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Effect of Diesel Engine Fuelled with Biofuel Blends

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ABSTRACT
The present work was conducted on a 1-cylinder, 4S, DI CI engine, on which neat diesel, neem biodiesel and polanga biodiesel and ethanol fuel were tested by varying the load on the engine setup at various blend ratios such as: – diesel fuel 100% (D100), biodiesel neem 100% (N100), biodiesel polanga 50% blended with diesel 50% (P50), and ethanol 5% blended with diesel 95% (E5).The research carried was to compare the performance-emission characteristics of various blend samples w.r.t neat diesel fuel. The performance results show that, the BTE of N100, P50 fuel blends was less than E5 blend, as compared to neat diesel, whereas, the BSFC of D100, E5 blend had a decreasing nature than N100 and P50 blend. The CO emissions among the biofuel blends was maximum for N100 and then P50 blend but the least was for E5 blend w.r.t neat diesel. Also, the UHC emission for N100, P50 and E5 blends had a decreasing trend than neat diesel fuel. The D100 fuel had a maximum NOx emission in comparison to others and the least was by E5 blend. The CO2 emission of N100 and D100 was the highest than P50 and E5 blends during the operation. The unused O2for N100 fuel was the least than other fuel samples and the maximum was for E5 blend. The biofuel blends being used here had an effective outcome which can be utilised as an substitute for neat diesel.

Keyword: *Performance, emission, diesel engine, neem biodiesel, polanga biodiesel, ethanol.*

I. INTRODUCTION

The major issue being faced every day is the shortage of the petroleum oil in their origin, due to the excessive utilisation in automobiles, industries, etc. along with the increasing cost at various nations. With the excessive population, the need is inevitable. So, majorly petroleum oil is used in diesel engine, since it gives high efficiency along with heavy exhaust emission gases (i.e., PM, soot, smoke, CO_2, NO_x, UHC, CO). Though in the modern world with the emission regulation, new cutting edge innovative technology (mechanisms such as: CRDI, IDI, EGR, EGAT, etc.) to develop CI engine for reducing emissions from the engines. This emission has an adverse effect on the environment leading to climatic change, global warming, increased greenhouse gases; which directly or indirectly effects ourselves as well as the other living creatures, making them extinct in some areas. So, in order to cope up with the present scenario we need divert our attention towards alternative fuel technology, to fulfil the scarcity of petroleum products, save the environment, living creatures, reduce our dependence of oil import. Biodiesel is an effective alternate to petroleum oil, since, it is biodegradable, non-toxic, renewable, environmental friendly, easily grown and produced in the locality, reduce cost of oil if used in mass quantity. Also, biodiesel reduces greenhouse gas emissions, promote rural development by growing biodiesel plants such as neem, polanga, ricebran, thumba, jatropha, karanja, cottonseed, etc. which will increase farm economy, develop a global agricultural market as well. The biodiesel fuel can be directly injected in the engine and there is no need for any external or internal setup. Also, alcohols such as: methanol, ethanol, propanol, butanol, etc. were operated earlier in CI engines by blending with diesel and were being used in some nations as well. [1-2].

In the alternative fuel region, number of research has been done and which are being followed as. One researcher studied the effect of methyl ester at 15% blended with diesel-ethanol and diesel-butanol blends on combustion and emission of diesel engine, and results show that 15% of methyl esters was enough to avoid phase separation of diesel-alcohol blends, and also the use of diesel-alcohol blends reduced CO and soot emissions w.r.t biodiesel blends with the same oxygen content [3]. Another investigation was done on a 4-cylinder, 4S, DI diesel engine using anhydrous bio-ethanol-diesel blended with 10% ethanol in volume, the results which were obtained reveal a significant decrease on particulate emissions with no increment in other gaseous emissions [4]. With different blends of polanga biodiesel being operated on a single cylinder, diesel engine and when compared with diesel fuel, the polanga biodiesel blends resulted into improved performance and reduced emission w.r.t diesel fuel [5].Addition of ethanol as an oxygen at eadditive and dodecanol as the solvent to diesel shows higher brake specific fuel consumption with slight increase in brakethermalefficiency,howeverhigherethanolcontentreducescetanenumberofdiesel [6].Mohammadi et al. reported that blending ethanol with diesel fuel is effective in reducing nitrogen oxides (NOx) and particulate matter (PM),alsothe blending of fuel increased the HC and CO emissions [7]. Akash Paul et al. found the BTE of ethanol 10% blend with diesel fuel was highest along with least BSFC for ethanol 10% blend, whereas, the CO, UHC, NO_x got decreased for Thumba 100% and polanga biodiesel 30% when blended with diesel fuel [8].Another researcher, utilised biodiesel Jatropha- diesel blends along with a multi-DM-32dieseladditive, and the results show comparable performance efficiencies, and produce lowersmoke, $CO_2$and CO emissions [9].

