Performance and Emission Characteristics of Diesel Engine Fuelled by Biodiesel Derived from Linseed oil

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Abstract

Biodiesel with fuel additives has been gaining increased attention from engine researchers in view of the energy crisis and increasing environmental problems. The present work is aimed at experimental investigation in the present work the bio diesel is the linseeds oil which is obtained from the crude linseed oil by using the transesterification process. In the initial stage tests are to be conducted on the four stroke single cylinder direct ignition diesel engine and base line data is generated. Further in second stage the test was conducted on the same engine at same operating parameters by using the diesel blended with the linseed oil esters with different blending ratios such as L10, L20, L30 and the performance parameters (Brake Thermal Efficiency, Brake Specific Fuel Consumption) and also emission parameters (CO, HC, NOx, CO2, unused oxygen and smoke density) are evaluated. Among all the blends L30 has shown the better performance in the parameters and also in the emissions. So L30 is taken as the optimum blend. Finally the performance and emission parameters obtained by the above test are compared with the base line data obtained earlier by using diesel.

Keywords

Combustion characteristics, Diesel-Biodiesel blends, Transesterification process, performance and Emissions.

1. Introduction

Researchers have used different additives to petrol and diesel fuels for efficiency and emission improvement. The addition of alcohol based fuels to petroleum fuels has been increasing due to advantages like better combustion and lower exhaust emissions. Oxygenates like ethanol, I-propanol, I- butanol, I-pentanol and 1-hexanol improved performance parameters and reduced exhaust emissions (1, 2). Gasoline-ethanol blends with additives such as cyclooctanol, cycloheptanol increased brake thermal efficiency when compared to gasoline with reduction in CO, CO2 and NOx while HC and O2 increased moderately (3). Gasoline with additives like ethanol and ethanol-isobutanol increased the brake power, volumetric and brake thermal efficiencies and fuel consumption. The CO and HC concentrations in the engine exhaust decreased while the NOx concentration increased. The addition of 5% I-hexanol and 10% ethanol to gasoline gave the best results (4). Bio-additives (matter extracted from palm oil) as gasoline additives at various percentages (0.2%, 0.4% and 0.6%) showed improvement in fuel economy and exhaust emissions of SI engine (5). Methyl-ester of Jatropha oil diesel blends with Multi- DM-32 diesel additive showed comparable efficiencies, lower smoke, CO2 and CO (6). The addition of Di Methyl Carbonate (DMC) to diesel fuel increases efficiency marginally with reductions in NOx emissions while PM and soot emissions were reduced considerably (7, 8). Biodiesel with Di Ethyl Ether in a naturally aspirated and turbocharged, high- pressure, common rail diesel engine reduced NOx emissions with slight improvement in brake thermal efficiency (9,10). Ethanol addition to diesel-biodiesel blends increased brake thermal efficiency with reduction in carbon monoxide and smoke emissions and at the same time hydrocarbons, oxides of nitrogen and carbon dioxide emissions increased (11). Some researchers have used cetane improvers and some others have used additives in coated engines. Biodiesel blended fuel, and a cetane improving additive (2-EHN) reduced PM emissions (12). Addition of di-1-butyl peroxide and the conventional cetane improver, 2-ethylhexyl nitrate additives to diesel fuel reduced all regulated and unregulated emissions including NOx emissions (13).Present work attempts to investigate performance, combustion and emission characteristics of diesel engine with the linseed-biodiesel blends. The properties of linseed oil are shown in Table.

Table 1. Properties of Linseed Biodiesel

Properties	L10	L20	L30	DIESEL	Linseed Oil
Carbon%(w/w)	3.2	4.1	5.6	0.12	15.1
Flash Point(^{0}C)	64	73	89	58	185
Fire Point(^{0}C)	69	82	96	62	192
Density(g/cm^3)	822.5	826	829	830	896
Kinematic Viscosity(Stokes) at 40^{0}C	0.80	0.85	1.00	0.364	3.85
Specific Gravity	0.815	0.822	0.832	0.835	0.917
Calorific Value(kJ/kg)	42187	41861	41542	42500	39307

