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PERFORMANCE AND EMISSION CHARACTERISTICS OF DIESEL ENGINE FUELED WITH SESAME OIL METHYL ESTER BLENDS

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ABSTRACT

The rapidly increasing petroleum prices, uncertainties concerning its availability and growing concern of the environment revived research interests on the usage of alternative fuels in internal combustion engines. Biodiesel is a methyl or ethyl ester of fatty acids made from vegetable oils and animal fat. It can be used in diesel engines with very little or no engine modifications. In this present work the experimental investigations are carried out on the test engine operated with methyl esters of sesame oil and diesel blends. Comparative measures of performance parameters, smoke opacity, unburned hydrocarbons (HC), carbon monoxide (CO), Oxides of nitrogen (NOx), Carbon dioxide (CO_2) and unused oxygen (O_2) emissions are calculated. In the initial stage the tests are conducted on the four stroke single cylinder water cooled direct injection diesel engine by using diesel and base line data is generated. In the second stage, tests are carried out using Methyl esters of sesame oil with diesel blends at various loads and compared with the base line data obtained earlier. Engine performance in terms of higher brake thermal efficiency and lower brake specific fuel consumption and lower emissions (HC, CO, NOx) has observed for 20% Sesame oil and 80% diesel.

Keywords: Bio fuels, bsfc, emissions, Sesame methyl esters

INTRODUCTION

In present days the utilization of diesel engines are more compared with petrol engines for domestic purposes because of their higher performance and low cost of fuel. Since the petroleum crises in 1970s, the rapidly increasing petroleum prices and uncertainties concerning its availability, growing concern of the environment and the effect of greenhouse gases (GHGs) during the last decades, has revived more and more interests in the use of vegetable oils as a substitute of fossil fuel. Vegetable oils are widely available from various sources, and the glycerides present in the oils can be considered as a viable alternative for diesel fuel. They have good heating power and provide exhaust gas with almost no sulfur and aromatic polycyclic compounds. Vegetable oils are produced from plants, their burning leads to a complete recyclable carbon dioxide (CO_2). In diesel engines several alternative fuels can be used without any engine modifications to compensate the petroleum based fuel crises. Bello E.I et al [1] used castor oil and blends in a diesel engine to evaluate the load test, speed test and performance test. Castor oil had very high kinematic viscosity which was reduced by using high molar ratio during transesterification but still needed to be blended with diesel fuel to bring it to the limits for biodiesel. The torque and power output characteristics are about 10% less than that for diesel fuel but the load carrying capacity is about 20% higher as a result of it oxygen content which allowed for more complete combustion and operate to a lower speed. Sehmus Altun et al [6] used a blend of 50% sesame oil and 50% diesel fuel was used as an alternative fuel in a direct injection diesel engine. Engine performance and exhaust emissions were investigated and compared with the ordinary diesel fuel in a diesel engine. The experimental results show that the engine power and torque of the mixture of sesame oil–diesel fuel are close to the values obtained from diesel fuel and the amounts of exhaust emissions are lower than those of diesel fuel. Analyzing review on various alternate fuels it is concluded that the Sesame oil [6] can be used with the diesel with higher percentages (up to 50%). The experimental results show that the engine performance parameters of the mixture of sesame oil–diesel fuel are close to the values obtained from diesel fuel and the amounts of exhaust emissions are lower than those of diesel fuel.

Preparation of sesame oil methyl esters

The formation of methyl esters by transesterification of vegetable oil requires raw Sesame oil, 15% of methanol & 5% of sodium hydroxide on mass basis. However, transesterification is an equilibrium reaction in which excess alcohol is required to drive the reaction very close to completion. The vegetable oil was chemically reacted with an alcohol in presence of a catalyst to produce methyl esters. Glycerol was produced as a by-product of transesterification reaction. The mixture was stirred continuously and then allowed to settle under gravity in a separating funnel. Two distinct layers form after gravity settling for 24 hours. The upper layer was of ester and lower layer was of glycerol. The lower layer was separated out. The methyl ester was then blended with diesel in various concentrations for preparing biodiesel blends to be used in CI engine for conducting various engine tests.