II. METHODOLOGY

The fuels chosen for this present work were conventional diesel fuel, biodiesel neem, biodiesel polanga and ethanol. The fuels have been brought from the local market. The properties of the oil samples have been displayed in Table 1. The engine setup being employed for this operation consists of a 1-cylinder, 4S, water-cooled, DI, CI diesel engine, engine test bed, and also exhaust gas analyser for measuring the emission outputs from diesel engine exhaust gas. The investigation engine setup is shown in Fig. 1, and Table 2displays the engine details.

Table 1: Properties of Oil samples

Properties	Diesel	Neem Bio-diesel	Polanga Bio-diesel	Ethanol
Density, kg/m^3 at 20°C	842.4	912	889	788
Calorific Value, KJ/kg	42510	39500	38550	26800
Cetane Number	50	51	57.3	8
Kinematic viscosity, x10^{-2} m^2/s at 20°C	2.8	7.5	5.2	1.2
Latent heat of evaporation, (kJ/kg)	252	265	200	840
Flash point ($^\circ$C)	79	65	151	13.5
Auto-ignition temperature, ($^\circ$C)	251	288	363	420
Oxygen content (wt%)	0	13	10	34.8

For blending of neem biodiesel with diesel fuel, and blending of ethanol with diesel fuel did not require any engine modification, the fuel samples were directly inhaled by the engine.

For this investigation, the fuel blend samples prepared were – diesel fuel 100% (D100), biodiesel neem 100% (N100), biodiesel polanga 50% blended with diesel 50% (P50), and ethanol 5% blended with diesel 95% (E5). The engine was initially inhaled with neat diesel fuel and was operated by varying the load conditions as: 0%, 25%, 50%, 75% and 100%, to get the base data for diesel and to make an analysis in between the performance and emission data of different fuel blends. Any new blend before beginning the experiment, the engine was operated for sufficient time till the last drop to wipe out the leftover fuel droplets from the previous tests.

Table 2: Engine details

Parameters	Outputs
Make-Model	Kirloskar-Varsha
No. of Cylinder	Single
Bore X stroke	75 mm X 80 mm
Max. power	3.12 kW
Compression Ratio	20:1
Engine speed	1500 rpm
CC Position	Vertical
Ignition method	Compression Ignition

