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Effect of Performance and Emission Parameters Fuelled with Biofuel Blends on Diesel Engine

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Abstract:- In the present research, the renewable biofuel is applied to reduce our reliance on petroleum fuels and move towards alternative fuel usage in IC engines. The probes have been carried on a one-cylinder, water-cooled, four-stroke, CI engine, in order build comparison of performance-emission characteristics in between diesel fuel, neem biodiesel, polanga biodiesel and ethanol blends. The diesel engine has been fuelled with following blends: diesel fuel (D100), neem biodiesel 100% (B100), polanga biodiesel 20% with addition of diesel 80% (B20), and ethanol 10% with addition of diesel 90% (E10). The engine performance factors such as BTE of E10 was higher than the diesel fuel but the blends B100, B20 was close enough to diesel fuel; whereas, the BSFC of E10 was the least among the rest and for B100 and B20 also it decreased. The emission parameters as such CO, NO_x and UHC of the fuel blends were lower than diesel fuel. The CO_2 was in maximum released by B100 and least by E10, whereas, the O_2 released was vice versa. From the results, the consequences of direct usage of biofuel blends in IC engine were analyzed properly and in our future these alternative fuels can be utilized in our society.

Keywords:- *Diesel engine, performance, emission, polanga biodiesel, neem biodiesel.*

I. INTRODUCTION

In the past decades, the petroleum products have been depleting from the various sources available globally due to their excessive usage in various countries along with the increasing cost. The rise in fossil fuel intake had an adverse effect on our ecosystem as such, too much pollution in air, increase in global temperature. In some nations, the petroleum has to be imported from various gulf countries. So, in order to deal with the present scenario, almost many researchers from different nations are devoting themselves to find out a substitute for petroleum oil, such that the alternative is favourable to our environment and is renewable. On the contrary, diesel engine used mostly in trucks, buses, farming and industry etc., has been a major pollutant (i.e., CO, HC, CO_2, NO_X, PM, Smoke, Soot) contributor despite of its higher thermal efficiency, high BP, low fuel consumption [1,2]. As an alternative, biodiesel is in much demand in different nations, since it is nontoxic, renewable, and biodegradable and reduces emissions except NO_x. It has some disadvantages as such: increase in kinematic viscosity, rise in pour point temperature, low volatility in comparison to diesel [3]. Also, ethanol has been in use since 1970s, because it is also a renewable source and can be made from various staples such as sugarcane, corn, biomass, etc. In some countries it is being utilized as a fuel but there are some limitations of its usage, such as, miscibility, low certain number, low viscosity [4].

Hebbal et al. has found lower emissions and incremented in performance with 50% volume of Deccan hemp biodiesel and 50% volume of diesel fuel blend [5]. A researcher used fish oil with marine gas oil and was inhaled successfully as diesel engine fuel [6]. Ajav et al. has noticed with blends of diesel-ethanol being used then BSFC is increased and EGT is decreased [7]. Chauhan et al. shown results on ethanol fumigation in a compact diesel engine, the results obtained exhibit increased engine performance with decreased NOx, CO, CO2 and EGT but resulted in higher UHC emission [8]. One of the researcher tested honne biodiesel oil on a stationary CI engine and result show that the BTE of biodiesel honne was decreased in equivalence to diesel fuel [9].

II. MATERIALS AND METHODS

In this research paper, the fuels chosen for the operation were diesel fuel, neem biodiesel, polanga biodiesel and ethanol. All these fuels were brought from the local shops. The fuel/oil properties have been detailed in TABLE I. The experimental engine arrangement comprises of a one cylinder, four-stroke, water cooled diesel engine, engine test bed, and exhaust gas analyzer for metering the emission from diesel engine exhaust gas. The engine arrangement is displayed in Fig. 1, and for engine specification, it is displayed in TABLE II. For blending biodiesel, ethanol with diesel fuel no engine modification is required, it is being directly added with diesel fuel.

Properties	Diesel	Neem Biodiesel	Polanga Biodiesel	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 (°C)	79	65	151	13.5
Auto-ignition temperature, (°C)	251	288	363	420
Oxygen content (wt%)	0	13	10	34.8

