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EXPERIMENTAL INVESTIGATION ON PERFORMANCE AND EMISSION CHARACTERISTICS OF DIESEL-ETHANOL-BIODIESEL BLEND IN DIESEL ENGINE

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ABSTRACT

In this paper the performance and emission characteristics of the blends are made from biodiesel of soybean oil and E10 (10% ethanol and 90% diesel) in the proportions ranging from 20% to 40% of biodiesel. Extraction of biodiesel from the soybean oil was made by using the transesterification method. Anhydrous ethanol (10%) was added as an additive to the diesel-biodiesel blends which helps to reduce the ignition delay and slight reduction of oxides of nitrogen (NO_x) emission. Performance test was conducted at steady state DI diesel engine at constant speed by varying loads at no load, 25%, 50%, 75% and full load. The above tests were taken without any engine modifications or tuning. It is observed that as the increasing of biodiesel ratio, there is a slight increase in brake thermal efficiency (BTE) and carbon dioxide (CO_2) emission, while carbon monoxide (CO), and hydrocarbons (HC) emission reduced and a slight reduction of oxides of nitrogen (NO_x) emission due to addition of anhydrous ethanol to the blends.

Keywords: Soybean Bioiesel, Anhydrous Ethanol, Performance and Emission

INTRODUCTION

Fossil fuel products were consumed by various sectors as transportation, agriculture and power source for prime mover. In our country (India), over million liters of fossil fuel products were consumed, more than half were imported from the other nations. Nearly more or less 60% of people in over country they are using two-wheelers and remaining 40% of them using cars for their domestic use or transportation. Increase in number of vehicles depleting the fossil fuels in a faster way. Environmental issues, such as pollutants emission and global warming were also playing an important role in the usage of fossil fuels. This triggers the researchers to find alternative for fossil fuels. Indian government has given the permission to run the engine by using biodiesel blends up to 20%. Biodiesel can also replace the diesel because it has the similar physical and chemical properties and it can also be a promising fuel when it was blended with diesel. Using of biodiesel with the diesel has the advantage like improves the lubrication of the blend fuel which leads to improve engine components life and it also reduces the emissions like co. but it has the major draw backs like poor performance in cold flow and kinematic viscosity limit which make the fuel to atomize into small droplets. Alcohol based fuels like ethanol or methanol can be added as a co-solvent to improve performance and also act as oxygenates for complete combustion[1].

Jose R.Sodre[2] et al. studied the performance and emission of the DI diesel engine fuelled with soybean biodiesel-ethanol-diesel at different blend ratios. Increasing the concentration of biodiesel in blends increase carbon dioxide (CO_2) and oxides of nitrogen (NO_x) however there was a reduction of carbon monoxide (CO), hydrocarbon (HC) and particulate matter (PM) emissions. Addition of anhydrous ethanol to the blend concentrating 20% biodiesel (B20) reduces theNO_x emission and global warming.

Zhen Huang[3] et al. studied the performance and combustion of ethanol-biodiesel blends in four cylinder heavy duty engine. It was reported that there was a reduction of NO_x emission due to low combustion temperature. It was concluded that presence of more oxygen content in ethanol leads to lower smoke, HC and CO emission.

OrkunOzener[4] et al. studied the combustion, emission and performance characteristics of diesel fuel blended with soybean

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biodiesel ranged up to 30% in single cylinder direct injection diesel engine, by varying speeds from (1200 to 3000RPM) and loads. The observation says that there was a slight decrease in torque and 2-9% increase in brake specific fuel consumption (BSFC) than diesel and there was a significant reduction in carbon monoxide (CO), unburned hydrocarbon (UHC), there was an increase of NO_x and CO_2 emission.

