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Experimental Investigation Of A Diesel Engine Using Nerium Oil As Alternative Fuel

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ABSTRACT

The world's fossil fuel reserves are depleting rapidly, according to the survey, 75% of fossil fuel production will be decreased in coming 11 years. Developing countries like India, invests heavily on imports of fossil fuels. Diesel fueled vehicles discharge significant amount of pollutants like CO, HC, NO_x*, lead, soot, which are harmful for the environment. In this present work, four different blend ratios of Nerium oil esters in varying proportions viz., 20%, 30%, 40% pure Nerium oil with diesel are used. for investigating performance and emission characteristics.*

Experiments are carried out on a diesel engine using Nerium oil as alternative fuel which is a single cylinder, four-stroke, water cooled, and constant speed engine capable of developing a power output of 6.6 kW at 1500 rpm. Performance parameters such as brake power, specific fuel consumption, and thermal efficiency are calculated based on experimental analysis of the engine. Emissions such as carbon monoxide, carbon dioxide and unburned hydrocarbon are measured.

INTRODUCTION

Compression ignition engines are employed particularly in the field of heavy transportation and agriculture on account of their higher thermal efficiency and durability. However, diesel engines are the major contributors of oxides of nitrogen and particulate emissions. Hence more stringent norms are imposed on exhaust emissions. Following the global energy crisis in the 1970s and the increasingly stringent emission norms, the search for alternative renewable fuels has intensified.

The details of the experimental set up are presented in this chapter. The experimental setup is fabricated to fulfill the objective of the present work. The various components of the experimental set up including modification are presented in this chapter

NEED FOR ALTERNATE FUELS

Probably in this century, it is believed that crude oil and petroleum products will become very scarce and costly to find and produce. Although fuel economy of engines is greatly improved from the past and will probably continue to be improved, increases in number of automobiles alone dictate that there will be a great demand for fuel in the near future.

Bio-diesel is reliable, renewable, biodegradable and non toxic. It is less harmful to the environment for it contains practically no sulphur and substantially reduces emissions of HC, CO, sulphates, polycyclic aromatic and particulate matter. It has fuel properties comparable to mineral diesel and because of great similarity; it can be mixed with mineral oil and used in standard diesel engines with minor or no modifications at all. Bio diesel works well with new technologies such as catalysts, particulate traps and exhaust gas recirculation. It can be produced from any kind of oil both vegetable and animal source. Used frying oil can also be used and therefore be a very promising alternative for waste treatment.

Being an agricultural product, all countries have the ability to produce and control this energy source, which is a situation very different to crude oil business. It can strengthen economy by creating more jobs and create independence from the imported depleting commodity petroleum.

Another reason for bio-diesel development is the fact that large percentage of crude oil must be imported from other countries which decrease the dependency on foreign fuel and increase the Indian economy.

MATERIALS AND METHODS

Rapid depletion of conventional energy sources, along with increasing demand for energy is a matter of serious concern. To solve both the energy concern and environmental concern, the renewable energies with lower environmental pollution impact should be necessary. Biodiesel is renewable and environmental friendly alternative diesel fuel for diesel engine. It can be produced by trans-esterification process. Trans-esterification is a chemical reaction in which vegetable oils and animal fats are reacted with alcohol in the presence of a catalyst. The products of reaction are fatty acid alkyl ester and glycerin, and were the fatty acid alkyl esters known as biodiesel.

Transesterification of Nerium Oil:

To reduce the viscosity of the Nerium oil, trans-esterification method is adopted for the preparation of biodiesel.

Methyester of Nerium oil:

The procedure involved in this method is as follows: 1000 ml of Nerium oil is taken in a three way flask. 12 grams of sodium hydroxide (NaOH) and 200 ml of methanol (CH3OH) are taken in a beaker. The sodium hydroxide (NaOH) and the alcohol are thoroughly mixed until it is properly dissolved. The solution obtained is mixed with Nerium oil in three way flask and it is stirred properly. The methoxide solution with Nerium oil is heated to 60 ^{0}C and it is continuously stirred at constant rate for 1 hour by stirrer. The solution is poured down to the separating beaker and is allowed to settle for 4 hours. The glycerin settles at the bottom and the methyl ester floats at the top (coarse biodiesel). Methyl ester is separated from the glycerin. This coarse biodiesel is heated above 100°C and maintained for 10-15 minutes to remove the untreated methanol. Certain impurities like sodium hydroxide (NaOH) etc are still dissolved in the obtained coarse biodiesel. These impurities are cleaned up by washing with 350 ml of water for 1000 ml of coarse biodiesel. This cleaned biodiesel is the methyl ester of Nerium oil.