Table 1. Properties of oil samples

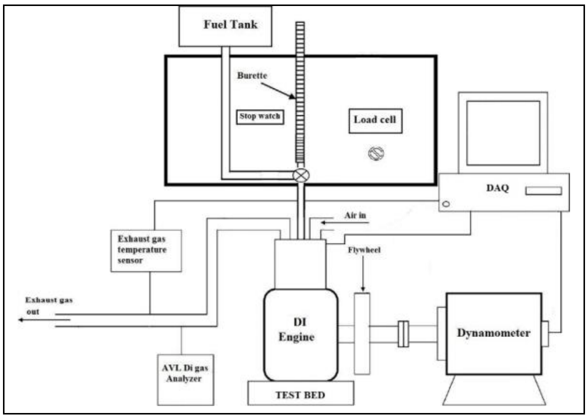

Fig 1:- Experimental engine arrangement

The fuels prepared for this investigation are diesel fuel (D100), neem biodiesel 100% (B100), polanga biodiesel 20% with addition of diesel 80% (B20), and ethanol 10% with addition of diesel 90% (E10). Initially, the engine was fuelled with diesel fuel and was tested at various loads as such: 0%, 25%, 50%, 75% and 100%, to get the base data and to make a comparison in between the variation of performance and emission data of different fuel samples. Before experimenting with a new blend, the engine was operated for sufficient time till the last drop to wipe out the leftover fuel from the previous experimentation. Special attention was taken to maintain the constant speed (i.e., 1500rpm) of the engine and the authenticity of the data is also increased by taking 3 consecutive readings of individual blends and averaging them to get the final data for the diesel engine. The entire experimentation is conducted at an closed temperature of 25-27 ^{0}C. The performance output data such as BTE and BSFC were displayed on the DAQ system. The exhaust emissions such as CO, UHC and NO_X were measured by AVL 5 gas analyzer.

Parameters	Details
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

Table 2. Engine details

III. RESULT & DISCUSSIONS

A. Brake Thermal Efficiency

Fig. 2 shows the variation of Brake thermal efficiency Vs Load for different fuel blends. It was found that in all the fuel samples as well as for D100 the BTE incremented with the rise in the percentage of load. For B20, B100 fuel, the BTE

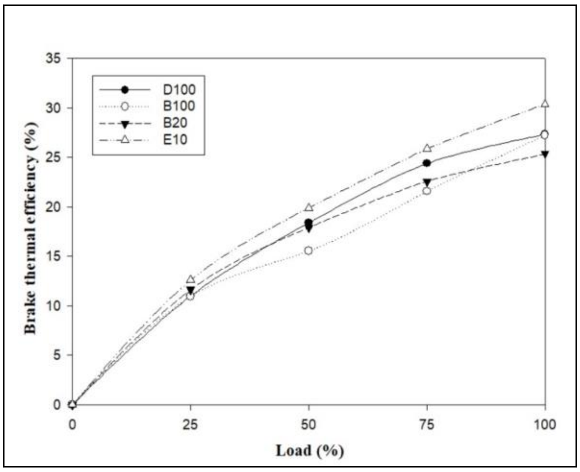

Fig 2:- Brake thermal efficiency Vs Load

was decreased throughout the operation in comparison to D100, which might be because of rise in neem biodiesel kinematic viscosity; as a result of which, the samples could not get much leaner in order to produce higher BTE. Whereas, E10 blend showed a rising trend of BTE during the whole process. The BTE of E10 increased by 8.16%, 5.94%, 11.20% at 25%, 75% and 100% load condition as compared to D100. It may be on account of the rise in auto-ignition temperature, low viscosity and reduced density of the blend owing to the low percentage of ethanol.

B. Brake Specific Fuel Consumption

Fig. 3 shows the change of BSFC Vs Load for all fuel samples. The BSFC shows a decreasing trend during the complete procedure of all the blends. The BSFC of B100 decreased with an increasing trend w.r.t other fuel blends except during the full load where it lowers than B20 blend. The BSFC of E10 showed a decreasing order throughout the operation w.r.t the other fuel samples. The BSFC of E10 decreased by 10.3%, 4.34%, 2.94% and 6.66% at 25%, 50%, 75% and 100% in comparison to D100.

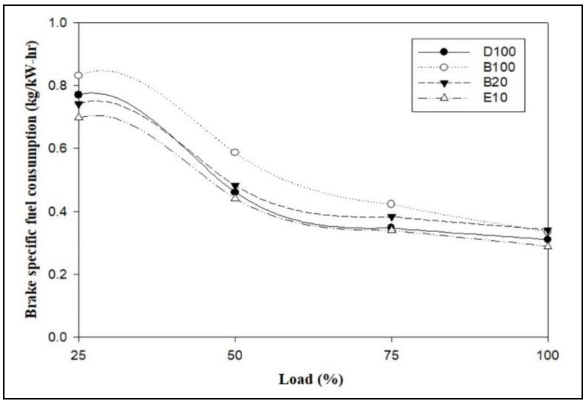

Fig 3:- Brake specific fuel consumption Vs Load

C. Carbon Monoxide

Fig. 4 displays the variation of Carbon Monoxide Vs Load for all fuel samples. The graphical representation of CO had shown a decreasing inclination from the initial to the full load equivalent. The CO for D100 was maximum for the entire duration. Whereas, the biofuel blends such as B100, B20 and E10 shows a decreasing trend in comparison to

D100, which is because of excess amount of oxygen content of biodiesel and ethanol percentage in blends addition along with diesel fuel, as a consequence of which, these blends during the engine exhaust emission elevated the oxidation of CO. The CO of B100, B20 and E10 decreased by 5%, 5.75% and 8.5% at full load in comparison to D100.