2. Experimental set up and procedure

2.1 Experimental set up

The engine shown in plate.1 is a 4 stroke, vertical, single cylinder, water cooled, constant speed diesel engine which is coupled to rope brake drum arrangement to absorb the power produced. The engine crank started. Necessary dead weights and spring balance are included to apply load on brake drum. Suitable cooling water arrangement for the brake drum is provided. Separate cooling water lines fitted with temperature measuring thermocouples are provided for engine cooling. A measuring system for fuel consumption consisting of a fuel tank, burette, and a 3-way cock mounted on stand and stop watch are provided. Air intake is measure during an air tank fitted with an orifice meter and a water U- tube differential manometer. Also digital temperature indicator with selector switch for temperature measurement and a digital rpm indicator for speed measurement are provided on the panel board. A governor is provided to maintain the constant speed.

Table 2. Specifications of the Test Engine

Specifications of the Test Engine	
Particulars	**Specifications**
Make	Kirloskar
Rated Power	3.7 kw(5hp)
Bore	80 mm
Stroke Length	110 mm
Swept volume	562 cc
Compression ratio 16.5:1	Compression ratio 16.5:1

Diesel Engine Test Rig

2.2Test Fuels

For experimental investigations, biodiesel derived from linseed oil was mixed with diesel in varying proportions 10%, 20% and 30% by volume respectively to all the blends.

2.3Experimental Procedure

Calculate full load (W) that can be applied on the engine from the engine specifications. Clean the fuel filter and remove the air lock. Check for fuel, lubricating oil and cooling water supply. Start the engine using decompression lever ensuring that no load on the engine and supply the cooling water allow the engine for 10 minutes on no load to get stabilization. Note down the total dead weight, spring balance reading, time taken for 20cc of fuel consumption and the manometer readings. Repeat the above step for different loads up to full load. Connect the exhaust pipe to the smoke meter and exhaust gas analyzer and corresponding readings are tabulated. Allow the engine to stabilize on every load change and then take the readings. Before stopping the engine remove the loads and make the engine stabilized Stop the engine pulling the governor lever towards the engine cranking side. Check that there is no load on engine while stopping

3. Results and Discussion

3.1Performance Analysis

The experiments are conducted on the four stroke single cylinder water cooled diesel engine at constant speed (1500 rpm) with varying loads. Various performance parameters such as, the variation of brake thermal efficiency with load for different fuels is presented in Fig. 1. In all cases, it increased with increase in load. This was due to reduction in heat loss and increase in power with increase in load. The maximum thermal efficiency for L30 (34.48 %) was higher than that of diesel [32.16%]. This blend of 30% also gave minimum brake specific energy consumption. Hence, this blend was selected as optimum blend for further investigations and long-term operation. The variation of mechanical efficiency with brake power is shown in the Fig.2. From the plot it is observed that Increase in mechanical efficiency observed in L10 because of lowest frictional powers compared to diesel. The variation of volumetric efficiency with Brake Power is shown in Fig. 3. From the plot It is observed diesel contains 89.7% at full load, in case of L30 at full load 77.88%.therfore the decrease in volumetric efficiency11.82% while using L30. The decrement in the volumetric efficiency is due to the decrease in the amount of intake air due to high temperature in the cylinder. The variation in BSFC with load for diesel and linseed oil blends is presented in Fig 4.Inallcases, The BSFC of L30 is decreases up to 4.56% as compared with diesel at full load condition. The main reason for this could be that percent increase in fuel required to operate the engine is less than the percent increase in brake power due to relatively less portion of the heat losses at higher loads. The BSFC for L30 was observed lower than diesel. The variation of Indicated Specific fuel Consumption(ISFC) with Brake Power is shown in Fig 5.From the plot it is observed that the indicated specific fuel consumption is slightly higher than the diesel for the blends of linseed oil. This improvement in ISFC was perhaps due to better combustion of the fuel, which may be attributed to the presence of oxygen in the blend. Hence ISFC in L30 blend was improve 2.39% compared to diesel fuel at full load condition initially it is higher than the diesel but coming to the full load condition it is coming closer to the diesel. The variation of Air-Fuel Ratio with Brake Power is shown in Fig 6. From the plot it is observed A/F for diesel is 25.59, where as in case of L30 22.61 from that it is observed decrease in A/F up to 11.6% compares with diesel at full load condition. The air fuel ratio decreases due to increase in load because of the compensation of load can only be done with increasing the quantity of fuel injection to develop the power required to bare the load.