Ethyl ester of Nerium oil:

The procedure involved in this method is as follows: 1000 ml of Nerium oil is taken in a three way flask. 12 grams of sodium hydroxide (NaOH) and 200 ml of Ethanol (C2H5OH) are taken in a beaker. The sodium hydroxide (NaOH) and the alcohol are thoroughly mixed until it is properly dissolved. The solution obtained is mixed with Nerium oil in three way flask and it is stirred properly. The ethoxide solution with Nerium oil is heated to 60°C and it is continuously stirred at constant rate for 1 hour by stirrer. The solution is poured down to the separating beaker and is allowed to settle for 4 hours. The glycerin settles at the bottom and the ethyl ester floats at the top (coarse biodiesel). Ethyl ester is separated from the glycerin. This coarse biodiesel is heated above 100°C and maintained for 10-15 minutes to remove the untreated ethanol. Certain impurities like sodium hydroxide (NaOH) etc are still dissolved in the obtained coarse biodiesel. These impurities are cleaned up by washing with 350 ml of water for 1000 ml of coarse biodiesel. This cleaned biodiesel is the Ethyl ester of Nerium oil. This bio-diesel of methyl ester of Nerium oil and ethyl ester of Nerium oil was then blended with mineral diesel in various concentrations for preparing biodiesel blends to be used in CI engine for conducting various engine tests.

Properties of Nerium oil

Properties	**Diesel**	**Nerium oil**
Kinematic viscosity at 40 ^{0}C (cSt)	3.52	4.88
Density at 15 ^{0}C (kg/m^3)	830	910
Flash point (^{0}C)	49	148
Calorific value (kJ/kg)	42000	36570
Sp.gravity	0.83	0.91

EXPERIMENTAL SET UP

The experimental set up consists of engine, an alternator, top load system, fuel tank along with immersion heater, exhaust gas measuring digital device and manometer.

Engine:

The engine which is supplied by M/s Alamgir Company. The engine is single cylinder vertical type four stroke, Air-coo1ed, compression ignition engine. The engine is self governed type whose specifications are given in Appendix 1.is used in the present work.

REASONS FOR SELECTING THE ENGINE

The above engine is one of the extensively used engines in industrial sector in India. This engine can with stand the peak pressures encountered because of its original high compression ratio. Further, the necessary modifications on the cylinder head and piston crown can be easily carried out in this type of engine. Hence this engine is selected for the present project work.

Dynamometer

The engine is coupled to a generated type electrical dynamometer which is provided for loading the engine.

Fuel injection pump

The pump is driven by consuming some part of the power produced by the engine; it will provide the required pressure to the injector. The pump is BOSCH fuel injection pump.

Fuel injector (BOSCH)

A cross sectional view of a typical BOSCH fuel injector

The injector assembly consists of

i. A needed valve

ii. A compression spring

iii. A nozzle

iv. An injector body

CALCULATIONS AND GRAPHS

The parameters that are determined at different loads are as fallows

1. Brake Power, B.P = $\frac{VI\cos\emptyset}{\eta_{tran} \times \eta_{gen} \times 1000}$ kW

Where,

V = voltage, volts
A = current, amperes
Cos = Power factor = 1
η_{tran} = Transmission Efficiency = 0.98
η_{gen} = Generator Efficiency = 0.9
Brake Power, B.P =

2. T.F.C = $\frac{20 \times 0.85 \times 3600}{t \times 1000}$ Kg/h

Where,

T.F.C = Total Fuel Consumption, Kg/h
Specific gravity of diesel = 0.85
t = Time taken for 20 c.c fuel, seconds
T.F.C =

3. Brake Specific Fuel Consumption, bsfc = $\frac{T.F.C}{B.P}$ Kg/kwh

Brake Specific Fuel Consumption, bsfc = Kg/kwh

4. Heat Input = T.F.C X C.V kW

Where,

C.V = Calorific Value of Fuel, kJ/kg k

5. Frictional Power, F.P = kW (from graph by William's line method)

6. Indicated Power = B.P + F.P

Indicated Power = kW

7. Mechanical efficiency = $\frac{B.P}{I.P}$ x 100 %

Mechanical Efficiency, η_{mech} = %

8. Brake thermal efficiency = $\frac{B.P}{\text{Heat Input}}$ x 100 %

9. Indicated thermal efficiency = $\frac{I.P}{\text{Heat Input}}$ x 100 %

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10. Brake Mean Effective Pressure, bmep = $\frac{B.P \times 60}{L \times A \times n \times k}$ kN/m^2