D. Unburnt Hydrocarbon

Fig. 5 highlights the Unburnt Hydrocarbon Vs Load for all fuel samples. The UHC for all the samples increase during the intermediate load condition and then decreased for the rest operation, which might be because of improved combustion after the initial load equivalent. The UHC of diesel fuel remain increased during the entire process. B100 had decreased UHC by 3.7%, 3.35% and 10.35% at low, mid and full load as compared to D100. It might be as of high CN of neem biodiesel. The UHC further decreased for B20. The least was for E10 by 6.25% and 15.1% at mid and full load as compared to D100, which is on account of the increase in oxygen content of ethanol.

E. Oxides of Nitrogen

Fig. 6 displays the change of NO_x Vs Load in all fuel samples. The NO_x showed an increased scenario throughout the engine operation, whereas, NO_x for D100 was maximum throughout. The B100 fuel NO_x emission decreased by 51.1%, 32.6% and 7% at low, mid and maximum load in comparison to diesel fuel. The B20 blend NO_x emission decreased by 64.4%, 57.4% and 23% at low, mid and maximum load equivalent in comparison to conventional diesel fuel. The NO_x was least for E10. In the above cases, the reason is on account of combustion temperature of biodiesel during the load conditions.

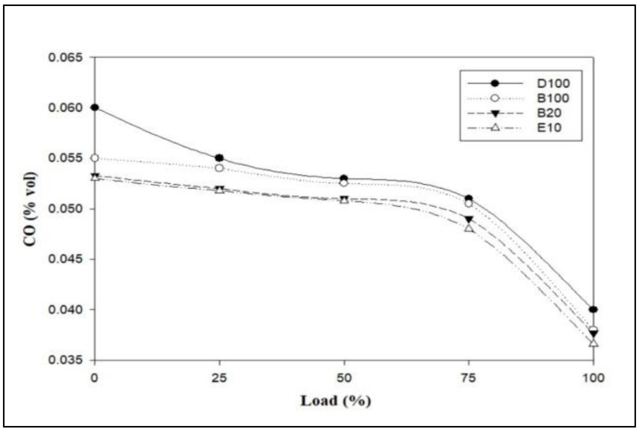

Fig 4:- Carbon monoxide Vs Load

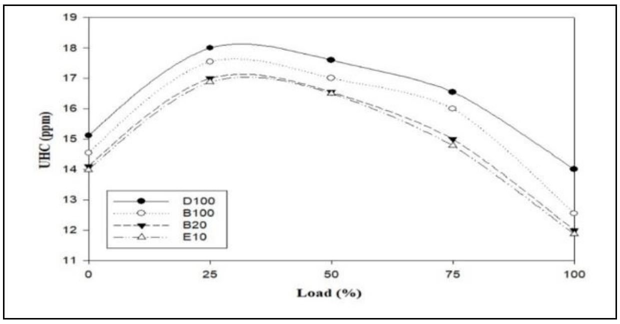

Fig 5:- Unburnt Hydrocarbon

F. Carbon Dioxide

Fig. 7 depicts the change of CO_2 Vs Load for all fuels. The CO_2 emissions increased for all the load variations in all fuel samples. The B100 and B20 fuel sample had an increased CO_2 than D100. The CO_2 emission was least for E10 as in comparison to diesel fuel.

G. Unused Oxygen

Fig. 8 shows the variation of Unused Oxygen Vs Load for all fuel samples. The unused O_2 for B100 decreased the most by 20.8%, 4.29% and 4.9% at low, mid and maximum load as compared to D100. The unused O_2 of E10 had an increasing trend when comparing to other blends. In comparison to D100, the B20 unused O_2 emission decreased by 10.2% and 2.1% at mid and maximum load.