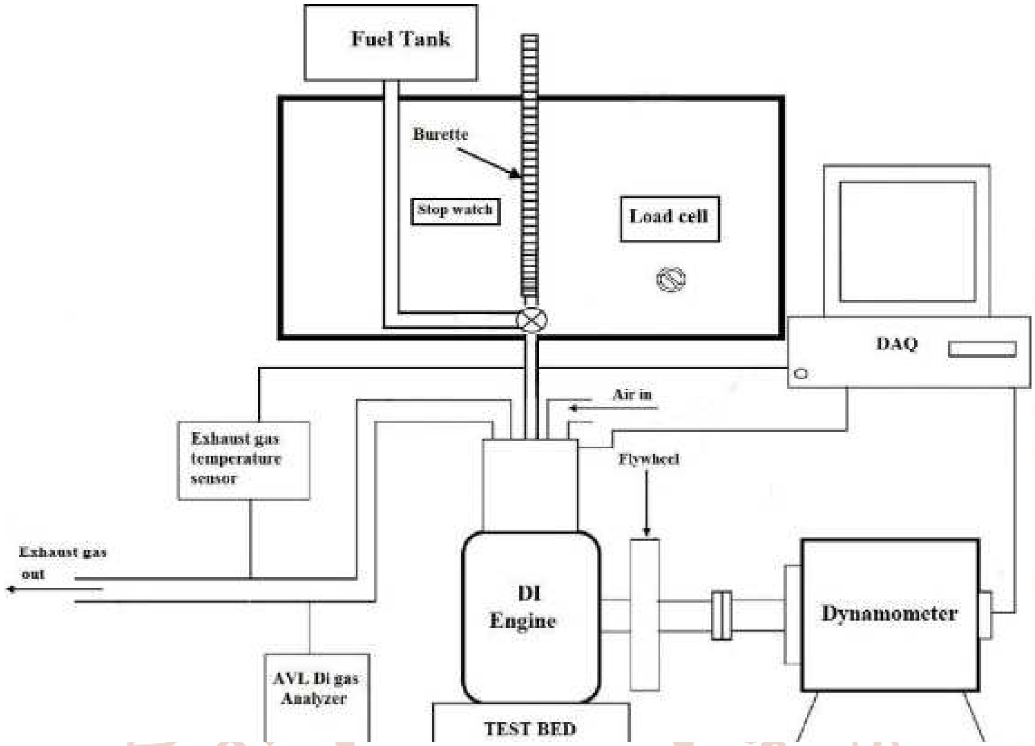

Fig. 1: Experimental Setup

To maintain the constant speed (i.e., 1500rpm) of the engine, special attention was taken and the data authenticity was increased by taking 5successive readings for each fuel blends and at last averaged them to get the final data for the diesel engine. The entire investigation was conducted on an isolated space at a temperature of 27^{0}C. The performance values such as BTE and BSFC were displayed on the DAQ system, whereas, for the exhaust emissions values such as CO, UHC and NO_X were measured by AVL 5 gas analyzer.

III. RESULT & DISCUSSIONS

The current research showcases the detailed discussions of performance and emission parameters for the different fuel blends which are as follows:

A. Brake Thermal Efficiency

Fig. 2 demonstrates the variation of Brake thermal efficiency w.r.t Load for various fuel blends. In all the fuel blends it was found thatE5 blend shown increased BTE at full load, which might be because of increased auto-ignition temperature, low viscosity and reduced density of ethanol. The BTE for D100 increased with the rise in the percentage of load as well but at the full load it decreased. For N100 i.e., neem biodiesel, the BTE was decreased

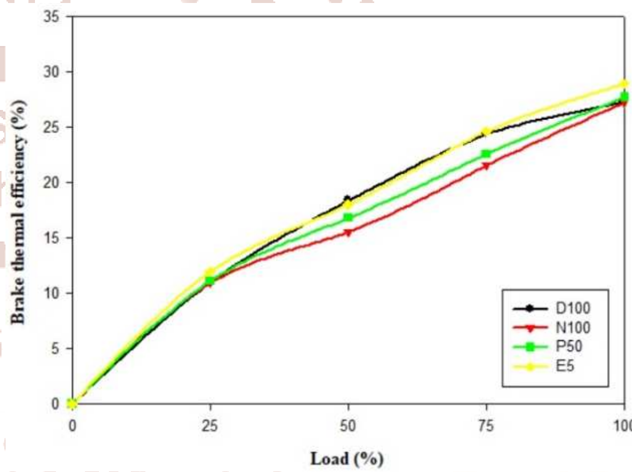

Fig. 2: Brake thermal efficiency w.r.t Load

Throughout the operation in comparison to D100, which might be because of richness of neem biodiesel kinematic viscosity; due to which, the fuel could not get much leaner in order to produce increased BTE. Also, the BTE for P50 blend was lower throughout the operation.

B. Brake Specific Fuel Consumption

Fig. 3 demonstrates the change of Brake Specific Fuel Consumption w.r.t Load for all fuel blends. The BSFC displays a decreasing nature during the whole operation for all the blend samples. For E5 blend, the BSFC was the least throughout. The BSFC of N100 was highest w.r.t other fuel blends, but decreased with the increase in load equivalent. This may be due to the

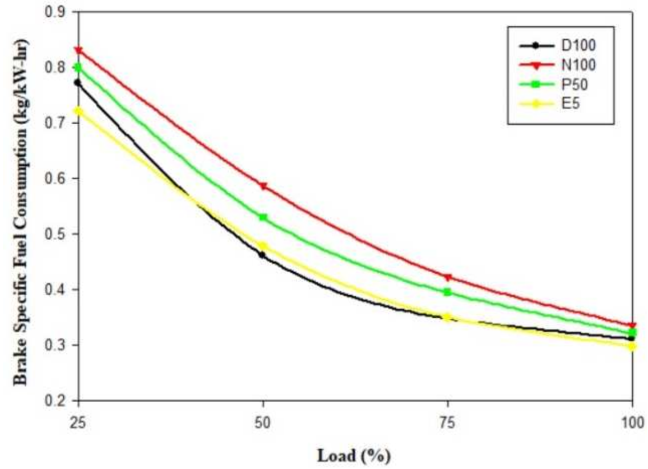

Fig. 3: Brake specific fuel consumption w.r.t Load

increased viscosity of neem biodiesel that in order to produce the same power output the consumption of fuel was maximum than other fuels. The BSFC of P50 blend also decreased throughout the operation but it's BSFC was more than neat diesel and E5 blend. The same reason as prescribed for N100 fuel is also stated here as well, since the percentage of polanga biodiesel was 50% in volume and the rest is neat diesel, so the BSFC for P50 blend is lesser than N100.