Agarwal[5] et al. says that there is no requirement for modification of engine when it was fuelled with diesel-biodiesel blends containing upto 20% of ethanol. It was concluded that there was a slight reduction in NO_x and CO emissions. Ribeiro[6] et al. in his study he mainly discussed about increase of NO_x emission while using the biodiesel alone as alternative fuel and replacement of engine components like injectors was necessary. Canakci[7] et al. studied the combustion and emission of soybean biodiesel-diesel blends concluded that particulate matter (PM), Hydrocarbons (HC), CO emissions were reduced slightly, but there was increase in NO_x emission.

Sandun[8] et al. discussed that reducing of the NO_x emission, will obtained by using the water injectors and retarding injection timing we when the engine was fuelled with biodiesel. Kegl[9] et al. explains the effect of adding the rapeseed biodiesel with diesel fuel on fuel injection and on engine exhaust emission. By advancing the injection timing reduction of exhaust emission like NO_x, CO, HC and PH. Injection delay period was also cut down to some extent when it was fully runned with (B100) biodiesel. The experimental investigation was carried out on pure soybean biodiesel (B100) and 50% of biodiesel in diesel fuel (B50) was made by Fontaras[10] under European Driving cycle and Avtemis driving showed that the increase in biodiesel concentration increases acceleration time CO_2 emission and fuel consumption got increased.

In this study ethanol 10% along with diesel by volume % is taken as base fuel and the proportions of biodiesel from soybean oil has been varied up to 40% as blends for testing. Performance and emission characteristics of the blends were studied in a diesel engine, comparison has been made with diesel as fuel.

MATERIALS AND METHODS

The biodiesel used in this study was produced from soybean refined oil by using transestrification process with methanol (CH3OH), catalyzed by potassium hydroxide (KOH). To know the exact amount of KOH required to neutralize the Free Fatty acids in soybean refined oil a titration was performed. 10.2g of KOH plus 200ml of methanol (CH3OH) were required for every 1 liter of soybean oil. For transestrification process, a stirred reactor vessel was used to stir it at 400 RPM throughout the process and the reaction was carried out at 65^0C for 3 hours. Once the transestrification process was completed, esters (biodiesel) and glycerol the two major products were obtained. The biodiesel phase is much lesser denser than the glycerol which helps to settle at the bottom. The phase separation will be visible after 10 minutes and completes after several hours. Both the glycerol and biodiesel are debased with an un-reacted oil, catalyst and alcohol during the transestrification process. Specified properties are listed in Table 1 and blend properties are listed in Table 2.

Table 1. Comparison of Properties

parameters	Diesel	Biodiesel	Ethanol
Chemical Formula	C_nH_{2n+2}	$C_{18}H_{34}O_2$	$C_{19}H_{24}O_2$
Density(g/m^3)	0.830	0.877	0.798
Kinematic viscosity (cst)	3.14	5.15	1.13
Calorific Value kj/kg	44800	39480	29700
Flash Point^{o}C	64	123	16
Cetane Index	51	56	6

Table 2: Blend properties

Parameters	B20E10	B40E10
Density(g/m^3)	0.8279	0.8323
Kinematic viscosity (cst)	2.41	2.67
Calorific Value kj/kg	39476.04	38258.49
Flash Point^{o}C	24	20
Fire Point^{o}C	30	30
Cetane Index	56	51

Experimental apparatus:

The engine used in this study was constant speed kirloskar oil engine at 1500RPM with single cylinder, four stroke, water cooled, direct injection engine. The basic specification of the engine is given in Table.3. An eddy current dynamometer was coupled to engine which was used for loading the engine. The injector is located at the center of the combustion chamber, fuel was injected at a pressure of 205 kg/cm^2 and the injection timing before top dead center (TDC) at 23^{o}C. Proximity sensor was used to measure the speed of the engine

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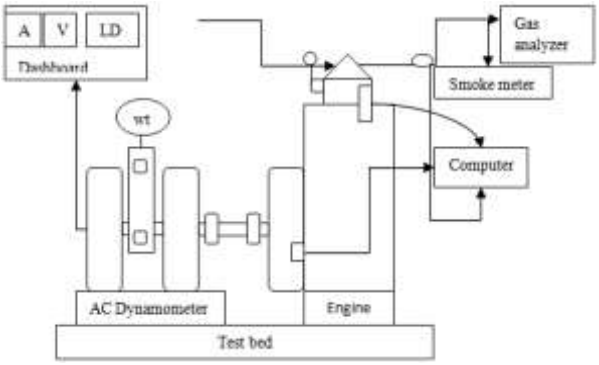
and located near the output shaft, another sensor was located in exhaust pipe to measure exhaust gas temperature. 5 gas analyzer (*avl* type 777) and smoke (avl) meter were also connected to engine and experimental setup was shown in Figure 1.