Properties of the Bio-diesel

The properties of sesame oil methyl ester were found in the fuels laboratory. The results obtained are shown in Table 1.

Table 1: Properties of Biodiesel blends

Property	Diesel	Sesame Methyl Ester	S10	S20	S30
Heating value (kJ/kg)	43000	39 349	42583	42167	41834
Cetane number	47	40.2	46.32	45.64	44.96
Carbon residue (% by weight)	<0.35	0.25	0.34	0.33	0.32
Density (g/cc)	0.840	0.882	0.830	0.842	0.852
Kinematic Viscosity(cSt) at 40^0C	3.5	5.34	3.68	3.87	405

EXPERIMENTAL SETUP

The experimental set up shown in Figure (a) is a single cylinder, four-stroke, naturally aspirated, DI diesel engine. The set up is provided with necessary instruments like Rope brake dynamometer, Smoke meter (Netel's-NPM-DSM), Gas analyzer (Netel's-NPM-MGA-2) etc., for performance and emission analysis. Specifications of test engine are shown in Table 2.

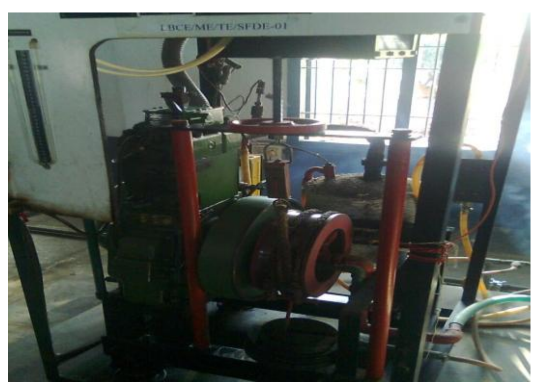

Figure (a): Engine Test Rig

Table 2: Specifications of test engine

BHP	5HP
Speed	1500rpm
Bore	80mm
Stroke	110mm
Compression ratio	16.5:1
Orifice diameter	17mm
Method of start	Crank start
Make	Kirloskar
Type of Ignition	Compression Ignition

RESULTS AND DISCUSSION

The performance and emission characteristics of a high speed diesel engine at various loads from no load to full load fuelled with sesame oil methyl esters compared with diesel are discussed below as per the results obtained.

Specific Fuel Consumption

The BSFC obtained from calculations was plotted against brake power and compared the results for different blends of fuels as shown in Figure 1.

The plot reveals that the BSFCs obtained at full loads for D100 and S10, S20, S30 blends are 0.26 Kg/KW-hr, 0.25 Kg/KW-hr, 0.25 Kg/KW-hr and 0.27 Kg/KW-hr respectively. From the plot it is observed that BSFC is decreasing compared to D100 for S10 and S20 blends. Considerable decrease in BSFC has been observed for both S10 and S20 blends. The BSFC of the engine decreased because of better combustion due to the availability of excess oxygen in these blends.

BSFC for D100 is 0.26 kg/kW-hr but for S10 and S20 it is 0.25kg/kW-hr. The percentage of decrease in BSFC for both these blends is 3.8% compared to diesel.

Mechanical Efficiency

The Mechanical efficiencies which were obtained from calculations are plotted against brake power and compared the results for all the blends when using diesel are shown in Figure 2. From the plot it is observed that the mechanical efficiencies obtained at full loads for D100, S10, S20, S30 are 63.11%, 65%, 60.6% and 60% respectively. The variation of Mechanical efficiency has been observed with various blends compared to Diesel. But considerable change in Mechanical efficiency has not observed since the fuel properties are not so different for diesel and other blends.

Brake Thermal Efficiency

The brake thermal efficiencies which were obtained from calculations was plotted against brake power and compared the results for different blends of fuels as shown in Figure 3 for S10,S20,S30 and D100.