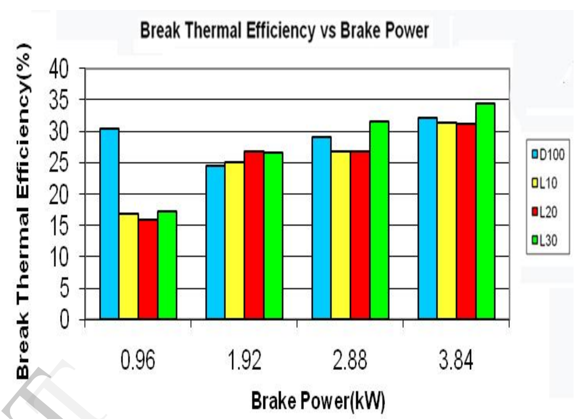

Fig 1: Variation of Brake Thermal Efficiency with Brake Power Using LSOEE Blends

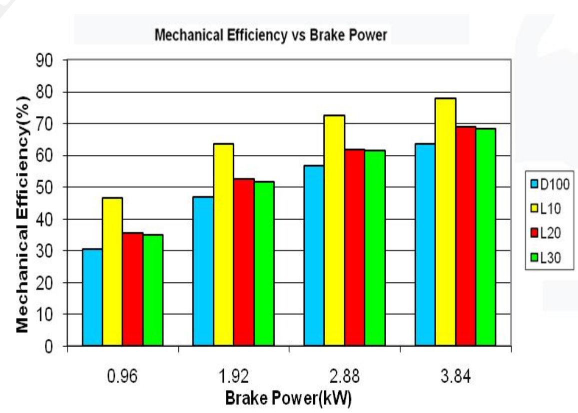

Fig 2: Variation of Mechanical Efficiency with Brake Power Using LSOEE Blends

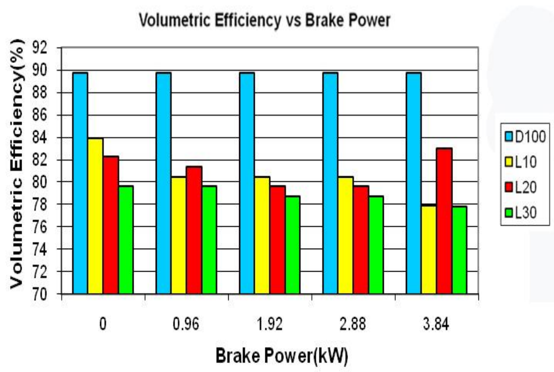

Fig 3: Variation of Volumetric Efficiency with Brake Power Using LSOEE Blends

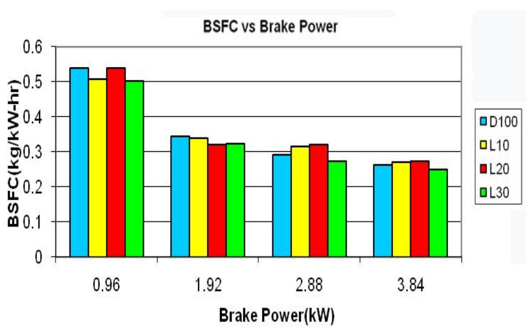

Fig 4: Variation of BSFC with Brake Power Using LSOEE Blends

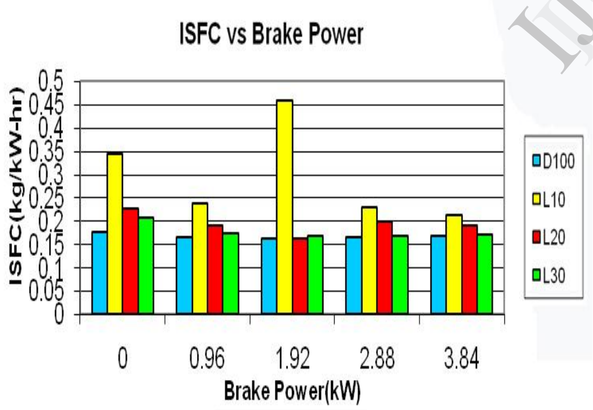

Fig 5: Variation of ISFC with Brake Power Using LSOEE lends

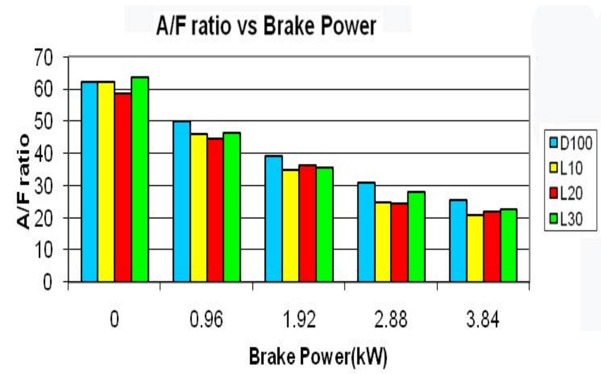

Fig 6: Variation of Air Fuel Ratio with Brake Power Using LSOEE Blends

3.2Emission Analysis Using Diesel and Linseed Oil Blends

The experiments are conducted on the four stroke single cylinder water cooled diesel engine at constant speed (1500 rpm) with varying loads. Various emission parameters in the sense of smoke density, unburned hydro carbons, carbon monoxide and nitrogen are discussed below. The variation of Smoke density with Brake Power is shown in Fig 7.The Smoke is nothing but solid soot particles suspended in exhaust gas the variation of smoke level with brake power at various loads for different blends likeL10, L20 andL30 tested fuels. It is observed that smoke is decreases for LOB-DIESEL blends at full load conditions. The decrease in smoke density of L10, L20and L30 is 24.6%, 25.9% and 19.6% respectively compared with diesel fuel at full load. The variation of CO emission with Brake Power is shown in Fig 8. The plot it is observed that is interesting to note that the engine emits more CO for diesel as compared to biodiesel blends under all loading conditions. The CO concentration is decreases for the blends of L10, L20 and L30 for all loading conditions. At full load conditions the CO emissions for the diesel is lower than the other blends and at full load condition the blend L30 given the lower emissions compared to all blends. CO emissions for all blends of Linseed oil are lower in comparison with diesel. The emissions of CO of different blends are found to be increasing with increase in load and decrease with increase in percentage of blend of biodiesel due to 10-12% of excess oxygen and better combustion due to higher cetane number. The decreased CO