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"PERFORMANCE AND EMISSION CHARACTERISTICS OF DIESEL ENGINE FULLED WITH BLENED BIODIESEL FROM NEEM AND NYGER"

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ABSTRACT

The contribution of Neem and Nyger as a source for biodiesel production will be of great importance in the upcoming days. In India Neem tree is a widely grown up in many areas of study. Neem is a large tree growing about 20 m in height with spreading branches forming a broad crown, starts fruiting after 4 years. It thrives well in dry, stony shallow soils and even on soils having hard calcareous or clay pan, at a shallow depth. Nyger seeds observe as sunflower seeds in shape, but is smaller in size and black. It bears a fairly thick, adherent seed coat and can be stored for up to a year without deterioration. Biodiesel production from Neem and Nyger oil, which is monoester produced using transesterification process. It has high lubricity, clean burning fuel and can be a fuel component for use in existing unmodified diesel engine.

***Keywords**: Nyger, Transesterification, BSFC, Unburnt hydrocarbon.*

I. INTRODUCTION

The internal combustion engine is an engine in which the combustion of a fuel (normally a fossil fuel) occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit. In an internal combustion engine, the expansion of the high temperature and high pressure gases produced by combustion apply direct force to some component of the engine. This force is transferred to crankshaft through connecting rod, transforming chemical energy into useful mechanical energy. In the year 1892, compression ignition engine was introduced by RUDOLF DIESEL (1858-1913) a German engineer born in Paris. Here, compression of air alone to sufficiently high temperature ignited the fuel without the help of ignition systems. Today CI engine is a very important prime mover, being used in buses, trucks, locomotives, tractors, pumping sets and other stationary industrial applications, small and medium electric generation and marine propulsion.
The importance of CI engine (Diesel) is due to:-

- Its thermal efficiency is higher than Petrol engines (SI)
- Diesel engines fuels being less expensive than Petrol engine fuels. Since Diesel engines fuels have a higher specific gravity than petrol.
- These factors make the running of the CI engines much less than SI engine and hence make them attractive for all industrial, transport and other applications. However, in passenger cars it has not found much favor because of the main drawbacks of a CI engine in relation to SI engine i.e., heavier weight, noise and vibration, smoke and odor. Because of the utilization of higher compression ratios (12:1 to 22:1 compared to 6:1 to 11:1 of SI engine) the forces coming on the various parts of the engines are greater and therefore heavier parts are necessary. Performance tests are necessary to carry out for an engine to assess the fuel and thermal efficiencies. Further, it is also required to study the effect of different parameter on the engine performance, i.e. incomplete combustion of heterogeneous mixture, and droplet combustion. Compression ignition engines, because of their varied applications, are manufactured in a large range of sizes, speed and power inputs. The reasons behind choosing biodiesel as an alternative fuel are several. This fuel has various numbers of advantages over fossil fuels. Biodiesel can be used as a very good alternative fuel for diesel engine. Its low carbon content makes it as an alternative to heating oil. With the help of biodiesel we are cycling carbon instead of releasing stored carbon into the atmosphere. Sunlight and carbon dioxide are the two essential components necessary for the growth of a plant and the necessary carbon that is stored in the plant during its growth is same as that released during the combustion process. This results in a positive energy balance. Energy balance is defined as the ratio of comparison of energy stored in the fuel to the energy required to grow, process and distribute that fuel. The energy balance ratio of biodiesel is no less than 2.5 to 1.

II. METHODOLOGY

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1) EXTRACTION OF NEEM AND NYGER OIL:

- First, each five kg of Neem and Nyger oil collected in different bickers and clean by hand picking of impurities.
- Then individually heated upto 100 ºC to vaporize all moisture contents. After the straining process Four kg of purified Neem and Nyger oil was obtained.
- Purified Three kg of Neem and nyger oil was used for experimentation.