From the Plot it is observed that BTH at full load conditions for D100, S10, S20 and S30 are 32.82%, 33.8%, 34.6% and 32% respectively. The maximum BTH is observed for S20 blend. As the blend mixture strength is increasing the calorific value decreases and there will be variation in the brake thermal efficiency. From graph it is clear that BTH is more for the blends when load reaches the maximum. But only slight improvement in BTH has been observed for S20 at full load as 34.6% and for D100 it is 32.82%. The percentage of increase in BTH by using S20 is 4.6% compared to diesel. The reduction in viscosity because of increase in cylinder temperatures at maximum loads leads to better evaporation and mixing with air resulted in more complete fuel combustion caused the maximum thermal efficiency. It was also observed that the brake thermal efficiencies were closer to each other for all blends and diesel.

Oxides of Nitrogen

The most important factor for the emissions of NOx is the combustion temperature in the engine cylinder and the local stoichiometry of the mixture. The reduction of NOx emissions is possibly due to the smaller calorific value of the blends. Cetane number is also effective in NOx emissions. Cetane number of the sesame oil is smaller than that of the diesel fuel. The smaller the cetane number,the longer the ignition delay and the burning. This causes lower temperatures inside the cylinder and low NOx emissions in the exhaust gases. Exhaust gas temperatures of the blend are lower than those of the diesel fuel due to the lower heating value of the blend. It is proved that the lower temperature causes low NOx emissions when compared with diesel fuel. The variation of NOx emissions for D100 and SME blends with B.P is shown in Figure 4. NOx content is drastically reduced for S10 and S20 blends compared with D100 which is 1236ppm to 1061ppm and 1040ppm respectively, means it is reduced by 14% and 15% for the blends S10 and S20 compared to Diesel.

Smoke

The variation of smoke density with brake power of the engine for D100, S10, S20 and S30 by volume of concentrations is shown in Figure 5. It was observed that the smoke density of all the blends is lower than that of diesel at maximum load. The maximum smoke density recorded using diesel was 79.6 HSU and 58.8 HSU for S10 and 60 HSU for S20 at maximum brake power. Because of the oxygen enrichment contained by S10 and S20, it improves fuel evaporation during diffusion combustion which subsequently reduces the smoke density. The decrease in smoke density by percentage compared to D100 for S10 and S20 is 26% and 24.6% respectively. But for the S30 blend Smoke density slightly increased because of increased viscosity and incomplete combustion.

Carbon Monoxide

CO emission depending on many parameters such as air–fuel ratio and the engine temperature are the causes of exhaust gas emissions in the internal combustion engine. It is one of the toxic products of combustion due to the improper burning of hydrocarbon (HC). Figure 6 shows the variation of CO emissions for D100 with other blends. From the plot it is observed that the CO emissions at full load for D100, S10, S20 and S30 are 0.07%, 0.06%, 0.07% and 0.06% respectively. It is clear from the plot that CO emissions decreases with S10, S30 blends, produced significantly lower CO emissions than that of diesel fuel because of Oxygen availability from this blend for complete combustion.

Unburned Hydrocarbons

The variation of HC with brake power of the engine for D100 and S10, S20, S30 blends are shown in Figure 7. Because of the oxygen enrichment contained by S10 and S20 improves fuel evaporation during diffusion combustion which slightly reduced the unburned Hydrocarbons. For D100, HC content is 58ppm but for S10, S20 it is reduced to 56ppm. These reductions indicate a more complete combustion of the fuel. The presence of oxygen in the fuel was thought to promote complete combustion. Unburned hydrocarbons are reduced by 3.4% using the blends S10 and S20 as compared with diesel.

Carbon Dioxide

The variation of CO_2 with brake power of the engine for D100 and S10, S20, S30 blends are shown in Figure 8. From the plot it is observed that the CO_2 content for D100, S10, S20, S30 blends at full load conditions are 8.5%, 8.4%, 8.3% and 8.5% respectively. But there is no considerable change in CO_2 only slight decrease in CO_2 occurred for S20 blend compared to D100. Since enough amount of oxygen is available for complete combustion. The CO_2 emissions from a diesel engine indicate how efficiently the fuel is burnt inside the combustion chamber. The ester-based fuel burns more efficiently than diesel.

