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Study of Diesel Engine Performance and Emission Trend Fuelled with Biodiesel-Diesel Blends

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Abstract:- The present research was carried on to check the comparison of performance and emissions parameters of a single cylinder, naturally aspirated, 4-S, water cooled diesel engine when operated with diesel fuel, thumba biodiesel, and diesel–polanga biodiesel blends. The blends which were prepared are: 100% thumba biodiesel (T100), 50% diesel fuel with 50% of polanga biodiesel (P50), and 80% diesel fuel with 20% of polanga biodiesel (P20) were tested. The performance and emissions parameters of these blends and the diesel fuel under different load variations were tested. Based on the comparative analysis in between the fossil diesel, polanga biodiesel blends and thumba biodiesels, which resulted that, polanga biodiesel improved performance throughout the load condition by lowering the BSFC and increasing the BTE. In case of emissions, for polanga biodiesel resulted in lower carbon monoxide (CO), oxides of nitrogen (NOx), Carbon Dioxide (CO2) and Unused oxygen (O2) in the exhaust gas w.r.t diesel fuel.

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

I. INTRODUCTION

The petroleum fuels have been slowly moving towards emptiness of various fuel tanks in the entire world throughout the beginning of the extraction of fuels. Due to the increasing utilization of fuels for daily needs, oils are imported in various countries with increasing price. Also, the petroleum fuels damage our environment by exhausting harmful pollutants, for which the government imposes strict regulations on automotive industries to reduce emissions. CI engine is the major contributor of emissions such as – UHC, CO, smoke, NOx, soot, PM, etc., despite its performance outcome. So, engine building companies have to innovate cutting-edge technology to follow the government emission regulations [1]. The biofuel is the next possibility for our sustainability since it nullifies the petroleum fuel scarcity as well as protects our surrounding nature. Biodiesel can be an effective alternative source w.r.t diesel fuel, and is produced from animal fats or vegetable oils, since it is nontoxic, oxygenated, renewable, biodegradable and reduces greenhouse gas emissions, and also generates income for the rural area by promoting thumba, polanga, jatropha, Karanja, etc., plant farming. It has some demerits such as higher viscosity, lower volatility, cold flow properties which might damage the fuel filter, clog fuel injector [2]. So, to solve this issues preheating, or blending of additives with diesel-biodiesel can be done before the engine inhales the fuel. Biodiesel can be produced from the seeds of their plants such as neem, Karanja, jatropha, polanga, thumba, rapeseed, mahua, etc.

Several researchers have tested some biodiesels fuel and its blends with diesel fuel or with other additives in CI engine. Raheman and ghadge [3], investigated with the usage of Karanja biodiesel in a diesel engine by varying compression ratio and found that BSFC and EGT increased whereas BTE decreased with rise in biodiesel percentage in the blend. Another researcher has revealed that biodiesel jatropha could be used as a diesel fuel substitute in diesel engine [4]. Also, the use of biodiesel Karanja and their blends on the diesel engine can be a alternative for neat diesel [5]. Some research outcome depicts increment of CO and NOx emissions whereas others show less CO, smoke and UHC emissions for Karanja biodiesel [6, 7]. Neem biodiesel gives slightly less BTE and high BSFC [8].

II. MATERIALS AND METHODS

A single cylinder, 4-S, naturally aspirated, water cooled diesel engine set up fitted on a sturdy bed was used for our current investigation along with AVL gas analyser for exhaust gas emission data and DAQ, the DAQ gives the performance data for our engine. The pressure sensor, crank angle sensor, a temperature sensor for EGT were pre-installed in the engine; also to measure rpm and engine load, the CI engine was paired with eddy current dynamometer. The BSFC was measured by a burette of 50cc and a timer for e.g.: stopwatch. The details of the engine were shown in TABLE I and the diesel engine set up is displayed in Fig. 1. In this research paper, the fuels used were diesel fuel, thumba biodiesel, polanga biodiesel; and their properties were shown in TABLE II. All these fuels were obtained from local markets. For direct intake of biodiesel and its blends with diesel fuel, no engine modification was required.