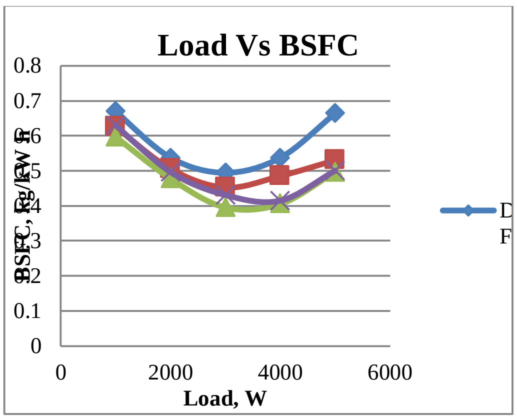
Where L = length of the stroke, m n = speed of the engine = 1500/2

A = Area of the cylinder, m^2 k = no. of cylinders

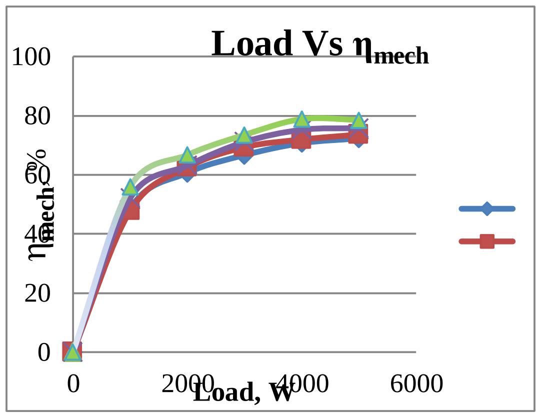
11. Indicated Mean Effective Pressure, Imep = $\frac{I.P \times 60}{L \times A \times n \times k}$ kN/m^2

12. Volumetric efficiency, $\eta_{vol} = \frac{\text{actual volume flow rate of air}}{\text{the rate at which volume is displaced}} \times 100\ \%$

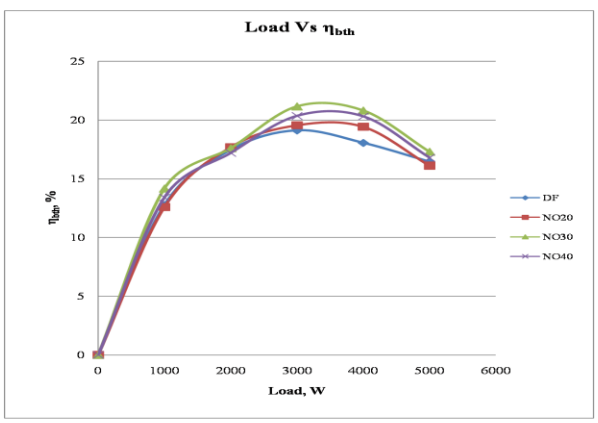
$$= \frac{\text{area of inlet pipe} \times \text{velocity of air}}{\left[\begin{matrix}\text{are of}\\ \text{the cylinder}\end{matrix}\right] \times \left[\begin{matrix}\text{length of}\\ \text{the stroke}\end{matrix}\right] \times \left[\begin{matrix}\text{revolutions}\\ \text{per second}\end{matrix}\right]} \times 100\%$$



