Performance and Emission Characteristics on Diesel Engine with Biodiesel Blend using Ballnutt Oil

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Abstract— Due to the increasing demand for fossil fuel and more liberation of pollutants in environment, a number of renewable sources of energy have been studied worldwide. Non-edible oil contains several unsaponifiable and toxic components, which make them unsuitable for human consumption. An attempt is made to assess the suitability of vegetable oil for diesel engine operation, without any modification in its existing construction. Biodiesel is a clean and renewable fuel which is considered to be best substitution for diesel fuel. In order to achieve this, Biodiesel was prepared from the non-edible oil of ball nut by transesterification of the oil with methanol in the presence of NaOH as catalyst. The important fuel properties of biodiesel produced from ballnut oil, like viscocity, flash point, fire point, calorific value and emission should be found out to compare with the properties of Indian standard biodiesel for its use.

Key words: Diesel Engine, Biodiesel Blend, Ballnutt Oil

I. INTRODUCTION

Biodiesel is simply a liquid fuel derived from vegetable oil and fats, which has similar combustion as regular diesel fuel. Biodiesel can be produced from straight vegetable oil, animal oil/fats, tallow of waste cooking oil. Biodiesel is biodegradable, nontoxic, and has significantly fewer emissions than petroleum-based diesel when burned.

Biodiesel is an alternative fuel similar to conventional or "fossil/petroleum" diesel. The process used to convert these oils to biodiesel is called transesterification. This process is described in more details. The largest possible source of suitable oil comes from oil crops such as soyabean, rapeseed, corn etc.,

At present, oil straight from the agricultural industry represent the greatest potential source, but it is not being used for commercial production of simply because the raw oil is too expensive. After converting it to biodiesel the price is too high to complete with petroleum diesel. Waste vegetable oil can often be obtained free or treated. One disadvantages of using waste oil is it must be treated to remove impurities like free fatty acids(FFA) before conversion to biodiesel. Biodiesel produced from waste vegetable/animals oil and fats can complete with the prices of petroleum diesel without subsidies.

II. BALL NUTT SEED

Ball nutt seed is a large tree of shorelines and coastal forests. It usually grows 12–20 m (40–65 ft) in height, but open-grown trees can become wider than they are tall, often leaning, with broad, spreading crowns. Trees growing along the shoreline may reach out with trunks almost parallel to the ground. The tree canoften be recognized at a distance by its large, spreading horizontal branches. The opposite leaves are dark green, shiny, and hairless with broadly elliptical blades 10–20 cm (4–8 in) long and 6–9 cm (2.4–3.6 in) wide. Both the tip and base of the leaves are rounded. Leaf veins run parallel to each other and perpendicular to the midrib. The scientific name Calophyllum comes from the Greek words for ―beautiful leaf.

III. PERFORMANCE CHARACTERISTICS

Thermal Efficiency is defined as break power of a heat engine as a function of the thermal input from the fuel. BTE constantly increases based on the load condition. This was due to a reduction in heat loss and increase in power with increase in percent load. The brake thermal efficiency is quite higher than that of diesel. Specific fuel consumption, abbreviated SFC, compares the ratio of the fuel used by an engine to a certain force such as the amount of power the engine produces. Higher proportions of ball nutt oil in the blends increases the viscosity which in turn increases the specific fuel consumption due to poor atomization of fuel.

IV. LITERATURE REVIEW

Md. Nurun Nabi, Investigated the combustion and exhaust gas emission characteristics when the engine was fuelled with blends of methyl esters of neem oil and diesel. The optimum blend of biodiesel and diesel fuel, based on the trade-off of particulate matter decrease and NOx increase, was a 20/80 biodiesel/diesel fuel blend. After an injection (BOI) delay of 3o NOx emissions reduced while maintaining emission reductions associated with fueling a diesel engine with a 20/80 biodiesel/diesel fuel blend. The retarded timing reduced the time for combustion to occur in the cylinder, reducing the peak pressures and temperatures that enhance the formation of NOx emissions. Canakcia et al. [9] used artificial neural network for analyzing and predicting the performance and exhaust emissions from diesel engines.

Pramanik, Blends of varying proportions of jatropha curcas oil and diesel were prepared, analyzed and compared with diesel fuel for the compression ignition (C.I.) engine. Among the various blends, the blends containing up to 30% jatropha oil have viscosity values close to that of diesel fuel. The blend containing 40% vegetable oil has a viscosity slightly higher than that of diesel. Heating the blends further reduced the viscosity. The viscosity of the blends containing 70% and 60% vegetable oil became close to that of diesel in the temperature ranges of 70–75°C and 60–65°C, respectively. From the engine test results, It is established that up to 50% jatropha curcas oil can be substituted for diesel for use in C.I. engine without any major operational difficulties.

