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Preparation and investigation of Diesel Engine using Neem Oil

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ABSTRACT: Fuel crisis and environmental concerns have led researchers to look for alternative fuels of bio-origin sources such as vegetable oils, which can be produced from forests and oil-bearing biomass materials. Vegetable oils have energy content comparable to that of diesel fuel. Straight vegetable oils posed several operational problems and durability problems when subjected to long-term usage in compression ignition engine. These problems are attributed to higher viscosity and lower volatility. In this study, performance and emission parameters of a diesel engine operating on neem oil and its blends of 5, 10, 15 and 20 vol% are evaluated and compared with diesel operation. The results indicate that the brake thermal efficiency is improved with the use of neem oil–alcohol blends with respect to those of neat neem oil. The smoke intensity, CO and HC emissions with neem oil–alcohol blends are observed to be lower with respect to those of neat neem oil at higher loads. The NO_x emission is very slightly reduced with the use of neem oil–alcohol blends except for the neem oil–ethanol blend compared with that of neat neem oil.

I. INTRODUCTION

The growing demand for fuel and the increasing concern for the environment due to the use of fossil fuel have led to the increasing popularity of biofuel as a useful alternative and environmentally friendly energy resource. The increasing population of both the developing nations of the world, their steady increasing in the diesel consumption, the nonrenewability of the fossil fuels as well as their environmental effects are some of the reasons that has made the biofuels as alternative and attractive. Diesel engines are the major source of power generation and transportation hence diesel is being used extensively, but due to the gradual impact of environmental pollution there is an urgent need for suitable alternate fuels for use in diesel engine without any modification. There are different kinds of vegetable oils and biodiesel have been tested in diesel engines its reducing characteristic for greenhouse gas emissions.



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Biodiesel (a mixture of fatty acid methyl esters, FAMES) has become very attractive as a biofuel because of its environmental benefits as it has less air pollutants per net energy than diesel and is nontoxic and biodegradable because it is produced from renewable sources with high energetic efficiency, biodiesel yields from an estimated 90% to 40% more energy than the energy invested in producing it.

Biodiesel derived from a wide variety of sources can be used as a direct substitute for petro-diesel fuels. They are several non-edible oil seed such as thevetia (thevetiaperuviana), karanja (pongomia pinnate), jatropha (jatropha curca), neem (azadirachta indica) etc. Among these, azadirachta

India is one of the largest producer of neem oil and its seed contains 30% oil content. It is an untapped source in India. Implementation of biodiesel in India will lead to many advantages like green cover to wasteland, support to agriculture and rural economy and reduction in dependence on imported crude oil and reduction in air pollution.

The neem oil plant is a fast growing plant with a long productive life span of 150 to 200 years, its ability to survive on drought and poor soils at a very hot temperature of 44°C and a low temperature of up to 4°C. The crude neem oil was purchased from the market and it has to be transesterified which means that it has to be made operable in the engine. The process of transesterification is nothing but the breaking of the longer chain molecules into smaller chain molecules by means of heating the oil and some chemical reactions. The transesterification process done in this project is a two-step process, i.e., crude oil is subjected to the acid and base catalyzed transesterification process. In addition to that there are some other processes of transesterification applied to the crude neem oil which produced less amount of yield. After the completion of the transesterification process, it will be subjected to the analysis of performance characteristics of the bio diesel in the diesel engine. The analysis of performance characteristics can be evaluated by changing the compression ratio operated on the diesel engine. The performance characteristics such as brake thermal efficiency and brake specific fuel consumption for each compression ratio and the various blends of biodiesel are analysed. Experimental determination of brake thermal efficiency and brake specific fuel consumption of a diesel engine fuelled with biodiesel without changing the compression ratio was studied. In addition to that the emission parameters such as smoke, NO_x, carbon monoxide and the unburnt hydrocarbons of the diesel engines subjected to bio diesel without changing the compression ratio are studied. The emission parameters are analysed by changing the compression ratio for the various blends and are studied. Experimental investigation of a diesel engine was made with 20% (B20), 40% (B40) and 60% (B60) blending of Ziziphus jujuba oil with diesel for a compression ratio from 15:1 to 18:1 and the results were compared with diesel.