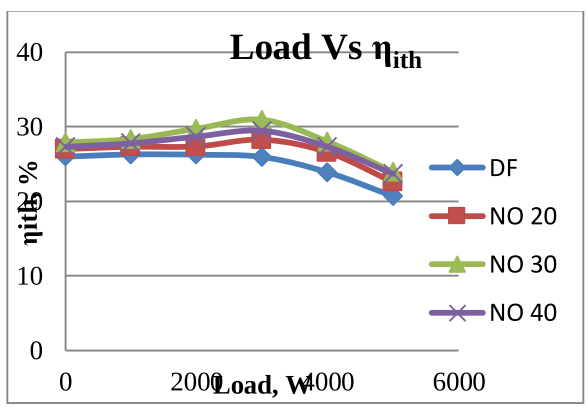
Load Vs B.S.F.C



Load Vs Mechanical efficiency



Load Vs Brake Thermal Efficiency



Load Vs Indicated Thermal Efficiency

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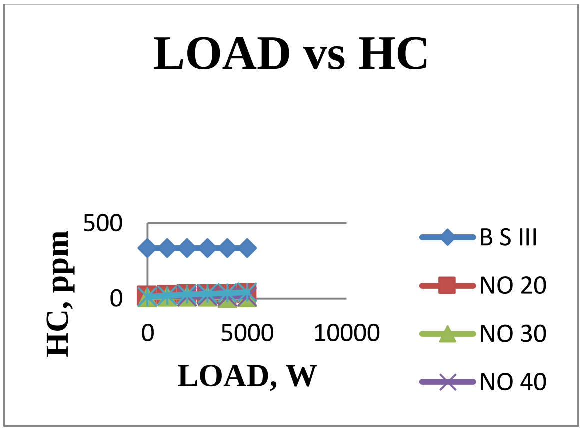
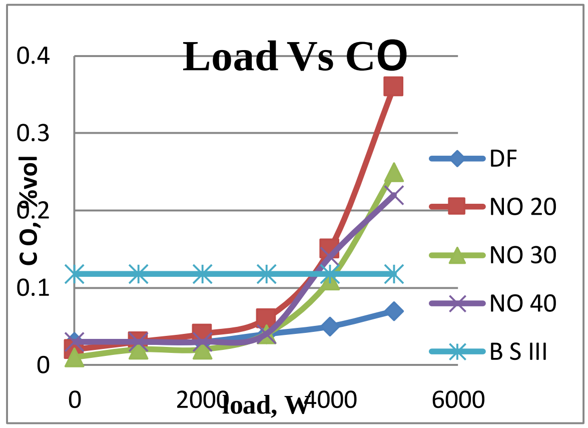


Load Vs Hydro carbons



Load Vs Carbon monoxide

RESULTS AND DISCUSSIONS

Experiments were conducted when the engine was fuelled with Nerium oil and their blends with diesel in proportions of 20:80, 30:70 and 40:60 (by volume) which are generally called as NO-20, NO-30 and NO-40 respectively. The experiment covered a range of loads.

The performance of the engine was evaluated in terms of brake specific fuel consumption, brake thermal efficiency and volumetric efficiency. The emission characteristics of the engine were studied in terms exhaust gas temperature, concentration of HC, CO and CO_2. The results obtained for Nerium oil and their blends with diesel were compared with the results of diesel.

BRAKE SPECIFIC FUEL CONSUMPTION:

The result for the variations in the brake specific fuel consumption (BSFC) is presented all the fuels the BSFC falls with increasing load up to 3000W and beyond that the BSFC increases with load. This indicates the existence of an optimum value of BSFC at a load of 3000W. From fig. it can be clearly seen that BSFC is maximum for diesel fuel and minimum NO 30 and in between NO 20 and NO 40 at given load. A similar trend is BSFC can be observed at all the load considered in present work. The maximum BSFC values are 0.67 kg/kW hr for diesel, 0.627 kg/kWhr for NO-20, 0.597 kg/kWhr for NO-30 and 0.63 kg/kWhr for NO-40.

BRAKE THERMAL EFFICIENCY:

The variation of brake thermal efficiency with respect to load for NO-DF blends and DF It can be observed that the thermal efficiency is increase with load up to 3000W and than after reducing. It can be observed that the engine fueled with NO 20, NO 30, NO 40 and Diesel gives brake thermal efficiency of 19.56%, 21.16%, 20.35 % and 19.12 respectively at 3000W load. Because of the changes in composition, viscosity, density and calorific value of NO-DF blends the brake thermal efficiencies of NO 20, NO 40 are low particularly at 3000W load and increased for NO 30. Part load thermal efficiency is good for the NO-DF blends.

INDICATEDTHERMAL EFFICIENCY:

The variation of Indicated thermal efficiency with respect to load for NO-DF blends and DF It can be observed that the thermal efficiency is 23.28% at 3000W load for diesel. It can be observed that the engine fuelled with NO 20, NO 30and NO 40 gives Indicated thermal efficiency of 27.6%, 30.63%, and 29.53% respectively at 3000W load. Because of the increase in brake power and reduction in frictional power, the Indicated thermal efficiencies of NO-DF blends are high particularly at load 3000W.