V. Ball Nutt Seed:

VI. Methodology

The process of producing the biodiesel through chemical reaction is of many types. We are using transesterification process in our pilot biodiesel plant. This process involves vegetable fats from oil begin reacted with short-chains alcohols (like methanol or ethanol).The alcohol used should be of low molecular weight. The alcohol we used for the biodiesel preparation is methanol. The transesterfication process consists of oil fats, base catalysts(NaOH or KOH) and alcohol(methanol or ethanol) react together to form the biodiesel and byproduct(i.e)glycerin.

Oil + Alcohol + Catalysts → Biodiesel + Glycerin

The biodiesel and the glycerin are formed by the above reaction. The biodiesel is formed in dark color and get deposited at the bottom. The glycerin is formed in white or light yellow color and float at the top of biodiesel. The top layer glycerin is removed and the biodiesel is collected. The process of converting the oil to biodiesel is called transesterification process. This process is long time process but it a simple process. The glycerin is formed because the oil fats are included in the ester family when they react with methanol or ethanol they form methyl or ethyl esters and a new alcohol called glycerol commonly called glycerin is formed. The used cooking oil can also be used to produce the biodiesel.

VII. Free Fatty Acid Test:

Fatty acids are the building blocks of fat sources in living organisms. Fat or lipids are made up of 3 fatty acids attached to a glycerol backbone to make up a triglyceride. Since fatty acids are necessary to create essential building blocks such as triglycerides, they are rarely found floating alone within cells. When these acids are floating alone, they are referred to as free fatty acids. Free fatty acids appear as lipids breakdown products and are therefore good indicators of degradation. There are many types of free fatty acids. They can be differentiated by the length of the carbon chain, the presence and number of double bonds and the alignment of the carbons at the double bonds. The procedure for FFA test is given below.

The 5gm of fat is to be taken and added with 50ml of methanol. The solution is heated till the bubblescome.

50 ml of NaOH (0.1) poured in the burette.

Phenolphthalein indicator of 2 drops is to be added in the conical flask.

When colour change occurrs in the solution the titration is to be stopped as show in fig (4.1)

The burette readings are noted

VIII. Preparation of Biodiesel

1 litre of ball nut oil is taken.Heat the oil up to 50deg to remove the water content present in it.Then cool down the temperature of the ball nut oil.200ml of methanol is to be filled in a beaker.4.5 gm of NaOH pallets are to be dissolved in the methanol solution;it will act as catalyst for traneseterification process.The methoxide solution preparationIn the process ball nut oil is made to react with methanol in the presence of base catalyst (NaOH).

The pre-heated ball nut oil to be placed on hot plate.Maintain the temperature of 50-70deg.Stir the solution as shown in the fig2.400 rpm is to be maintained for stirring.Add the methoxide solution to the beaker.This process is to be continued for about 2 hrs

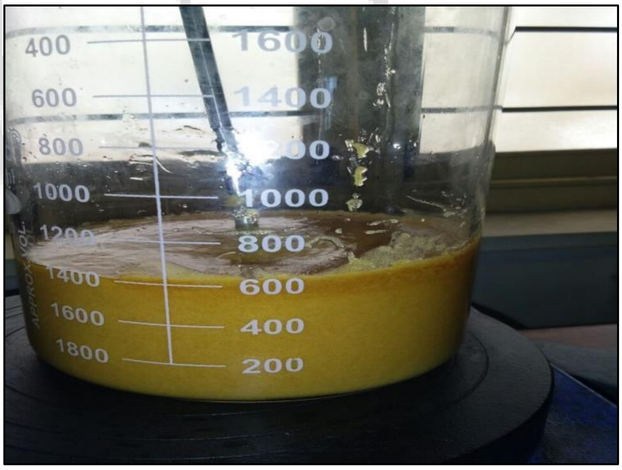


Fig. 2: stirring process

After the process is completed, glycerol and bio-fuel will be obtained.

After 24hrs glycerol at the bottom of the beaker and the bio-fuel.Float at the top layer as shown in fig3 .Then separate the glycerol and bio-fuel

Fig. 3: sediment solution

IX. Diesel Engine

An internal combustion engine (ICE) is a heat engine where the combustion of a 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 applies direct force to some component of the engine. The force is applied typically to pistons, turbine blades, rotor or a nozzle. This force moves the component over a distance, transforming chemical energy into useful mechanical energy.