2) FREE FATTY ACID TEST FOR NEEM AND NYGER:

Procedure:

- 10ml of Iso-propanol is taken in a flask
- 3-4 drops of phenolphthalein indicator is added to propanol
- 1 gram of Neem oil is then added to propanol and phenolphthalein indicator mixture
- KOH (0.01) solution is allowed drop by drop to the Neem oil solution till the solution become pink for 5-10sec and then disappear.
- KOH (0.01) solution consumed to get pink colour is noted down. Depending on the amount of KOH(0.01) consumed fatty acid present in the oil is decided.

FIG 1: FFA TESTING EQUIPMENT

- Calculation of Free Fatty Acid Test

FFA= 28.2*(normality of Sodium hydroxide)* (titration Value) / (Weight of the oil)
RESULT:
Total acid number = 10.3
Free fatty acid = 4.6

3) TRANSESTERIFICATION PROCESS:

Transesterification is the process of exchanging the organic group R″ of an ester with the organic group R′ of an alcohol. These reactions are often catalyzed by the addition of an acid or base catalyst.
The Trans-esterification process was carried out for the purified Neem and Nyger oil by a two stage process which involves

1. Acid catalyzed esterification
2. Base catalyzed esterification

4) SULFURICACID CATALYZEDESTERIFICATION:

Stepwise procedure:

1. 1 liter of Neem oil is heated to 70 degree centigrade.
2. Add 300ml methanol, 8ml of isopropyl alcohol and 2ml sulphuric acid into a beaker.
3. Transfer the heated Neem oil to the round bottom flask of the esterification set up.
4. Pour the methanol and acid mixture to the other beaker in the set up.
5. Slowly allow the methanol acid mixture by opening the valve into the flask containing Neem oil.

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6. The magnetic stirrer stirs the mixture of Neem oil, methanol and acid, there by does not allow the mixture to solidify.
7. The stirring is carried on for 90 minutes.
8. In a test tube a sample of mixture is taken and kept aside for few minutes to check if the FFA is are forming a separate layer on top.
9. If the FFA is form a separate layer the process is complete.
10. Pour the mixture in the flask to the settling flask and allow settling for 60 minutes for the FFA is to form a separate layer.
11. Separate the FFA is layer from the remaining.

Fig 2: Trans-esterification setup

5) BASE CATALYZED ESTERIFICTION:

Stepwise procedure:

1. The product of acid catalyzed esterification obtained from is heated for 70 degree centigrade.
2. In a beaker add 150ml of methanol and 10 grams of KOH pellets and allow it to dissolve.
3. Transfer the heated Neem oil to the round bottom flask of the esterification set up.
4. Pour the methanol and KOH mixture to the other beaker in the set up
5. Slowly allow the methanol, KOH mixture by opening the valve into the flask containing Neem oil.
6. The magnetic stirrer stirs the mixture of Neem oil, methanol and KOH, there by does not allow the mixture to solidify.
7. The stirring is carried on for 90 minutes.
8. In a test tube a sample of mixture is taken and kept aside for few minutes to check if the glycerine is forming a separate layer in the bottom.
9. If the glycerine forms a separate layer the process is complete.
10. Pour the mixture in the flask to the settling flask and allow settling for 60 minutes for the glycerine to form a separate layer.
11. Separate the glycerine layer from the remaining biodiesel.

FIG 3: Formation of Glycerine Layer

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6) RECOVERY OF METHANOL FROM BIO-DIESEL:

- Transfer the bio-diesel into the reaction vessel (3-neck flask).
- Make the necessary arrangement for the distillation setup like heating, stirring and fixing the double wall condenser along with the recovery flask.
- Maintain the RPM speed at 100 RPM(slow rotation).
- Maintain the temperature at 700C (boiling [point 64.070c).
- Methanol starts evaporating.
- Collect the methanol condensate, measure the quantity and record it.
- Switch off system when the methanol condensation stops.

7) WATER WASH:

The biodiesel obtained is washed 3 times with water to remove the catalyst. If clear wash water is got back it indicates that the catalyst is not present in the biodiesel. This is later heated to 100 degree centigrade to get dry biodiesel which is free from moisture .Thus neat bio diesel is obtained.