emissions are 40% than diesel fuel for L30 at full load. The variation of carbon dioxide with brake power is shown in Fig 9. The plot is revels that different specified blends are indicated. The co2 emission for all the fuels tested followed an increasing trend with respect to load. At full load condition diesel contains 6.0 % of CO2 emissions where as in case of L30 it is 6.40 %.The increase in CO2 emissions is 0.40%.The CO2 emissions increased with load for all the fuel modes. At varying loads, the oxygen content in the LSOEE improves the combustion process, which leads to a complete combustion and hence increased CO2 emission than that of diesel. The variation in HC emissions with Brake Power is shown in Fig 10. The plot it is observed that the HC emission variation for different blends is indicated. That the HC emission decreases with increase in load for diesel and it is drastic decreases for all biodiesel blends. Traces are seen at no load and full load. At full load condition the HC emissions for diesel is high compared to the all the blends, the blend L30 has shown the maximum reduction in the HC emissions. As the Catani number of ester based fuel is higher than diesel, it exhibits a shorter delay period and results in better combustion leading to low HC emission. Also the intrinsic oxygen contained by the biodiesel was responsible for the reduction in HC emission. The variation of NOx emission with Brake Power is shown in Fig 11. The plot it is observed that for different blends is indicated. The NOx emission for all the fuels tested followed an increasing trend with respect to load. At full load condition the blend F30 has given the most decrement in the oxides of nitrogen compared to all higher load conditions. A reduction in the emission for all the blends as compared to diesel was noted. With increase in the biodiesel content of the fuel, corresponding increment in emission was noted. The variation of unused oxygen emission with brake power is shown in Fig 12. From the graph it is observed that as the load increases the unused oxygen decreases. At full load condition the unused oxygen obtained are 13.78%, 18.7%, 14.09% and 14.49% for the fuels of diesel, L10, L20 and L30 respectively. The decrement of unused oxygen due to CO emission converts into CO2 emission.