The first commercially successful internal combustion engine was created by Étienne Lenoir around 1859 and the first modern internal combustion engine was created in 1876 by Nikolaus Otto.

The term internal combustion engine usually refers to an engine in which combustion is intermittent, such as the more familiar four-stroke and two-stroke piston engines, along with variants, such as the six-stroke piston engine and the Wankel rotary engine. A second class of internal combustion engines use continuous combustion: gas turbines, jet engines and most rocket engines, each of which are internal combustion engines on the same principle as previously described. Firearms are also a form of internal combustion engine.

In contrast, in external combustion engines, such as steam or Stirling engines, energy is delivered to a working fluid not consisting of, mixed with, or contaminated by combustion products. Working fluids can be air, hot water, pressurized water or even liquid sodium, heated in a boiler. ICEs are usually powered by energy-dense fuels such as gasoline or diesel, liquids derived from fossil fuels. While there are many stationary applications, most ICEs are used in mobile applications and are the dominant power supply for vehicles such as cars, aircraft, and boats.

Typically an ICE is fed with fossil fuels like natural gas or petroleum products such as gasoline, diesel fuel or fuel oil. There is a growing usage of renewable fuels like biodiesel for ICE and bioethanol or methanol for spark ignition engines. Hydrogen is sometimes used, and can be obtained from either fossil fuels or renewable energy.

X. Performance Calculation

Given Data
N = 1500rpm
W = 44.145N
L = 0.110m
D = 0.0875 m
IMEP = 2.24 bar
T = 90.60 sec

A. Brake Power (BP):

$$= \frac{2\times\pi\times N\times(W\times 9.81)\times R_m}{60\times 1000} \text{ kw}$$

$$= \frac{2\times 3.14\times 1500\times 4.5\times 9.81\times 0.185}{60\times 1000}$$

$$= 1.26 \text{ KW}$$

B. Indicated Power (IP):

$$= \frac{(IMEP)\ 10^5\times L\times A\times N/2}{60\times 1000}$$

$$= \frac{2.24\times 10^5\times 0.110\times(6\times 10^{-3})\times 1500}{60\times 1000}$$

$$= 1.88 \text{ KW}$$

3. Total fuel consumption (TFC)

$$= \frac{q}{t}\times \text{Density of diesel}$$

$$= \frac{10\times 10^{-6}}{0.02502}\times 868$$

$$= 0.3469 \text{ kg/hr}$$

4. specific fuel consumption (SFC)