FIG 4: Water Wash

8) DRYING OF BIO-DIESEL:

- Transfer the washed BIO-diesel from the washing funnel to the 1 liter beaker. Add the magnetic pellet and adjust RPM to suitable speed.
- Heat the bio-diesel to a temperature of 1100C (moisture evaporates).
- Allow the Bio-diesel to cool gradually.
- Measure the final finished bio-diesel and records it.
- Store it in a clean, dry container.

9) BASE CATALYZED ESTERIFICTION:

Stepwise procedure:

1. One liter of Nyger oil is heated to 70 degree Celsius temperature.
2. In a beaker add 150ml of methanol and 10 grams of NaOH pellets and allow it to dissolve.
3. Transfer the heated Neem oil to the round bottom flask of the esterification set up.
4. Pour the methanol and NaOH mixture to the other beaker in the set up
5. Slowly allow the methanol, NaOH mixture by opening the valve into the flask containing Neem oil.
6. The magnetic stirrer stirs the mixture of Neem oil, methanol and NaOH, thereby does not allow the mixture to solidify.
7. The stirring is carried on for 90 minutes.
8. In a test tube a sample of mixture is taken and kept aside for few minutes to check if the glycerine is forming a separate layer in the bottom.
9. If the glycerine forms a separate layer the process is complete.
10. Pour the mixture in the flask to the settling flask and allow settling for 60 minutes for the glycerine to form a separate layer.
11. Separate the glycerine layer from the remaining biodiesel.

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FIG 5: Formation of Glycerine Layer

10) WATER WASH:

The biodiesel obtained is washed 3 times with water to remove the catalyst. If clear wash water is got back it indicates that the catalyst is not present in the biodiesel. This is later heated to 100 degree centigrade to get dry biodiesel which is free from moisture .Thus neat bio diesel is obtained.

FIG 6: Water Wash (1st Water wash, 2nd Water wash)

11) DRYING OF BIO-DIESEL:

- Transfer the washed BIO-diesel from the washing funnel to the 1 liter beaker. Add the magnetic pellet and adjust RPM to suitable speed.
- Heat the bio-diesel to a temperature of 1100C (moisture evaporates).
- Allow the Bio-diesel to cool gradually.
- Measure the final finished bio-diesel and records it.
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12) BLENDING OF FUEL:

The produced bio diesel is blended with the regular in different percentages. Below are the notations for different fuel samples which are blended

Table 1: Blending Of Fuel

Sr. no	Biodiesel Percentage Neem and Nyger oil blends	Diesel Percentage	Notation
1	20%	80%	B20
2	40%	60%	B40
3	60%	40%	B60
4	80%	20%	B80
5	100%	0%	B100

FIG 7: Blend B00 ***FIG 8: BlendB20*** ***FIG 9: Blend B40***

The blending process was carried out with the help of a measuring jar and beaker. The appropriate percentages of diesel and biodiesel were added to the beaker and then transferred to bottle. The bottles were shaking well and were allowed to stay upside down to ensure proper mixing of fuels.

The bottles were stored in dry place and kept still for the next 24 hour. Blends were checked for every 6 hrs time intervals for any layer formation.

All the blends were stable and passed the 24 hrs stability test and were ready to be used on engine.

III. TESTING VARIOUS PROPERTIES OF NEEM AND NYGER OIL BIODIESEL

The blended fuel samples and biodiesel were tested for different chemical and physical properties.

1) CALORIFIC VALUE TEST:

The first test was to find out calorific values of the biofuel fuel samples and also for regular diesel. This is done by testing 60 grams of fuel in a bomb calorimeter and directly obtaining the calorific value of the fuel.