C. Carbon Monoxide

Fig. 4 demonstrates the variation of Carbon Monoxide w.r.t Load for all fuel blends. The CO for neat diesel i.e., D100 fuel was increased throughout the entire duration. Whereas, the CO emission for N100, P50 and E5 blends shows a decreasing nature w.r.t D100, which may be due to the richness of oxygen content of biodiesel neem and ethanol percentage in fuel blends along with addition of diesel fuel. The blends P50 showed decrease CO emission next toE5 blend, whereas, the N100 fuel also shown less CO than neat diesel but more than the other blends.

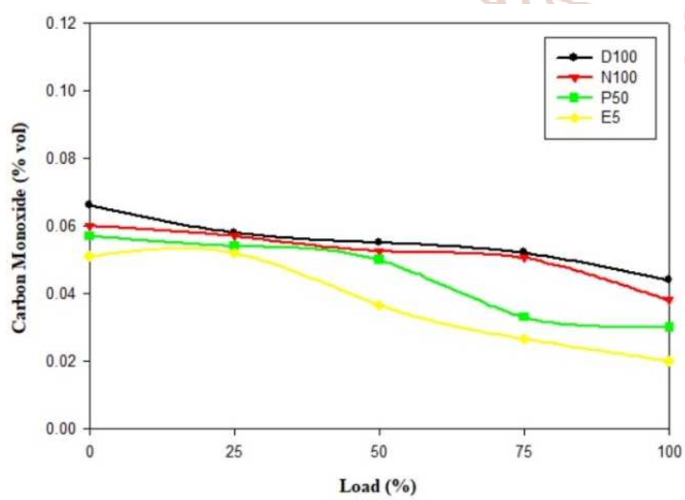

Fig. 4: Carbon monoxide w.r.t Load

D. Unburnt Hydrocarbon

Fig. 5 demonstrates the Unburnt Hydrocarbon w.r.t Load for all fuel blends. The UHC emission for all the blends increase in the initial phase but later decrease throughout, which might be due to better combustibility after the zero load condition. The UHC of diesel fuel was higher throughout the operation. The N100 fuel shown decreased UHC emission w.r.t neat diesel, which may be due to increased CN of biodiesel neem. The P50 blend shown lesser UHC emission w.r.t neat diesel and T100, but the least was shown by E10 blend as compared to other fuel samples; the increase in oxygen content of ethanol in blend may be the cause.

E. Oxides of Nitrogen

Fig. 6 demonstrates the change of Oxides of Nitrogen w.r.t Load in all fuel blends. The NO_x emission showed an increased trend during the whole procedure, which may be due to increase in in-cylinder temperature with the load increment. The NO_x emission for D100 was increased entirely. The N100 fuel NO_x emission got decreased than diesel fuel in comparison to other blends. The NO_x emission for P50 blend further decreased from neat diesel and neem biodiesel, but the NO_x emission was least for E10 blend.

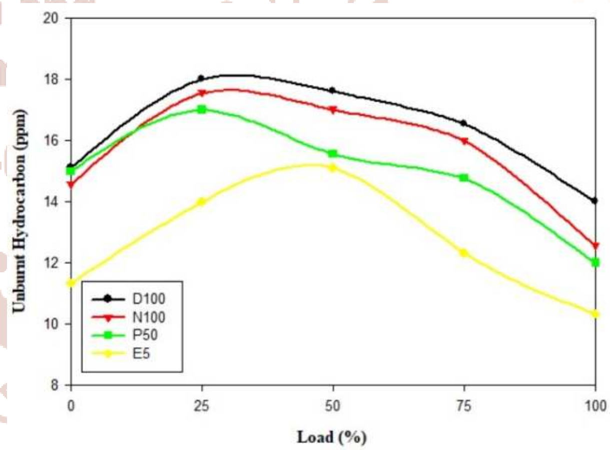

Fig. 5: Unburnt hydrocarbon w.r.t Load

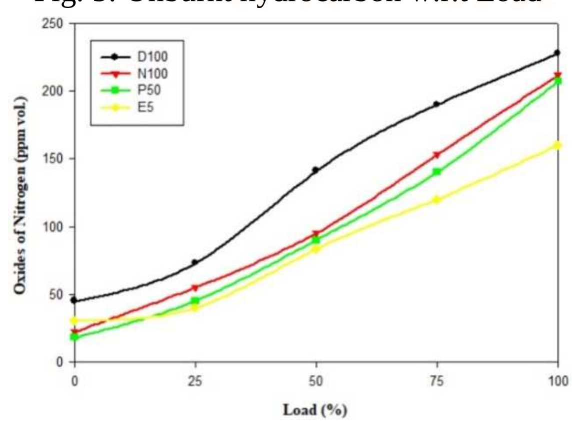

Fig. 6: NO_x w.r.t Load

F. Carbon Dioxide

Fig. 7 demonstrates the change of Carbon Dioxide w.r.t Load for all fuel blends. The CO_2 emissions increased at all load conditions in all fuel samples. The N100 and D100 fuels had an increased CO_2 than P50 blend. The CO_2 emission was lower for E5 blend w.r.t other fuel samples.