Table 3: Engine Specifications

Description	Specification
Bore	87.5mm
Stroke	110mm
Cubic capacity	0.662liters
Compression ratio	17.5:1
RPM	1500
No of cylinders	1
Engine Type	4-stroke, 2-valve engine
Fuel	Diesel
Cooling System	Water Cooled Engine

Experimental procedure:



A-Ammeter, V-Voltmeter, Wt-Weight, LD-Load Indicater

Fig 1. Experimental layout

For this type of experiment there was no need of modification of engine. Before running the engine with new blend make sure that, it was allowed for few minutes to consume the remaining fuel from the previous blend or experiment. Throughout this experiment study engine speed was maintained at 1500 RPM and load of the engine were varied from no load to full load condition. At each and every load condition engine was run at least 5-minuts after all data was collected. Exhaust emissions like CO, HC and NOx were measured by using 5 gas analyzer(avl type 777).

RESULTS AND DISCUSSION

Figs. 2-8 shows the performance and emission results obtained by using soybean biodiesel-ethanol-diesel blends and straight diesel readings comparison.

Brake Thermal Efficiency (BTE):

Brake Thermal Efficiency of all the blends were plotted in Figure 2. It was observed that there was increase of brake thermal efficiency for all blends in comparison with diesel. There was increase of brake thermal efficiency of the blends 14% higher than diesel at full load condition. Due more oxygen content present in the blended improves combustion at phase of diffusion-controlled combustion with the help of 10% ethanol and extra amount of lubrication with the help of biodiesel. Figure shows that as the load increases the Brake Thermal Efficiency also increases.

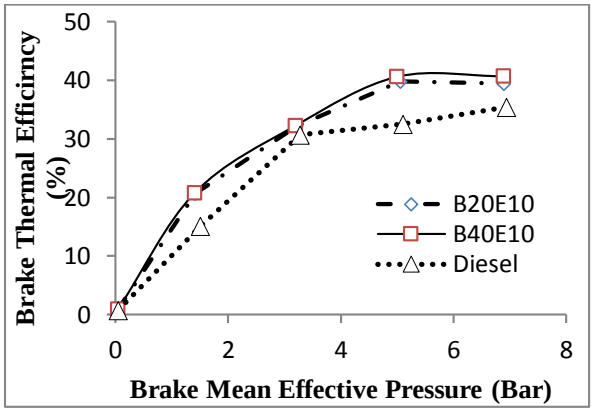


Fig 2. Comparison of Brake Thermal Efficiency forDiesel and diesel-biodiesel-ethanol blends

Brake Specific Energy Consumption (BSEC):

Brake specific energy consumption of the blends was presented in figure 3. Initially at no load condition the brake specific energy consumption of all blends the high and get decreased by increasing loads, at higher speed it required only small amount of fuel to run the engine. At maximum load brake specific energy consumption for all the blends were lower than diesel due to high density of biodiesel and lower heating value during the combustion.