2) PROCEDURE TO DTERMINE FLASH AND FIRE POINTS:

- The cup is washed with a solvent to remove any oil.
- The oil is filled up to the mark in the open vessel.
- The thermometer is used to note the rise in temperature.
- For everyone degree rise in temperature the testing flame is brought over cup
- The temperature at which a momentary flash occurs when the flame is brought near,

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- this temperature is known as "Fire point"

3) PROCEDURE TO DTERMINE VISCOSITY OF THE BIODIESEL USINGREDWOOD VISCOMETER:

Clean the viscometer thoroughly using kerosene and wipe it with clean paper. Weight the clean emptied specific gravity bottle and note down its weight. Fill the cylinder up to the mark with given liquid and place the bottle below the orifice of the viscometer. Let the base valve of the viscometer to be closed by the help of bail stopper.

Note down the temperature of the oil and the temperature of the water. If the temperature of these two is not equal, they can be made equal by stirring the water in the cylinder, if the temperature of the oil is more, it can be reduced by shutting off the power supply.

Open the base valve and note down the time taken for 50cc of oil to run through the orifice. Care should be taken to see that the oil does not spill outside the specific gravity bottle. Weight the bottle when it is filled up to the mark and note down the readings.

Repeat the procedure for different oils.

4) BIO-DIESEL DENSITY TEST:

A hydrometer is the instrument used to measure the specific gravity of bio-diesel. The hydrometer is made of glass and consists of a cylindrical stem and a bulb weighted with mercury or lead shot to make it float upright. The hydrometer contains a paper scale inside the stem, so that the specific gravity can be read directly.

- Measure 500 ml of the Bio-diesel in a clean dry 500 ml measuring cylinder.
- Bring down the temperature to the nearest- reference xx temperature (150c) and allow the bio-diesel to settle.
- Gently lower the hydrometer into the bio-diesel in the cylinder until it floats freely. Note the point at which the surface of the bio-diesel touches the stem of the hydrometer. Read the hydrometer level.
- The hydrometer reading *1000 is the density of the bio-diesel.

The results have been furnished below

Table 2: Properties of Biodiesel

SI No	PROPERTY	DIESEL	NEEM SEED	NYGER SEED
1	Calorific value, KJ/Kg	43500	37020	3640
2	Flash point, ^oC	44	179	160
3	Fire point, ^oC	49	215	180
4	Viscosity, Centipoise	3.8	5.35	5.90
5	Density , Kg/m^3	835	875	885

Table 3: Properties of Neem and Nyger oil Blends Biodiesel

Fuel Blends	Flash Point, ^oC	Calorific Value(KJ/kg)	Density(kg/m3)	Viscosity (cp)
DIESEL	**44**	**43500**	**840**	**3.8**
B100	**58**	**38400**	**863**	**5.1**

IV. EXPERIMENTAL SETUP FOR ENGINE PERFORMANCE TEST

1) ENGINE TEST PROCEDURE:

A four stroke, single cylinder water cooled diesel engine is employed for the present study. The detail specification of the engine used are given in table and experimental set up as shown in figure QROTEK 401 Five gas analyzer was used to measure the concentration of gaseous emissions such as Oxides of nitrogen, unburned hydrocarbon, carbon monoxide, carbon dioxide and oxygen level. The performance and emission tests are carried out on the C.I. engine using various blends of diesel-biodiesel blends as fuels. The tests are conducted at the constant speed of 1500rpm at various torques. In this experiment, engine parameters related to thermal performance of engine such as brake thermal efficiency, brake specific fuel consumption, brake specific energy consumption, exhaust gas temperature are measured. In addition to that, the engine emission parameters such as Oxides of nitrogen, unburned hydrocarbon, carbon monoxide, carbon dioxide and oxygen level.

2) EDDY CURRENT DYNAMOMETER:

The photograph of eddy current dynamometer with diesel engine is as shown in the above figure 16 It consists of a stator on which are fitted a number of electromagnets and a rotor disc made of copper and coupled to the output shaft of the engine. When a rotor rotates eddy current are produced in the stator due to magnetic flux set up by the passage of the field current in the electromagnets. These eddy current are dissipated in producing heat hence this dynamometer requires cooling arrangement. The torque is measured with the help of moment arm. The load is controlled by regulating the current in the electromagnets. The dynamometer used in this experiment is of foot mounted, continuous type and alternator rating of 3KVA and of speed 2800-3000RPM and voltage of 220V AC.