G. Unused Oxygen

Fig. 8 demonstrates the variation of Unused Oxygen w.r.t Load for all fuel blends. The unused O_2 for N100 fuel was the least as compared to other fuel samples. The unused O_2 of E5 blend was maximum throughout when comparing to fuel samples. P50 blend unused $O_2$was lower than neat diesel but more than E5 blend.

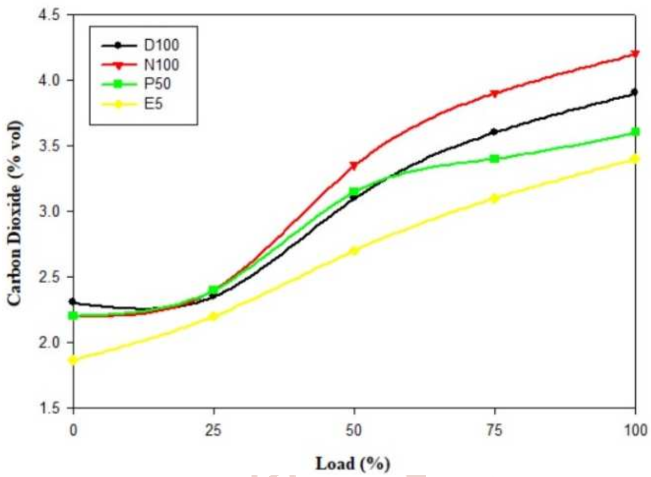

Fig. 7: Carbon Dioxide w.r.t Load

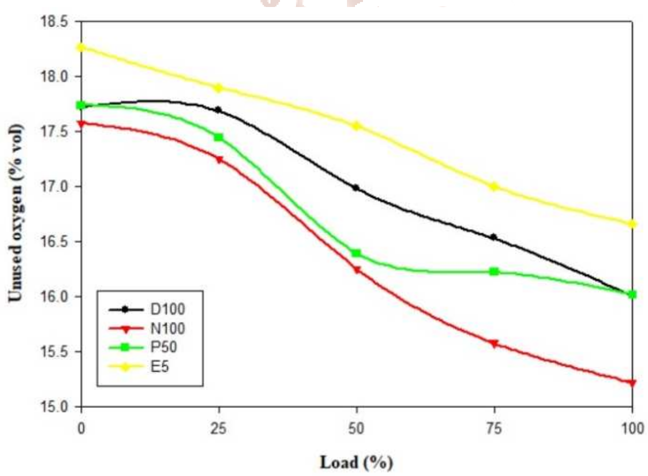

Fig. 8: Unused Oxygen w.r.t Load

IV. CONCLUSIONS

In this current research work, the entire operation was carried on a 1-cylinder, 4S, DI CI engine. The performance results show that, the BTE of N100, P50 fuel blends was less than E5 blend, although for neat diesel, the BTE was increase from the beginning but at full load it got decreased than the rest; whereas, the BSFC of D100, E5 blend had a decreasing nature than N100 and P50 blend. At full load, the least BSFC for E5 blend in comparison to other fuel samples. The CO emissions among the biofuel blends was maximum for N100 and then P50 blend but the least was for E5 blend w.r.t neat diesel. Also, the UHC emission for N100, P50 and E5 blends had a decreasing trend than neat diesel fuel. The D100 fuel had a maximum NO_x emission in comparison to others and the least was by E5 blend. The CO_2 emission of N100 and D100 was the highest than P50 and E5 blends during the operation. The unused $O_2$for N100 fuel was the least than other fuel samples and the maximum was for E5 blend. The performance and emission outputs forE5 blend is better; but the other blends output results were close enough to that of E5 blend, so those blends can also be utilized in CI engines. The blends carried for analysing the performance-emission characteristics with diesel fuel had an effect on the outputs, and similar kind of results were obtained by other researchers as well. So, with the necessity of alternative fuel in diesel engines, the petroleum fuel product import will decrease and the production of these alternative biofuel will rise, reducing their initial manufacturing cost and creating our clean environment to breathe.

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