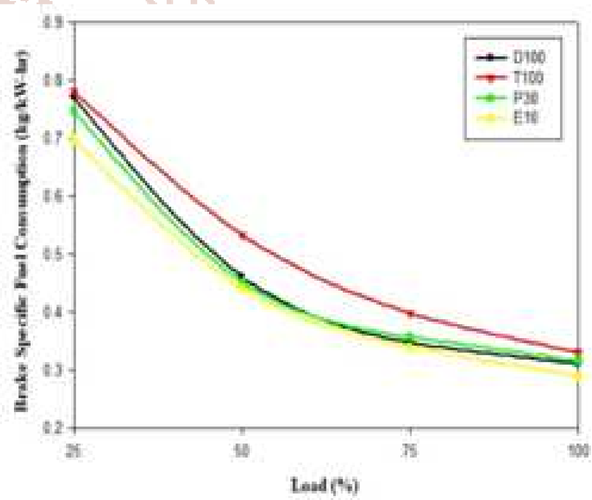

Fig. 3: Brake specific fuel consumption variation with Load

C. Carbon Monoxide

Fig. 4 displays the deviation of Carbon Monoxide against load for all the fuel samples. The emission of CO had a decreasing course throughout the entire operation. For the entire duration the CO emission for D100 fuel was maximum. Whereas, in comparison to D100 a decreasing trend was observed for all the biofuel blends such as T100, P30 and E10, which might be due to the rich oxygen content of biodiesel and ethanol in blends along with diesel fuel. The CO of P30 blend was the least during the peak load whereas, initially the E10 blend had the least CO emission.

D. Unburnt Hydrocarbon

Fig. 5 highlights the deviation of Unburnt Hydrocarbon against Load for all fuel samples. The UHC emission for all the samples increased initially but then lowered with the increase in load condition, which might be because of the improved combustion after the initial load. Emission UHC of diesel fuel remain higher during the entire operation. UHC of T100 fuel remain lower throughout as compared to D100, which could be due to the high CN of thumba biodiesel. The UHC was further lower for P30 blend and the lowest was for E10 blend w.r.t. D100, which could be due to the rich oxygen content of ethanol.

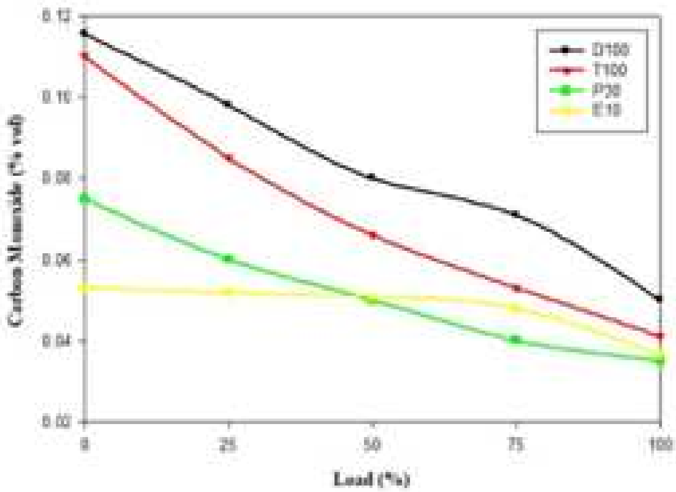

Fig. 4: Carbon monoxide variation with Load

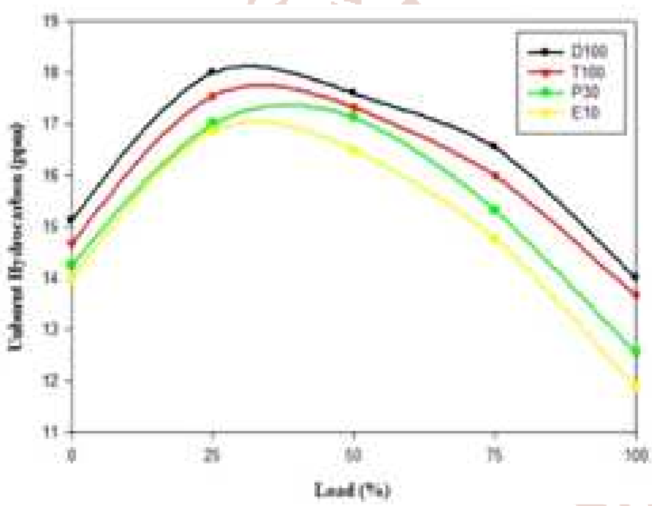

Fig. 5: Unburnt hydrocarbon variation with Load

E. Oxides of Nitrogen

Fig. 6 shows the deviation of Oxides of Nitrogen against Load in all fuel samples. The NO_x emission showed an increased trend during the engine operation, also, NO_x emission for D100 fuel was highest throughout. The T100 fuel NO_x emission was quite decreased w.r.t diesel fuel. The NO_x was lower for E10 but the NO_x emission for P30 blend was the least when compared to the other fuel samples. For each cases, the reason might be, with the increase of load the combustion temperature also increases which leads to the forming of higher NO_x emission.