Performance parameters such as specific fuel consumption, brake thermal efficiency and exhaust gas temperature for varying compression ratio and blending. Tamanu oil is considered for the alternative fuel, the engine performance is improved with significant reduction in emissions for the tamanu oils without any engine modification. The brake thermal efficiency of the VCR engine slightly increases at higher loads when compared with that of a standard engine. The specific fuel consumption is lower at all load conditions. The effect of compression ratio on combustion and performance of a variable compression ratio engine when fueled with preheated palm oil having blends of 5, 10, 15, 20% of bio fuel has been investigated and compared with the petroleum based diesel fuel. The blend 20% has given the maximum percentage of thermal efficiency. The specific fuel consumption is lower than petroleum based diesel fuel at B20. The engine performance is found to be optimum at a compression ratio of 20 at full load condition of blend B20. Brake thermal efficiencies have been computed for various blends of soya and mustered oils with petrol at different engine loads in a computerized variable compression ratio multi-fuel (CVCRM) engine test rig. It is concluded that out of the two soya-bean oil blends, 20-PRS shows the higher brake thermal efficiency compared to 15-PRS at the load of 7.5 KG also. It means that the blend 20-PRS shows the higher brake thermal efficiencies compared to 15-PRS at all the three loads. Various proportions of Karanja oil methyl ester blends (10%, 20%, and 30%) were used for conducting the performance test at varying load conditions. The brake thermal efficiency of biodiesel blends with diesel fuel was less when compared to diesel fuel. Fuel consumption was increased with increase in blend proportions. The emission level of CO and HC level decreased with increase in blend proportion in diesel fuel. NO_x emission increased with increase in blend proportion in diesel fuel. Biodiesel B-20 and lesser can be used as an alternative without any modifications of diesel engine.

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The performance and emission characteristics of blends are evaluated at variable loads and constant rated speed of 1500 rpm, the performance of S20 blend of simarouba oil gives result, that is near to the diesel and also found that the emission CO, CO₂, HC, smoke & NO_x of this blend is less than the diesel [18]. The experiments have been conducted at different blends of simarouba biodiesel with standard diesel, at an engine speed of 1500 rpm, fixed compression ratio 16.5:1, fixed injection pressure of 200bar and varying brake power, Methyl ester of Simarouba oil (S80) results in a nearly equal in thermal efficiency as compared to that of diesel. The specific fuel consumption of diesel is almost equal S80 at lower loads but at higher loads the SFC of all simarouba blends is equal to diesel. It is concluded that by using blends of simarouba biodiesel NO_x, CO, SMOKE increases, this is the draw back and main emissions like CO₂, HC decreases [19]. The Fatty acid methyl esters of Neem are produced through Transesterification process under lab setup and blended with petroleum diesel for various ratios (10%, 20%, 30%, 40% and 50%) to evaluate fuel properties. Engine performance with biodiesel does not differ much the neat diesel. Biodiesel blend B10 shows good results comparable with other blends.

II. BIO DIESEL PREPARATION

Two – step acid – base catalyzed transesterification

Crude neem oil when transesterified using NaOH catalyst produced a significant amount of soaps from saponification side reaction. This was due to the high level of free fatty acids and small quantity of moisture in the crude neem oil. Therefore, a two step process acid catalyzed esterification followed by alkali catalyzed transesterification was employed according to the method of Berchmans and Hirata (2008).

Acid pretreatment (acid catalyzed esterification)

The method of acid transesterification is listed below:

1. The crude neem oil of 200ml is taken.
2. It is heated at 60°C for about 10 min and mixed with 60 ml of methanol.
3. To the mixture 2ml of concentrated H₂SO₄ was added.
4. Then the mixture was stirred on magnetic hot plate for 1 h at 50°C.
5. It was allowed to settle for 2 hr.
6. The pretreated oil was separated from the methanol - water phase at the top.

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Figure 1 Magnetic stirrer with the neem oil

Base catalyzed transesterification

The method of base catalyzed transesterification is listed below

1. The pretreated oil was measured(200ml) and taken in beaker.
2. Methanol of 50 ml was taken and added to it.
3. The mixture is heated on the magnetic stirrer at a temperature of 60°C.
4. The agitation rate is kept at 1000 rpm.
5. A solution of NaOH in methanol (1%) was dissolved at room temperature and the pretreated oil was added.
6. The reaction was allowed for a period of 2hr.
7. The resulting mixture was poured into a separating funnel and allowed to settle under gravity for 24 hour for separation of biodiesel.
8. The lower glycerol layer was tapped off.

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Figure 2 Biodiesel in Separating Funnel

3.EXPERIMENTAL INVESTIGATION



Figure 3 Variable Compression Ratio Engine

Table 1 Specification of engine

The specifications of the engine are as stated as below.