CONCLUSIONS

From the above discussions it was proved that exhaust emissions of the sesame oil–diesel mixture were lower than that of using diesel and it can be used as an alternative fuel in view of reduced environmental pollution by reduction in HC, NOx, CO emissions and also in increased performance parameters like brake thermal efficiency and decreased brake specific fuel consumption. Properties of S20 are nearer to diesel and it is proved that SME can be used as alternate fuel for existing diesel engines.

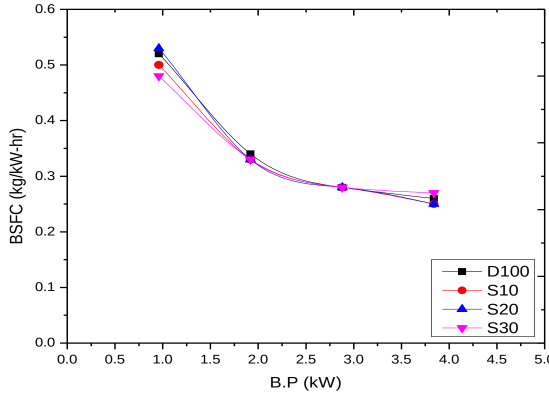

Figure:1 Variation of specific fuel consumption with brake power

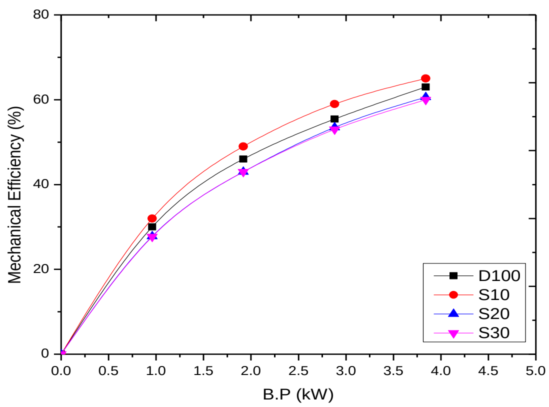

Figure:2 Variation of mechanical efficiency with brake power

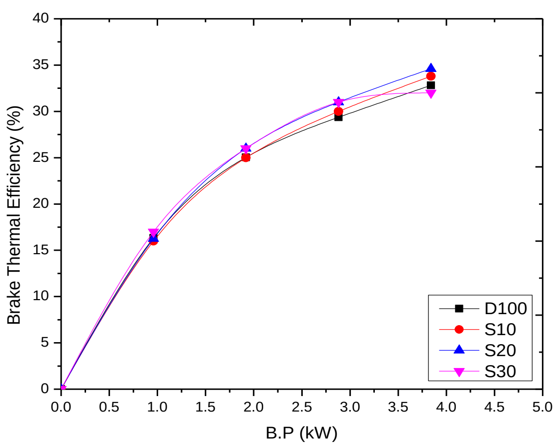

Figure:3 Variation of brake thermal efficiency with brake power

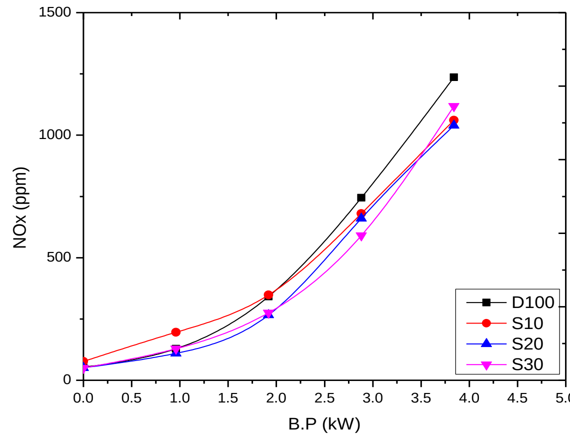