$$= \frac{TFC}{BP}$$

$$= \frac{0.3469}{1.26}$$

$$= 0.2753 \text{ kg/KW h}$$

5. Mechanical Efficiency (η_m)

$$= \frac{BP}{IP}\times 100$$

$$= \frac{1.26}{1.88}\times 100$$

$$= 0.18\%$$

6. Brake Thermal Efficiency (η_{BT})

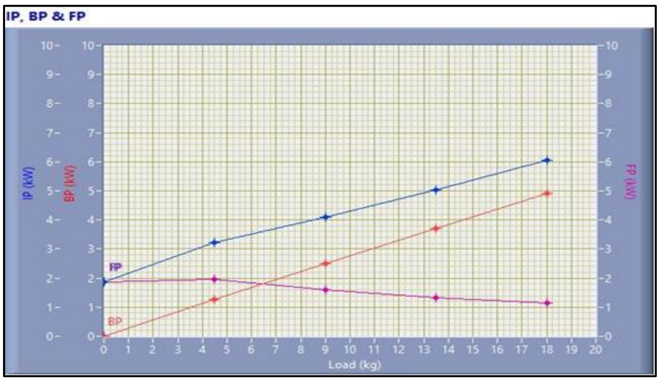
$$= \frac{BP}{TFC\times CV}\times 100$$

$$= \frac{1.26}{0.3469\times 43{,}500}\times 100$$

$$= 0.08\ \%$$

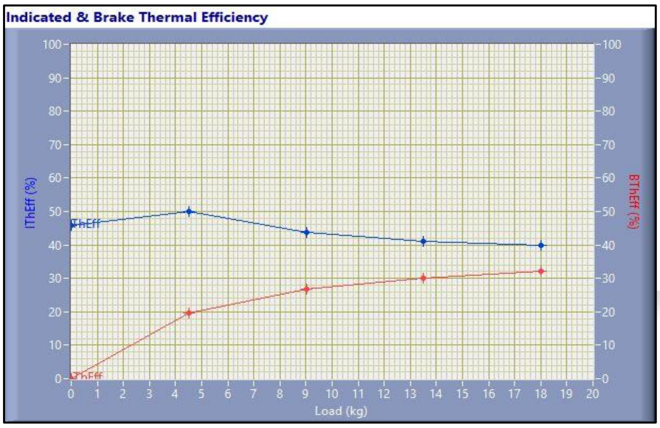
XI. EXPERIMENTAL RESULTS

A. Comparison between Brake Power and Indicated Power



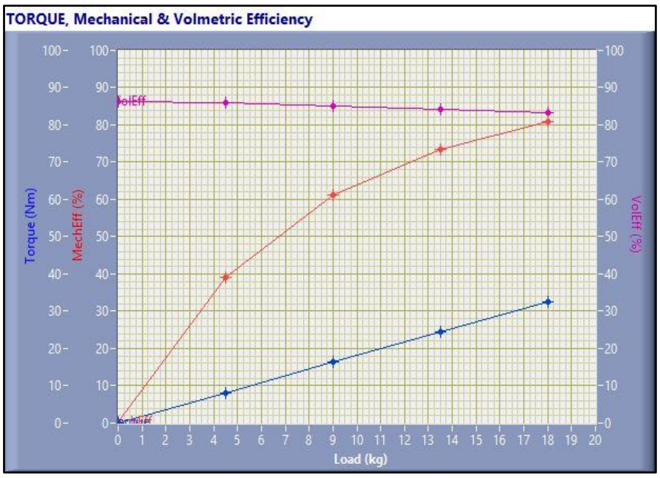
Three different B40 specimen has taken and conducted compression test for to identify the compression strength in the specimen. The graph shown, Load Vs Brake power, the load increased proportionally break power will increased and vice vesa. Similarly, load Vs indicated power and load Vs Feed power are also shown in the graph. It's also load increased gradually indicated power also increased and feed power.

B. Indicated VS Brake Thermal Efficiency



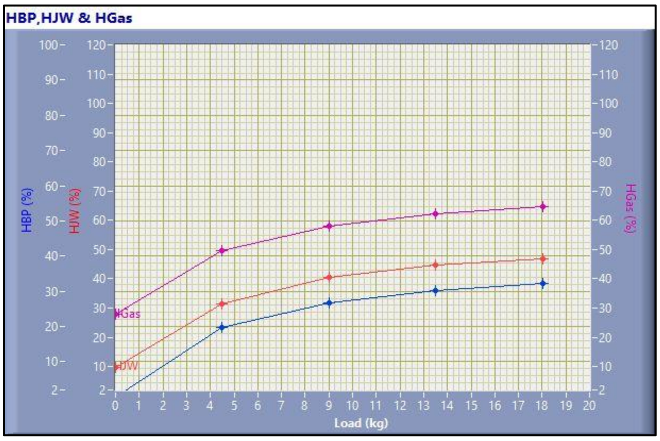
In this graph shown about the result of indicated power and brake thermal efficiency. Indicated power increased at the same time brake thermal efficiency also increased.

C. Torque, Mechanical and Volumetric Efficiency



In this graph shown about the graph of torque, mechanical and volumetric efficiency. Specimen 1 and specimen 2 are shown the similar graph, so we take the result from that, load directly proportional to the mechanical efficiency and volumetric efficiency. If load increased, at same time mechanical and volumetric efficiency will increased then viseversa.

D. Heat Brake Power, Heat Water Jacket, Heat Exhaust Gas.

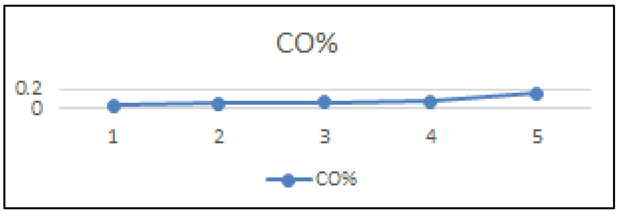


In this graph shown, load Vs heat brake power, heat water jacket and heat exhaust gas. First specimen shown load gradually increased at the time heat brake power and heat water jacket increased. Second specimen shown load increased from initially, heat brake power and heat water jacket start from near 10 Kw.