Engine	4 stroke, Variable compression diesel engine
No. of cylinders	Single cylinder
Cooling media	Water cooled
Rated capacity	3.5 kW @ 1500 RPM

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Cylinder diameter	87.5 mm
Stroke length	110 mm
Connecting rod length	234 mm
Compression ratio	12:1-18:1
Orifice diameter	20 mm
Dynamometer	Eddy current dynamometer

IV. RESULTS AND DISCUSSION

Worldwide, biodiesel is largely produced by methyl transesterification of oils. The recovery of ester as well as its kinematic viscosity is affected by the transesterification process parameters such as catalyst concentration, reaction temperature and reaction time. The above parameters were standardized to obtain methyl ester of neem oil with lowest possible kinematic viscosity and highest level of recovery. The engine performance parameters and exhaust gas emission characteristics of B40, B80 and diesel were compared.

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.

The brake thermal efficiency obtained for the variable compression ratio of the blends B40, B80 and diesel were compared and represented graphically. It is shown in figure 4. The brake thermal efficiency of B40 and B80 is less than that of diesel at the compression ratio of 15. Even when the compression ratio was increased from 15 to 18, the brake thermal efficiency was not increased. The various blends show less brake thermal efficiency to the increase in blend ratio. It shows that the brake thermal efficiency is found to be decreasing with the increasing in blends and also found to be increasing with the increase in compression ratio. The brake thermal efficiency of bio diesel is lower than diesel, because of biodiesel has a lower calorific value or lower heating value and high viscosity coupled with density.

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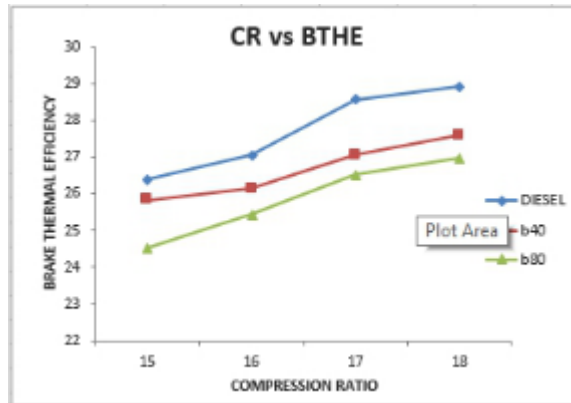


Figure 4

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.

The brake specific fuel consumption obtained for the variable compression ratio of the blends B40, B80 and diesel were compared and represented graphically. It is shown in figure 5. The brake specific fuel consumption of B40 and B80 has shown the less fuel consumption at the compression ratio of 15. With the increase in compression ratio from 15 to 18 the specific fuel consumption decreases for the both blends than diesel. The brake specific fuel consumption vs compression ratio results shows that the increase in compression ratio decreases the brake specific fuel consumption and also increase in blend ratio decreases the fuel consumption. BSFC of biodiesel is higher because they contain the oxygen content which results in the lower heating value.

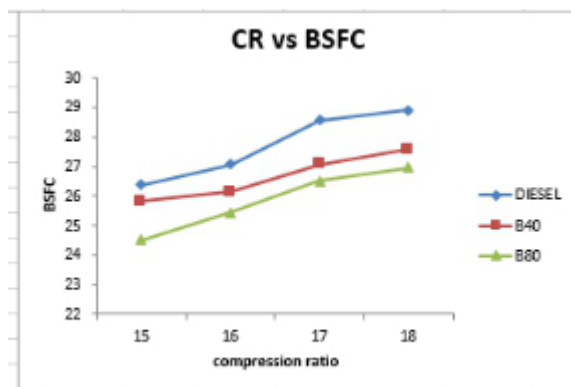


Figure 5

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Exhaust Emission:

Characteristics of CO Emissions

Carbon monoxide (CO) in diesel engines is formed during the intermediate combustion stages. Diesel engine operates well on the lean side of the stoichiometric ratio. The carbon monoxide decreases with increase in neem oil in fuel. Owing to the oxygen content in the neem oil, in addition to that in the air supplied during induction CO is reduced by combining oxygen with CO to form CO₂. B40 blend has higher CO emission than B80 due to its high viscosity and poor atomization tendency leads to poor combustion and higher carbon monoxide emission. The carbon monoxide emissions increase as the fuel-air ratio becomes greater than the stoichiometric value. Carbon monoxide concentration in the exhaust emission is negligibly small when a homogenous mixture is burned at stoichiometric air-fuel ratio mixture or on the lean side stoichiometric. It is interesting to note that, the engine emits more carbon monoxide using diesel as compared to that of biodiesel blends with increasing biodiesel percentage, carbon monoxide emission decreases. Biodiesel itself has high oxygen content in it. This helps for the complete combustion. Hence, carbon monoxide emission decreases with increasing biodiesel percentage in the fuel.