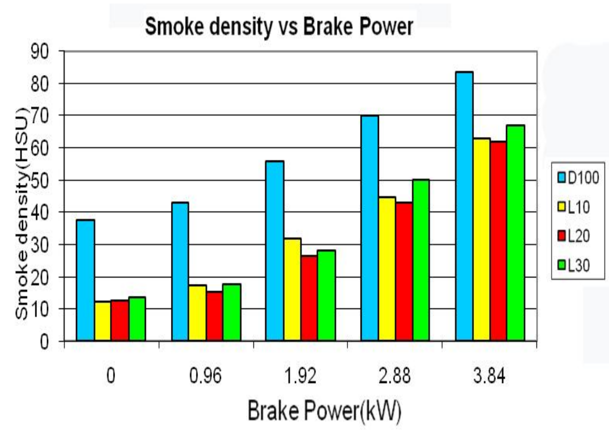

Fig 7: Variation of Smoke Density with Brake Power Using LSOEE

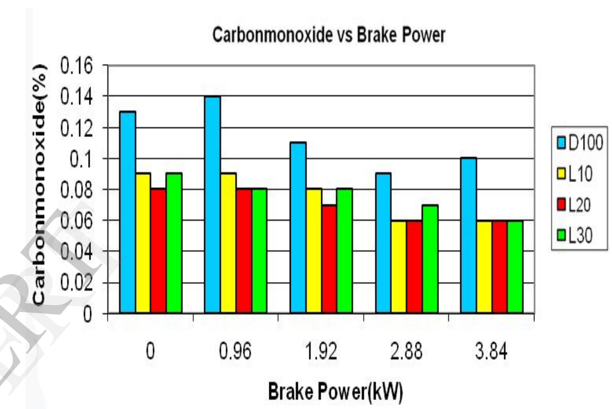

Fig 8: Variation of Carbon Monoxide with Brake Power Using LSOEE Blends

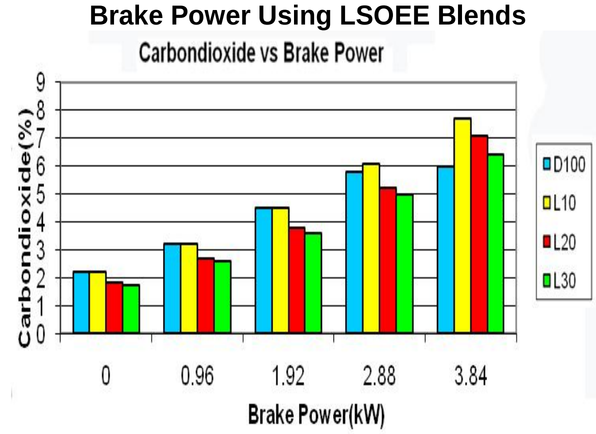

Fig 9: Variation of Carbon Dioxide with Brake Power Using LSOEE Blends

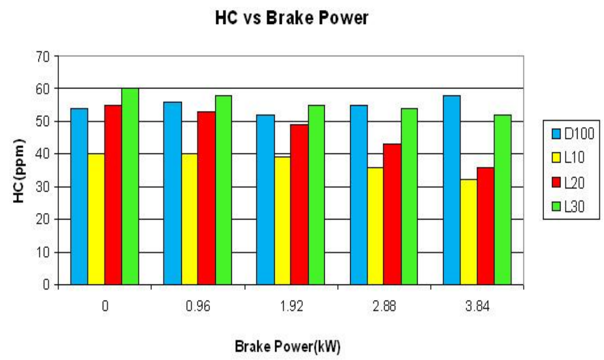

Fig 10: Variation of Unburned Hydrocarbons with Brake Power Using LSOEE Blends

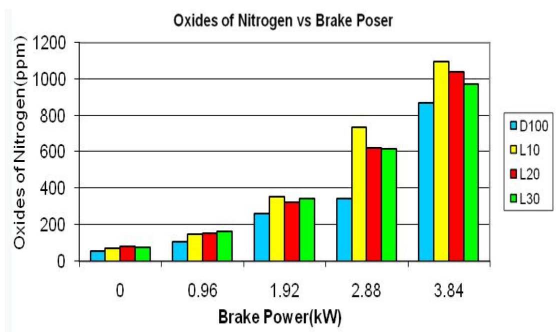

Fig 11: Variation of NOx Emission with Brake Power Using LSOEE Blends

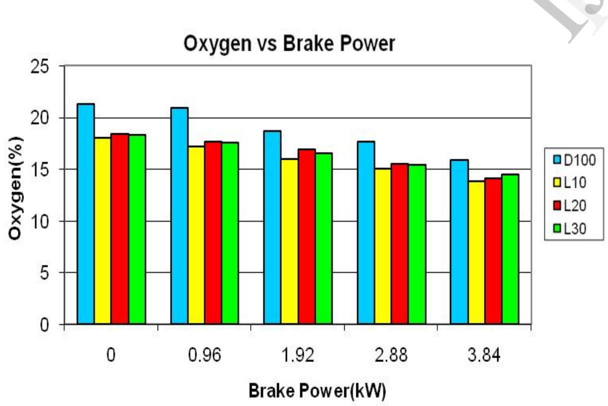

Fig 12: Variation of Unused Oxygen with Brake Power Using LSOEE Blends

Conclusions

The conclusions deriving from present experimental investigation to evaluate the experimental tests are conducted on 4-stroke, single cylinder, water cooled and direct injection diesel engine by using linseed oil blends of L10, L20 and L30, pure diesel at constant speed of 1500 rpm. From the first set of results it can be conclude that the blend L30 has given the better performance in the sense of brake thermal efficiency, specific fuel consumption and emission parameters. No engine seizing, injector blocking was found during the entire operation while the engine running with different blends of linseed oil and diesel are summarized as follows:

1. The BSFC obtained are 0.272 kg/kW-hr, 0.274 kg/kW-hr, 0.251 kg/kW-hr and 0.263 kg/kW-hr for fuels of diesel, L10, L20 and L30respectively.Theminimumfuel consumption is for L30 is 0.251 kg/kW-hr as to that of diesel are 0.263 kg/kW-hr. The BSFC of linseed oil blend L30 is decreases up to 4.56% as compared with Diesel at full load conditions