3) EXPERIMENTAL METHODOLOGY:

First the experimentation is performed with diesel (for getting the base line data of the engine) and then 100% biodiesel i.e. B100 and blends of different percent volumes of Biodiesel B20, B40, B60, B80 were carried out. The performance of the engine is evaluated in terms of brake thermal efficiency, brake specific energy consumption, exhaust gas temperature, and emission of the engine is analyzed (HC, CO, CO2, O2 and NOx)

4) MEASUREMENT OF PARAMETER REGARDING ENGINE PERFORMANCE ANDEXHAUST EMISSION

The computerized CI engine set up along with a high-speed digital data acquisition system, an eddy current dynamometer, a piezoelectric transducer and digital type temperature sensor was calibrated and used in the setup by Flow and Force engineers.

Following parameters were measured from the experimental CI engine setup.

1. Brake power
2. Fuel consumption
3. Air consumption
4. Exhaust gas temperature
5. Cooling water temperature (inlet and outlet)
6. Speed of the engine
7. Exhaust gas analysis (NOx, CO2, UBHC, CO and O2)

5) MEASUREMENTS OF PERFORMANCES:

Brake power is one of the most important parameter in the engine experiment. An eddy current dynamometer was used for present investigation. The fuel consumption of an engine is measured by determining the time required for consumption of given volume of fuel using a glass burette. The mass of fuel was calculated by multiplying volumetric fuel consumption to its density. An air box with orifice meter and manometer was used for accurate volumetric measurement of air consumption and finally mass flow rate was determined. Digital type temperature sensor was used for temperature measurement.

- **Brake Specific Fuel Consumption**

It defined as the fuel flow rate per unit power output. It is a measure the efficiency of the engine in using the fuel supplied to produce work. It is desirable to obtain a lower value of BSFC meaning that the engine used less fuel to produce the same amount of work. This is one of the most important parameters to compare when testing various fuels.

- **Brake Thermal Efficiency**

It is the ratio of the thermal power available in the fuel to the power the engine delivers to the crankshaft. This greatly depends on the manner in which the energy is converted since the efficiency is normalized with fuel heating value.

- **Exhaust Gas Temperature**

Exhaust gases of an I.C. engine contain significant enthalpy and may contain unburned combustion products (Hydrocarbon). When the air fuel ratio is high, the amount of incomplete combustion products is likely to be low, there is an insufficient amount of oxygen to complete combustion. The exhaust temperature is related to the determination of system efficiency.

6) MEASUREMENTS OF EMISSIONS:

Emission from the diesel engine can be classified into some categories as those from the gasoline. But the level of emission in these categories varies considerably. A sample of diesel exhaust may be free from smoke, smog and have no un burnt hydrocarbons or they may be heavy smoke led and heavy concentration of unburned hydrocarbons.

Smoke is defined as visible product of combustion which is due to improper burning of the Fuel. It originates in the combustion cycle in a localized volume of rich fuel-air mixture, any amount of smoke formed, depends on the air-fuel ratio, type of fuel and air pressure. In general, the smoke of diesel engine is of the two types,

- Blue white smoke
- Black smoke

FIG 10: AVL DIGAS 444 Exhaust analyser

7) BLUE WHITE SMOKE:

It is caused by localized droplets of lubricating oil or fuel line oil. While starting from cold, due to lower surrounding temperature and intermediate, products of combustion do not burn. This results in bluish air white smoke when exhausted.

8) BLACK SMOKE:

It is carbon particle suspended in the exhaust gas. It largely depends upon air fuel ratio and increase rapidly as the load is increased and the available air is depleted.