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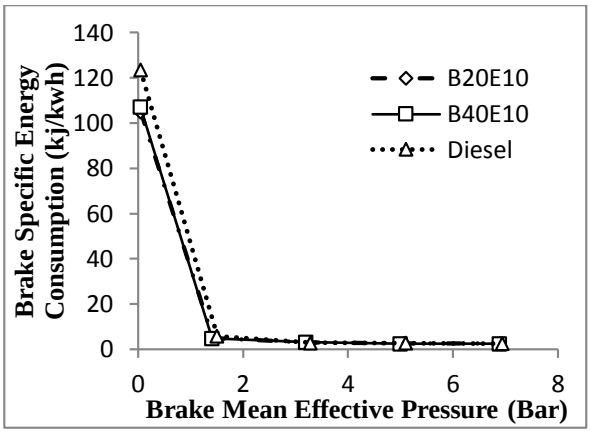

Fig 3. Comparison of Brake specific energy Consumption for Diesel and diesel- biodiesel-ethanol blends

Carbon Monoxide (CO):

Carbon Monoxide emission for all the blends was presented in Figer.4. It was observed that there was slight decrease of carbon monoxide emission for all blends at higher load condition in comparison with diesel. The decreases of carbon monoxide of the blends are 60% lower than diesel at full load for B40E10 blend. Due to addition of ethanol and biodiesel which enhances oxygen proportion and helps to promote the oxidation of CO during exhaust process.

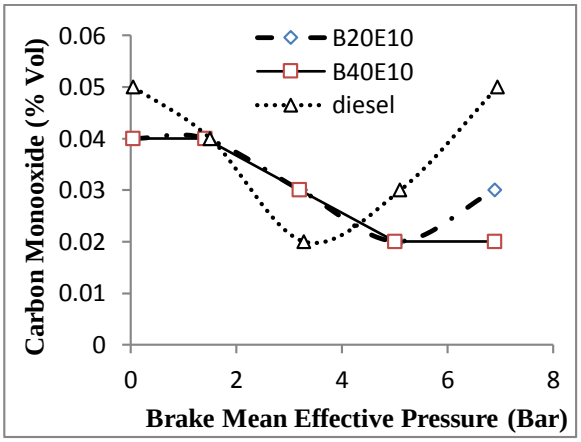

Fig 4. Comparison of Carbon Monoxide Emission Consumption for Diesel and diesel- biodiesel-ethanol blends

Oxide of Nitrogen Emission (NO_x):

Oxide of Nitrogen emission of the blends was presented in Figure 5. It was observed that there was a slight reduction of Oxide of Nitrogen for all blends in comparison with diesel. The decreases of oxides of nitrogen for the blends are 6.2% lower than diesel at full load due to addition of ethanol to blends act as coolant to cut down the combustion chamber temperature leads to reduction in Oxide of Nitrogen emission.

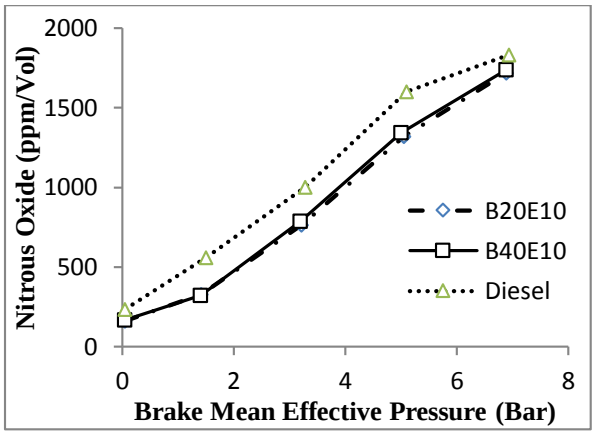

Fig 5. Comparison of Nitrous Oxide Emission Consumption for Diesel and diesel- biodiesel-ethanol blends

Hydrocarbon Emission (HC):

Hydrocarbon Emission for all blends was presented in figure 6. It was observed that there was decrease of hydrocarbon emission for all blends in comparison with diesel. The decrease of hydrocarbon emissions for all the blends is lower than diesel at full load condition due to high exhaust gas temperature, better combustion occurs due to more amount of oxygen content present in biodiesel.