Properties	Diesel	Polanga Biodiesel	Thumba Biodiesel
Density, kg/m^3 at 20̊C	842.4	889	891
Calorific Value, KJ/kg	42510	38550	41500
Cetane Number	50	57.3	51.6
Kinematic viscosity, $x10^{-2}$ m^2/s at 20̊C	2.8	5.2	5.3
Latent heat of evaporation, (kJ/kg)	252	200	210
Flash point (̊C)	79	151	174
Auto-ignition temperature, (̊C)	251	363	276
Oxygen content (wt%)	0	10	12

Table 1. Properties of oil samples

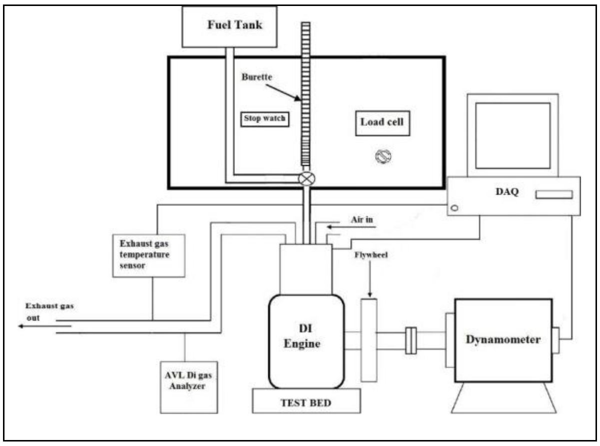

Fig 1:- Experimental engine arrangement

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

The performance and emission characteristics of a high speed diesel engine at various loads from 0% load to 100% load fueled with thumba biodiesel and polanga biodiesel and its diesel blends are discussed below as per the results obtained.

A. Brake Thermal Efficiency

Fig. 2 illustrates the change in the brake thermal efficiency (BTE) as a function of load. From the figure, we find that the BTE for diesel fuel was higher with the increase in load condition as compared to thumba and polanga biodiesel blends. The reason might be because of the high viscosity and density of biodiesel which results in poor atomization of fuel and finally leads to the poor combustion. The BTE of P50 blend was highest among all the other fuel blends. The BTE of P50 was maximum during the 100% load in comparison to blends.

B. Brake Specific Fuel Consumption

Fig. 3 illustrates the change in the brake specific fuel consumption (BSFC) with the variation of load. The BSFC of diesel fuel decreased as compared to thumba and polanga biodiesel blends with the increase of load. Biodiesels have more BSFC than diesel fuel at each load condition and increase with the increasing blending percentage of biodiesel. Both thumba and polanga biodiesel blends have low CV, increased density and viscosity as compared to diesel fuel, in contrary, it resulted into poor atomization and the formation of charge particles with biodiesel blends. So, more fuel is required in order to generate the same sum of power output as the biodiesel percentage in the blend increases. The BSFC of P50 blend was decreased among the other biodiesel blends but it was more than diesel fuel.