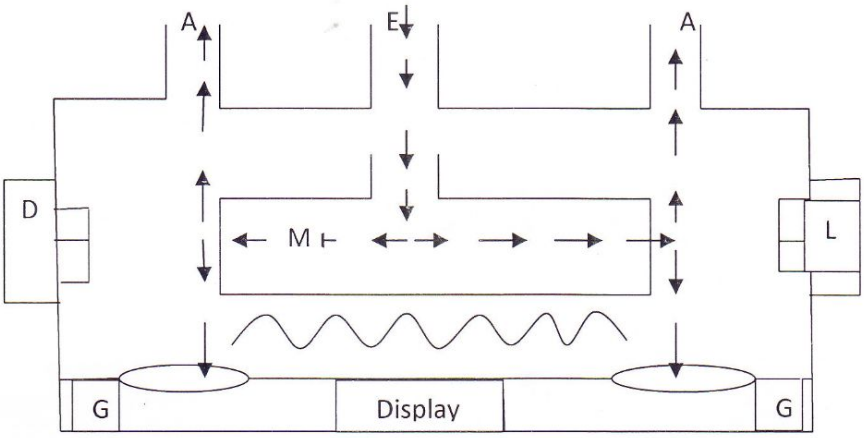

FIG 9: Line diagram for Smoke meter

V. ENGINEPERFORMANCE AND EXHAUST EMISSION ANALYSIS

1) PERFORMANCE CHARACTERISTICS:

The performance characteristics of the engine are the very important criterion for selection and suitability of alternate fuels. This study evaluates BSFC, BTE, A/F, ME and EGT of diesel blends

Table 4: Performance of diesel engine using B00 Blend as fuel

Load (Kg)	Speed (rpm)	BP (KW)	AFR	BSFC (Kg/KW-hr)	Exhaust gas temp(EGT) oC	η bth (%)
0	1440	0	0	0	141	0
5	1440	0.7	33.93	0.7	172	14.7

10	1440	1.8	24.82	0.56	241	18.31
15	1440	2.5	19.32	0.46	342	24.01
20	1440	2.93	16.46	0.34	380	27.34

VI. RESULTS AND DISCUSSION

Worldwide, biodiesel is largely produced by methyl transesterification of edible and non-edible oils. The studies were, therefore, conducted by transesterification process for Neem and Nyger oil biodiesel B100 and blends of different percent volumes of Biodiesel B20, B40, B60, B80 were carried out. The fuel consumption test and rating test of a constant speed CI engine was also conducted to evaluate the performance of the engine on diesel, Neem and Nyger oil biodiesel B100 and blends of different percent volumes of Biodiesel B20, B40, B60, B80.
In this chapter the engine performance and emission characteristics were also discussed and different graphs of showing the performance and emission characteristics were drawn and those graphs were analyzed in detailed.

VII. CONCLUSIONS

The overall studies based on the production, fuel characterization, engine performance and exhaust emission of Neem and Nyger oil biodiesel and its blends B20, B40, B60, B80 were successfully carried out. The following conclusions can be drawn:

- The production of Neem oil biodiesel is a two stage transesterification process whereas Nyger oil biodiesel is one stage transesterification process.
- Approximately 350 ml of methanol can be recovered from both oil.
- For one liter Neem oil the obtained biodiesel is 90% and for one liter Nyger oil they obtained biodiesel is 93%.
- The density of biodiesel is 865kg/m3 and it is more than fossil diesel (840kg/m3).
- The CV of B100 was found to be 38459.13 KJ/Kg and the CV of different blends was also determined according to ASTM standards. The CV of blends was found to be less than the fossil diesel (43500 KJ/Kg).
- The variation of brake thermal efficiency at various loads. the brake thermal efficiency slightly increases with increasing load. Among the blend B40 shows improved brake thermal efficiency than the other blends and diesel. Hence, this blend was selected as the optimum blend for further investigations and long-term operation.
- The specific fuel consumption decrease with increase in load among the blend B40 shows same fuel consumption at initial load and increase at next load compare to diesel.
- Engine performance of biodiesel and their blends are similar to those of diesel fuel. Performance of diesel engines varies with composition of blend used.
- Bio diesel fuel and their blends produce about lesser carbon monoxide (CO) and unburnt hydrocarbon (UHC) emissions than diesel fuel, while nitrogen oxide (NOX) emissions are higher than diesel fuel.

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