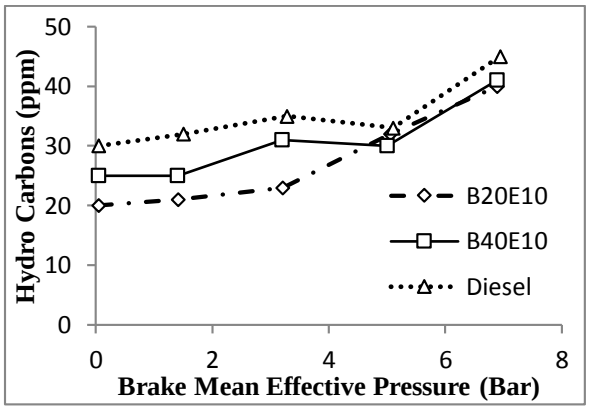

Fig 6. Comparison of Hydrocarbon Emission Consumption for Diesel and diesel- biodiesel-ethanol blends

Smoke Density:

Smoke density for all the blends were presented in figure 7. It was observed that there was increase of smoke density for all blends in comparison with diesel. The increase of smoke density of the blends is 18% higher than diesel at full load. The reason is that the lesser time availability for combustion at full load.

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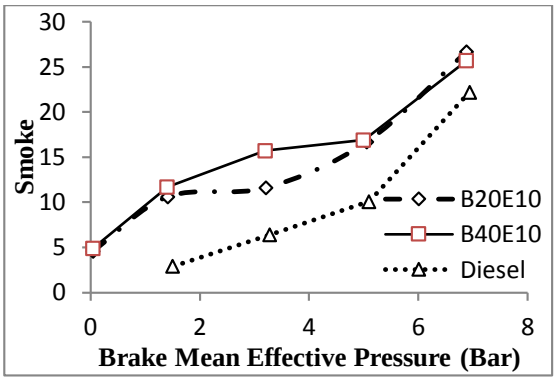

Fig 7. Comparison of Smoke Emission Consumption for Diesel and diesel- biodiesel-ethanol blends

Exhaust Gas Temperature:

Exhaust gas temperature for all the blends was presented in Figure 8. It was observed that there was increase of exhaust gas temperature for all blends in comparison with diesel. The increases of exhaust gas temperature of the blends are 12% higher than diesel at full load. Ethanol has higher latent heat of vaporization and lower cetane number than diesel which leads to higher ignition delay, faster combustion and shortened combustion duration than diesel.

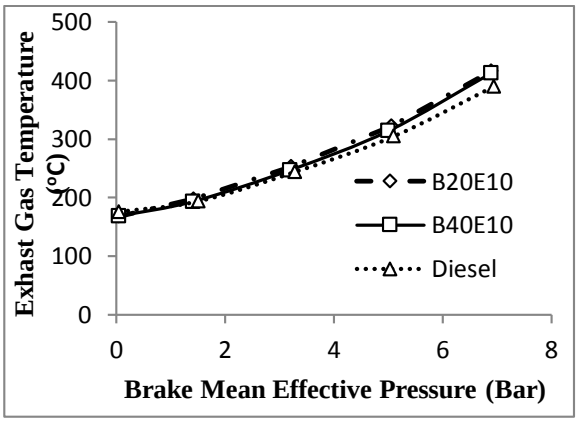

Fig 8. Comparison of Exhaust Gas Temperature Consumption for Diesel and diesel- biodiesel-ethanol blends

CONCLUSION

An Experimental investigation of addition of ethanol in diesel-biodiesel blends has been conducted and following condition were arrived

- Brake Thermal Efficiency (BTE) of all the blends was higher. There was an increase upto 14% at full load.
- BSEC of the blends were lower in compared with diesel.
- Emission of carbon monoxide (CO), hydrocarbon (HC) and oxides of nitrogen (NO_x) were all lesser than diesel.
- There was slight increase of smoke emission for the blends and the temperature of the exhaust gas when fuelled with blends was higher than diesel.
- This study gives an opportunity to utilize biodiesel from soybean oil to reduce the dependence of diesel to some extent with less emission. Future work can be done for the addition of higher amount of ethanol in diesel-biodiesel blends.

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