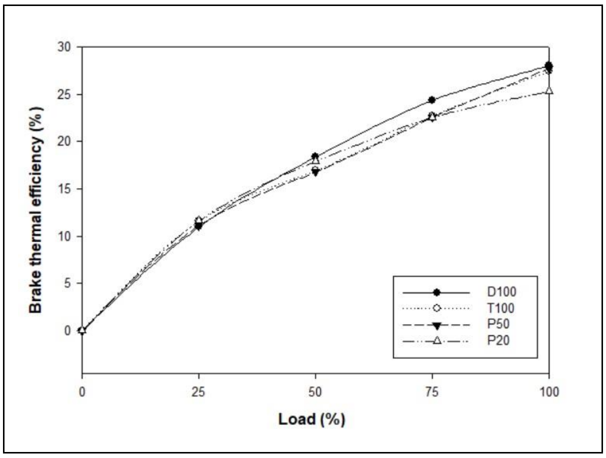

Fig 2:- Brake thermal efficiency Vs Load

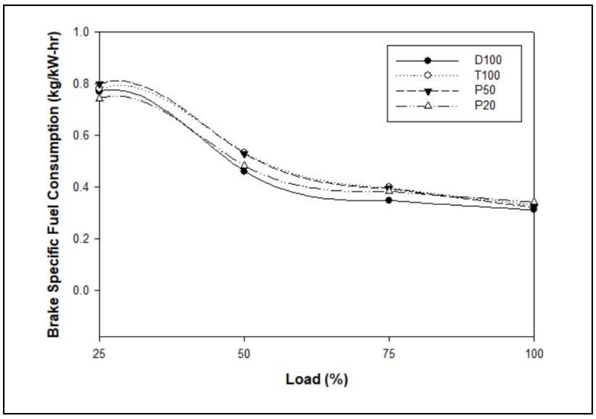

Fig 3:- Brake specific energy consumption Vs Load

C. Carbon Monoxide

Fig. 4 illustrates the change in the Carbon Monoxide (CO) with the variation of load. The CO emission decreases with the conversion of CO to CO2 at the exhaust, because of the rise in combustion temperature with increment of load at constant speed. The diesel fuel had the maximum CO emission throughout the entire operation and the least was by P20 blend. The biodiesel blends showed the reduction in CO emission in the exhaust with the increment of load, which can be because the presence of oxygen content in biodiesel.

D. Unburnt Hydrocarbon

Fig. 5 illustrates the change in the Unburnt hydrocarbon (UHC) with the variation of load. The UHC emission is developed because of lots of individual hydrocarbons mixture in the fuel sample supplied to the CI engine as well as partially burned hydrocarbons developed on the combustion mechanism. The UHC emission increased but decreased with the rise in load condition. The UHC emission was maximum for neat diesel fuel and least was for T100. These decreases of UHC emission for T100 are due to the increased cetane number and gas temperature of biodiesel.

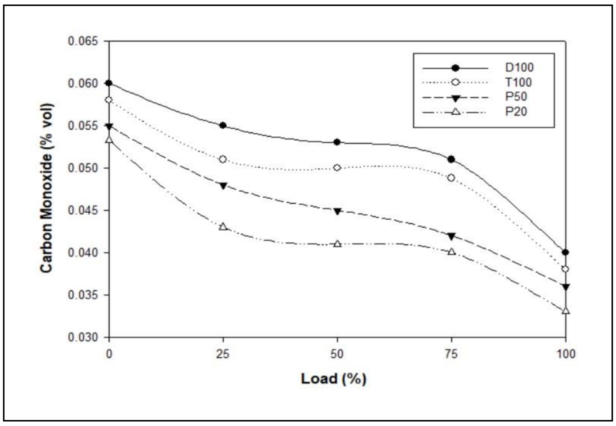

Fig 4:- Carbon monoxide Vs Load

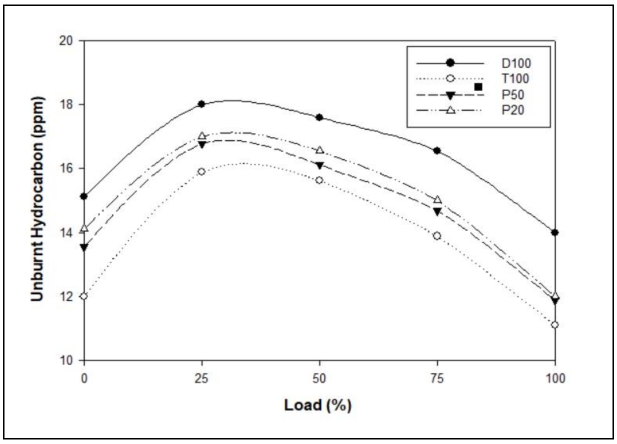

Fig 5:- Unburnt Hydrocarbon

E. Oxides of Nitrogen

Fig. 6 illustrates the change in the Oxides of Nitrogen (NOx) with the variation of load. The NOx emission shows a decreasing value for thumba and polanga biodiesel blends when compared to diesel fuel. NOx is produced by the maximum cylinder temperature. The CN of diesel and T100 fuel is quite higher which leads to better combustion resulting in higher gas temperature in the CC and exhaust gas. Also, the percentage of oxygen in the biodiesel blends led to the decrease in NOx emission.

F. Carbon Dioxide

Fig. 7 illustrates the change in the Carbon Dioxide (CO2) with the variation of load. The CO2 emission was increased throughout for diesel fuel as compared to other fuel samples. The P20 blend showed the least CO2 among all the other fuel samples.

G. Unused Oxygen

Fig. 8 illustrates the change in the unused oxygen (O2) with the variation of load. The O2 emission was higher in all load conditions for diesel fuel as compared to other fuel samples. The P20 blend showed the least O2 emission among all the other fuel samples.