Figure:4 Variation of oxides of nitrogen with brake power

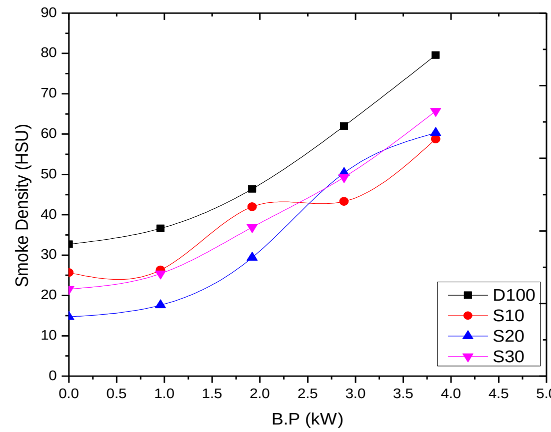

Figure: 5 Variation of Smoke with Brake power

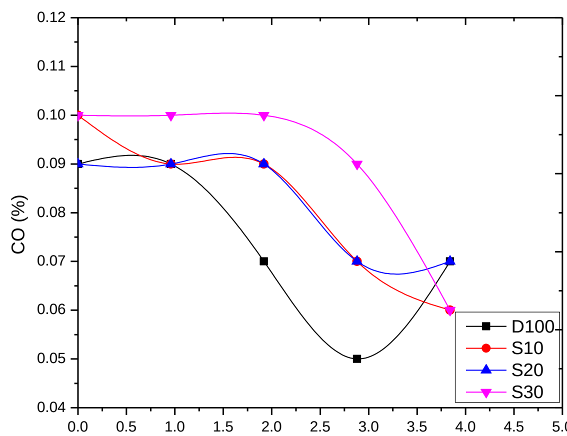

Figure:6 Variation of carbon monoxide with Brake power

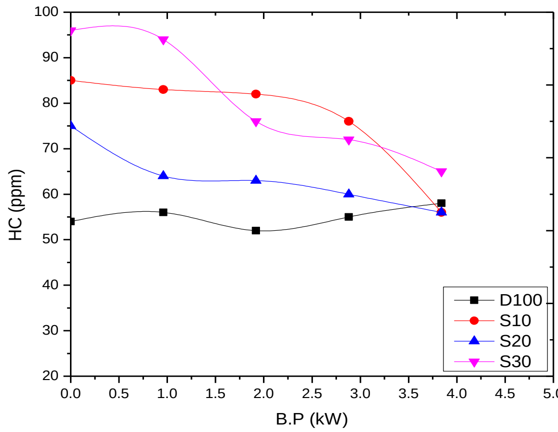

Figure:7 Variation of Unburnt Hydrocarbons with Brake power

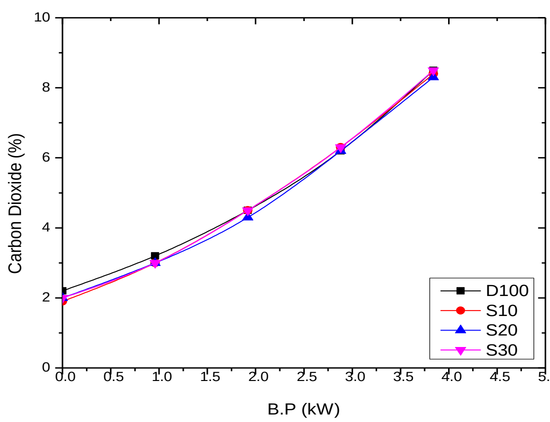

Figure:8 Variation of carbon dioxide with Brake power

NOMENCLATURE

B.P	Brake Power
BSFC	Brake Specific Fuel Consumption
BTH	Brake Thermal Efficiency
CO	Carbon Monoxide
CO_2	Carbon Dioxide
D100	Diesel
DEE	Di Ethyl Ether
HC	Hydro Carbon
HSU	Hatridge Smoke Unit
NO_x	Oxides of Nitrogen
ppm	parts per million
SME	Sesame Methyl Ester
S10	SME 10%, Diesel 90%
S20	SME 20%, Diesel 80%
S30	SME 30%, Diesel 70%
rpm	revolutions per minute

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