2. The brake thermal efficiencies are obtained 31.30%, 31.28%, 34.48% and 32.16% for the fuels diesel, L10, L20 and L30 respectively, among the three blends of linseed oil the maximum BTE is 34.48% which is obtainedforL30.The BTE of linseed oil is increases up to 7.21% as compared with Diesel at full load condition.

3. The smoke density obtained is 62.96 HSU, 61.90 HSU, 67.16 HSU and 83.57 HSU for the fuels of diesel, L10, L20 and L30. It is observed that smoke is decreases for linseed oil blends at full load conditions as compared to diesel.

4. The unburned hydrocarbons are obtained 32ppm, 36ppm, 52 ppm and 58 ppm for the fuels of diesel, L10, L20 and L30 respectively.

5. The CO emission obtained is 0.06%, 0.06%, 0.06% and 0.10% for the fuels of diesel, L10, L20 and L30 respectively. The decreased CO emissions are 40% than diesel fuel for L30 at full load.

6. The NOx emission obtained is 1095ppm, 1039ppm, 974ppm and 872ppm for the fuels of diesel, L10, L20 and L30 respectively. The reason could be NOx emissions increase with increase in

power for all the biodiesel blends of L10,L20 and L30 due to increase in the amount of fuel burnt with load, which results in increase in combustion temperature.

7. Exhaust emissions like smoke density, unburned hydrocarbons, and carbon monoxide are decreases of linseed oil blends as compared to diesel fuel.

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