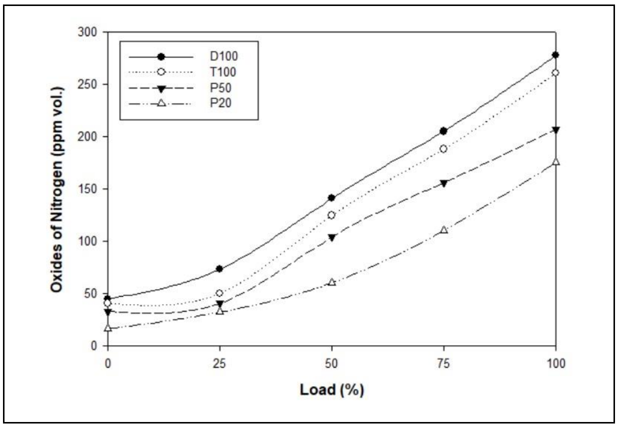

Fig 6:- NO_x Vs Load

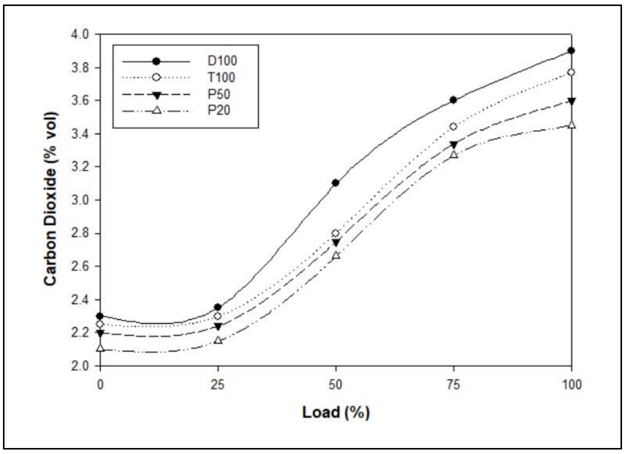

Fig 7:- Carbon Dioxide Vs Load

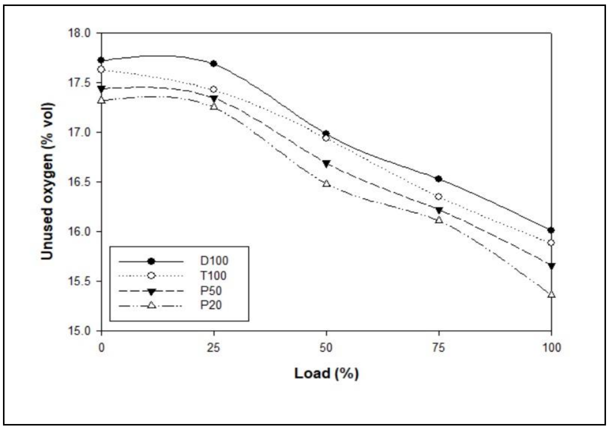

Fig 8:- Unused Oxygen

IV. CONCLUSIONS

The performance and emissions characteristics of a single cylinder, naturally aspirated, 4-S, water cooled, diesel engine fuelled with diesel fuel, thumba biodiesel and diesel-polanga biodiesel blends were investigated in this research work. The blends which were used are 100% thumba biodiesel (T100), 50% diesel fuel with 50% of polanga biodiesel (P50), and 80% diesel fuel with 20% of polanga biodiesel (P20). The blends and the diesel fuel were tested under different load variations. A comparative analysis between the diesel fuel, polanga biodiesel blends and thumba biodiesels reveals that the polanga biodiesel blend P50 performed better. Polanga biodiesel led to improved performance throughout the load condition by lowering the BSFC and increasing the BTE. In case of emissions parameters, for polanga biodiesel resulted in lower carbon monoxide (CO), oxides of nitrogen (NOx), Carbon Dioxide (CO2) and Unused oxygen (O2) in the exhaust gas w.r.t diesel fuel, whereas, the UHC emission was lower in case of thumba biodiesel w.r.t diesel fuel. Based on these outcomes, it is concluded that thumba biodiesel, polanga-diesel blended fuel could be effective alternative oil for diesel engines as compared to thumba biodiesel and diesel fuel. The investigation leads to continue further research on biofuel content to reach conclusions and obtain more details so that this biofuel can be used in diesel engines.

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%, T100 – Thumba Biodiesel 100%, P50 – Diesel 50% + Polanga Biodiesel 50%, P20 – Diesel 80% + Polanga Biodiesel 20%.

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