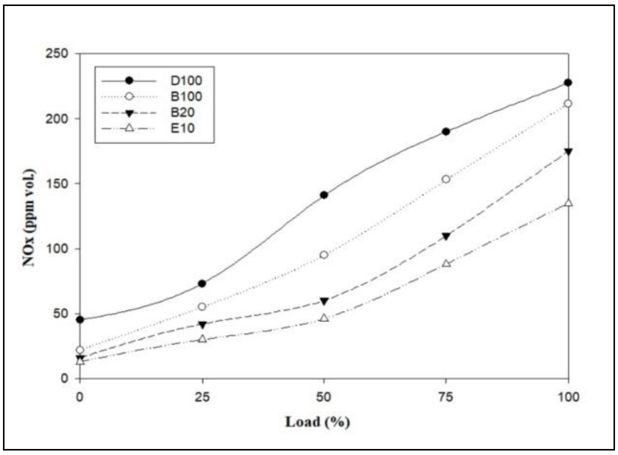

Fig 6:- NO_x Vs Load

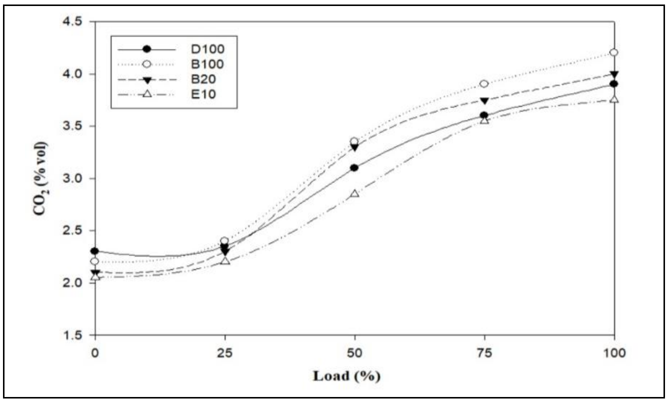

Fig 7:- Carbon Dioxide Vs Load

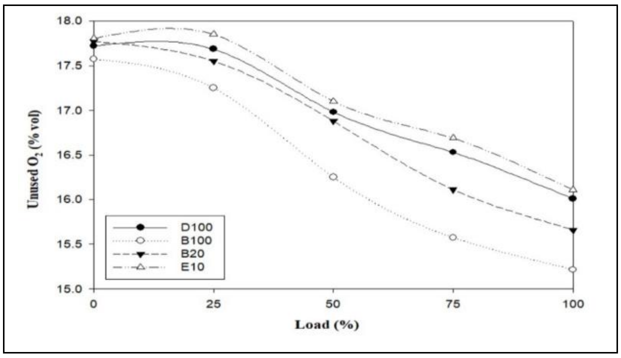

Fig 8:- Unused Oxygen

IV. CONCLUSIONS

In this research paper, the entire investigation was carried on a one-cylinder, four-stroke, CI engine. In the performance parameter, the BTE of B100, B20 fuel blends was less than D100, whereas, BSFC of B100, B20 fuel blends increased but with a decreasing trend than diesel fuel. The BTE was maximum for E10 in comparison to other fuels and the least was for B20. The BSFC was decreased the most for E10 in comparison to others. The CO emissions of the biodiesel fuel blends and ethanol blends decreased than that of conventional diesel. B100 and B20 blends had a decreasing UHC emission than D100 fuel. The NO_x emission of B20 and B100 was decreased in comparison to D100 fuel. The CO_2 of B100 and B20 was increased than diesel fuel throughout the process. B100 fuel showed decreased unused O_2 than other fuel samples. Even the unused O_2 for B20 was lower than D100 but the E10 blend showed an increased trend throughout in comparison to diesel fuel. The emission parameter such as CO, NO_x, UHC and CO_2 for E10 was least in comparison to other fuel samples. The above blends used for comparison of performance-emission characteristics with diesel fuel had an impact on the outcome, and other researchers also had similar kind of results. So, if there is demand for this alternative fuel in diesel engines, then import of petroleum fuel will decrease and the production of these biofuel will increase, decreasing their production cost and leading our environment to breathe clean air.

ABBREVIATIONS

IC - Internal Combustion, CI - Compression Ignition, DI – Direct Injection, BTE - Brake thermal efficiency, EGT - Exhaust Gas Temperature, BSFC - Brake specific fuel consumption CO/CO_2 - Carbon Monoxide/ Carbon Dioxide, UHC - Unburnt Hydrocarbon, NO_x – Oxides of Nitrogen, O_2 – Oxygen, PM - Particulate Matter, CN - Cetane Number, CC- Combustion Chamber, DAQ - Data Acquisition System, 4S – Four Stroke, PM – Particulate Matter, w.r.t – with respect to, i.e., - that is, D100 – Diesel 100%, B100 – Neem Biodiesel 100%, B20 – Diesel 80% +Polanga Biodiesel 20%, E10 – Diesel 90% + Ethanol 10%.

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