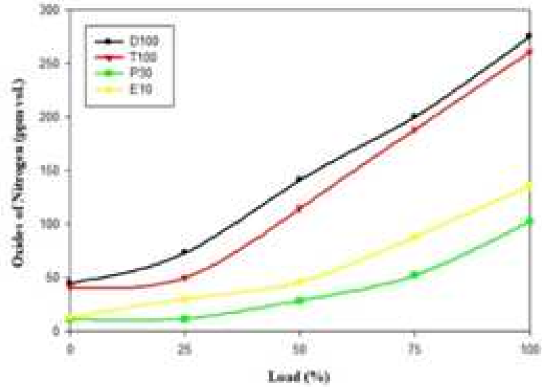

Fig. 6: Oxides of Nitrogen variation with Load

F. Carbon Dioxide

Fig. 7 highlights the deviation of Carbon dioxide against Load for all fuel samples. At different load conditions, the CO_2 emissions incremented throughout. The D100, T100 oil sample was increased CO_2 than E10 blend. The CO_2 emission got decreased for P30 blend w.r.t diesel fuel.

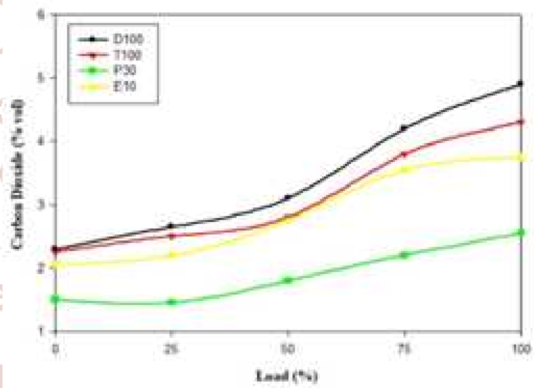

Fig. 7: Carbon Dioxide variation with Load

G. Unused Oxygen

Fig. 8 displays the deviation of Unused Oxygen against load for all fuel samples. The unused O_2 for T100 decreased the most during the peak load condition w.r.t D100 fuel. P30 blend had an increasing nature of unused O_2 w.r.t different fuel blends.

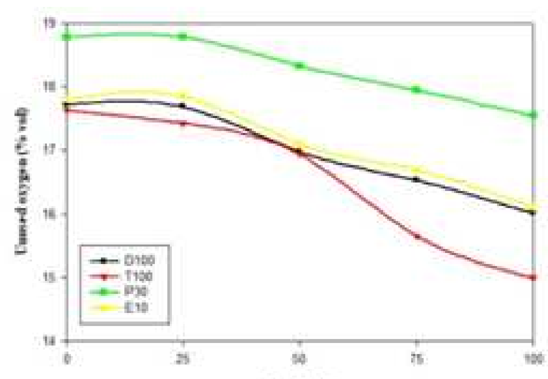

Fig. 8: Unused Oxygen variation with Load

IV. CONCLUSIONS

The present research, was conducted on a 1-cylinder, 4S, naturally aspirated, water cooled, CI diesel engine. In the performance characteristics, the BTE of E10, P30 fuel blends was more than D100 fuel, whereas, the BSFC of T100, P30 fuel blends increased but with a decreasing trend than E10 and diesel fuel. The BTE for E10 blend was highest w.r.t various fuel samples and the lowest was for T100 fuel. The BSFC was the least for E10 blend w.r.t others fuel samples. The CO emissions of the biodiesel fuel blends (T100, P30) and ethanol blends (E10) decreased than that of neat diesel (D100). For T100 and P30 blends, the UHC emission was decreasing in comparison to D100 fuel. NO_x emission of P30, E10 and T100 fuel samples got decreased in comparison to D100 fuel. The CO_2 emission of D100, T100 and E10 was increased than P30 fuel blend throughout the process. The T100 fuel shown decreased unused O_2 than other fuel samples. The unused O_2 for P30 and E10 blend was more than D100 but the T100 fuel blend showed a decreasing trend throughout the process. The emission gases such as CO, NO_x, and CO_2 for P30 blend was least w.r.t various fuel samples. For comparison of performance-emission characteristics with diesel fuel, the above blend samples used had a good effect on the output, and several investigators also had similar findings. In case, there is reduction for imported petroleum oil, then we can create our own renewable alternative fuel on our own land and run our automotive vehicles, and if the production of these biofuel would increase then their cost would decrease, resulting into increasing farm economy.

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