E. Specific Fuel Consumption and Fuel Consumption

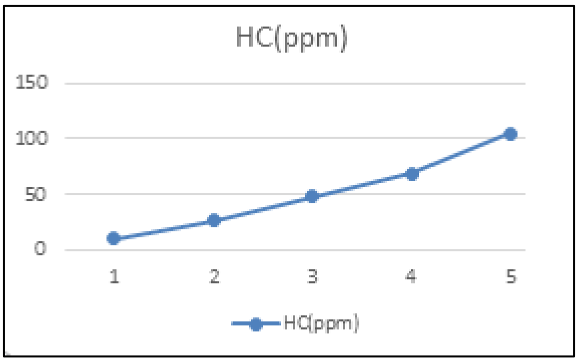
In the graph the results about the specific fuel consumption and fuel consumption. Load Vs specific fuel consumption and fuel consumption. Here load increased as well as fuel consumption also increased.

F. Emission of CO_X



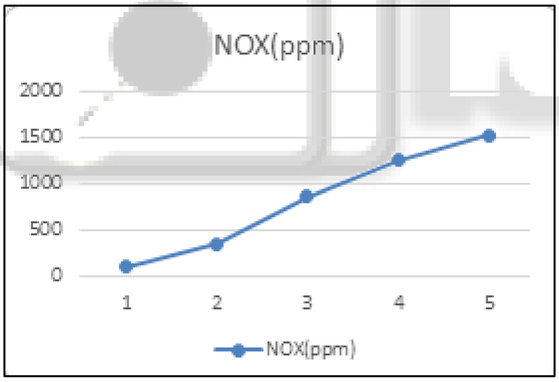
CO emissions at different idling conditions for diesel and biodiesel blend. The lowest CO emission is achieved for B40 at all the operating conditions. Also, in every condition diesel fuel produced maximum emission. As blend percentage of biodiesel in diesel increased emission decreased, this may be due to the higher concentration of O2 in the air–fuel mixture which ensured improved combustion and hence reduction in CO emission at idling conditions. Compared to ball nutt biodiesel, palm biodiesel showed less decrease in CO emission as blend percentages increased. This is may be due to the reason that palm biodiesel has higher viscosity than ball nutt biodiesel, which degraded the spray characteristics and caused improper mixing which led to improper combustion.

G. Emission of HC



HC emission at different idling conditions for biodiesel. It can be seen that, diesel fuel emits highest amount of HC at all conditions and B40 blend emits lowest. Again, as there is higher oxygen concentration in the biodiesel–diesel blends which enhances the oxidation of unburned hydrocarbons,HC emission decreases with increase in percentages of biodieselblends. Furthermore, increase in speed decreases HCemission for all tested fuel. This is due to the reason that increasein speed ensures better mixing of air and fuel.

H. Emission NO_X



NOX emission at different idling conditions for diesel and ball nutt biodiesel blends. Diesel fuel exhibited lowest emission at all condition. As blend percentages of biodiesel increases emission increases. Biodiesel blends produce higher emission due to having higher cetane number and lower ignition delay. However, it is observed that as engines peed increases emission decreases due to the fact that increase in speed reduces the ignition delay which results in less amount of time to form NOX.

XII. Conclusion

Biodiesel have been produced and their fuel characteristics have been evaluated. An experimental investigation has been carried out to figure out the engine performance and emission parameters at high idling conditions.

Biodiesel produced from ball nutt oil satisfies the ASTM standards and thus can be used as alternative to diesel fuel.

The Calophyllum oil possesses good oil characteristics for a CI engine which can be used as a blend with diesel.Due to its physic-chemical properties it could be used as a biodiesel feedstock and for Industrial application. The way of reducing the biodiesel production costs is to use less expensive feedstock containing free fatty acids, such as non-edible oils. With no competing food uses, this characteristic turns attention ball nutt sedd which grows in coastal area of in our country. The production of biodiesel from this oil may provide a valuable

Local, regional and national benefit. Ball nutt tree can be planted as an ornamental tree like Pongamia pinnata in the gardens, on road sides, railway track. To develop biodiesel into an economically important option in India, it is required to work on biological innovations to increase the yield & minimize the gestation period of ball nutt.

At high idling conditions, brake specific energy consumption for ball nutt biodiesel blends increased compare to diesel fuel. However, at the highest idling speed the difference of energy consumption was almost negligible. As blend percentages of biodiesel increased energy consumption increased.

CO and HC emission decreased with increase in blend percentages and at all tested conditions they were lower than diesel fuel. B40 achieved lowest emission in both the cases. Increase in NOX emission for small blend percentages were negligible compared to diesel.

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