VOLUMETRIC EFFICIENCY:

Volumetric efficiency variation for NO-DF blends and DF with respect to load is shown in the Fig.4.4.From the Fig.4.3,it may be observed that ,the Volumetric efficiency is maximum for NO 40 and minimum for Diesel and in between these two NO20 and NO 30 at a given load. Volumetric efficiency of DF is 67.04% at 3000W load and for NO 20, NO 30 and NO 40 is 69.56%, 71.04%and 73.56% respectively. Volumetric efficiency is slightly increased for all the NO-DF blends compared to Diesel.

BRAKE MEAN EFFECTIVE PRESSURE:

Brake mean effective pressure with respect to load exists for all kinds of test fuels can be observed At 4000W load Brake mean effective pressure for the diesel is 317.17kN/m^2, whereas for NO 20, NO 30and NO40 is 325.54 kN/m^2, 359.49 kN/$m^2$and 352.6kN/m^2 respectively. Linear variations of brake mean effective pressure can be observed and there is no significant deviation in brake mean effective pressure for the NO-DF blends from that of pure diesel.

INDICATEDMEANEFFECTIVEPRESSURE:

Linear variations of indicated effective pressure with respect to load exist for all kinds of test fuels can be observed Indicated mean effective pressure for the diesel at 4000W load is 451.75kN/m^2, where as for NO 20, NO 30and NO 40 is 465.09kN/m^2, 477.63kN/$m^2$and 447kN/m^2 respectively. Linear variations of Indicated mean effective pressure can be observed and there is no significant deviation in indicated mean effective pressure for the NO-DFblends fromthatofpurediesel.

CONCLUSIONS

Following are the conclusions based on the experimental results obtained while operating single cylinder air cooled diesel engine fuelled with Nerium Oil and its diesel blends.

* The blends of Nerium oil show lowest specific fuel consumption than the diesel at part loads. B.S.F.C is decreased the blend NO

* Brake Thermal efficiency of the tested diesel engine is improved when it is fuelled with Nerium oil-diesel blends.

* Mechanical efficiency for NO 30 is higher compared to Diesel fuel operation is observed.
* Brake mean effective pressure is also increased as the percentage of the Nerium oil increases with the diesel.
But this increment in Brake mean effective power is insignificant.

* Actual Breathing capacity of the engine also slightly increased which leads to increase in volumetric efficiency. It is noted that the volumetric efficiency is raised as the blend of the Nerium oil increases in the diesel.

* CO emission decrease with increase in percentage of Nerium oil in the fuel up to 3000W.

* CO_2 emissions of Nerium oil and its diesel blends are slightly lower than that of diesel.

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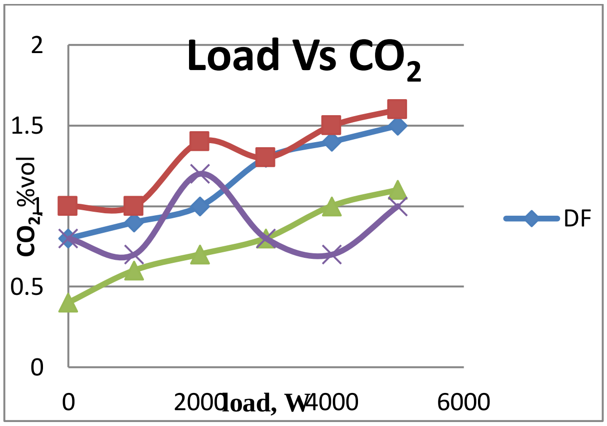
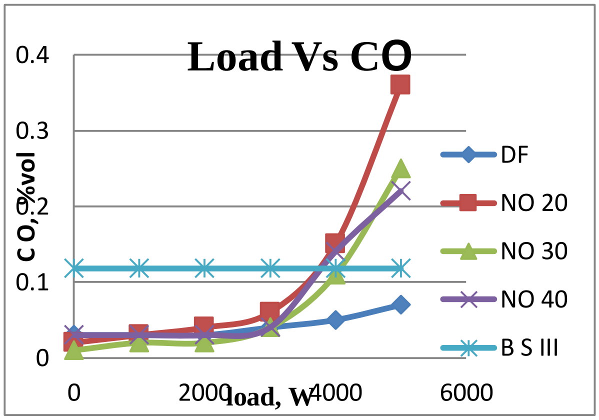
* HC emissions of Nerium oil and its diesel blends are lower than that of diesel

* From the above analysis the main conclusion is Nerium oil and its diesel blends are suitable substitute for diesel as they produce lesser emissions than diesel upto a load of 3000W and have satisfactory combustion and performance characteristics.



Load Vs Carbon dioxide



Load Vs Carbon monoxide