The variation of carbon monoxide with respect to load for different blends of biodiesel is shown in figure 6.

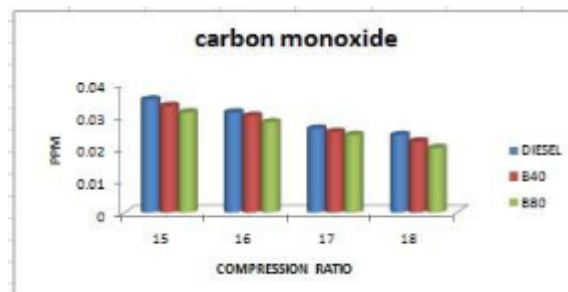


Figure 6

Unburned Hydrocarbons (HC)

Hydrocarbons in exhaust are due to incomplete combustion of carbon compounds in the blends. The values of HC emission decrease with increase in proportion of biodiesel in the fuel blends. The emissions of unburnt hydrocarbon for biodiesel exhaust are lower than that of diesel fuel. The possible reason for decrease in unburnt HC may be higher cetane number and increased gas temperature. The higher cetane number of biodiesel results decrease in HC emission due to shorter ignition delay. Increased temperature of burnt gases in biodiesel fuel helps in preventing condensation of higher hydrocarbon thus reducing unburnt HC emissions. At higher compression ratios unburnt HC emissions were low, may be because of increased temperature and pressure at higher compression ratios and better combustion can be ensured.

The variation of hydrocarbon (HC) with respect to engine power output for different fuels are shown in figure 7.

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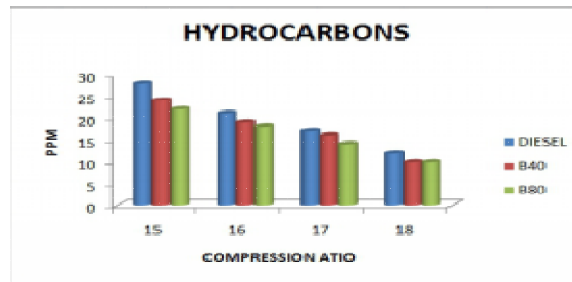


Figure 7

Smoke

Figure 8 shows variation of smoke emissions for different blends with the constant load for four different compression ratios. Smoke values for the compression 18 were the least amongst them. Since at higher compression ratios better combustion may take place inside the engine cylinder trying to reduce the smoke emissions. Smoke formation occurs at the extreme air deficiency. Air or oxygen deficiency is locally present inside the diesel engines. It increases as the air to fuel ratio decreases.

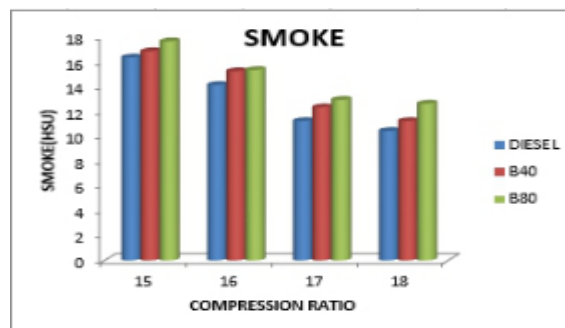


Figure 8

Nitrous oxide

NOX emissions are temperature dependent. It was observed that NO emissions increase with increase in compression ratios this is because of increase in temperature inside combustion chamber. NOX emissions were observed to be increased with increase in blend content. This is because of high oxygen content in the biodiesel fuel. Nitrogen from air can easily mix with oxygen and produces the NOX emissions. These emissions were observed to be increase with compression ratio due to lower ignition delay which increases the peak pressure and temperature. Figure 9 shows variation of nitrous oxide emissions for different blends with the constant load for four different compression ratios

V. CONCLUSION

From experimental observations it is concluded that

1. The brake thermal efficiency of the CI engine increases with the compression ratio value was less when compared to that of the diesel.
2. Brake specific fuel consumption was good when increasing the compression ratio.
3. The emissions such as carbon monoxide and unburnt hydrocarbons decreases with the blend ratio

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And compression ratio.

4. The smoke decreases with the compression ratio and increases with the blend ratio.

5. Nitrous oxide emissions increases with the compression ratio and blend ratio.

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