International Journal of Mechanical Engineering and Research, ISSN 0973-4562 Vol. 5 No.1 (2015)

Performance and Emission Characteristic Studies of Diesel Engine Fuelled with Neem Oil

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Abstract

This project deals with the experimental analysis of variable compression ratio diesel engine operated with the neem oil methyl ester. The crude neem oil is purchased and is prepared for experimental work in engine by means of transesterification. The transesterificationprocess for the neem oil is done by the constant operating parameters such as heating temperature, stirring speed, and methanol. The product output from the transesterification is subjected to the variable compression ratio engine operation. The blends such as b40 and b80 is taken and it is operated for the constant load of 12kg and injection pressure of 200bar, and variable compression ratio such as 15, 16, 17, and 18. The engine performance is experimentally conducted for the different compression ratios. The performance parameters such as brake thermal efficiency and brake specific fuel consumption are analysed experimentally, the results are compared and how the compression ratio made the effect on performance of diesel engine was studied graphically.The emissions at the variable compression ratio are subjected to comparision. The emission parameters such as hydrocarbons, nitrous oxides, carbon monoxide and smoke are taken.

Keywords: ***compression ratio, emission, performance, neem oil, transesterification***

1. INTRODUCTION

The growing demand for fuel and the increasing concern for the environment dueto the use of fossil fuel have led to the increasing popularity of biofuel as a usefulalternative and environmentally friendly energy resource.The increasing population of both the developing nations of the world, their steady increasing in the diesel consumption, the non-renewability 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 indiesel engine without any modification. There are different kinds of vegetable oils and biodiesel have been tested indiesel engines its reducing characteristic for greenhouse gas emissions

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 biodegradables because it is produced from renewable sources with high energetic efficiency, biodiesel yields from an estimated 90% to 40% more energy thanthe energy investedinproducing 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 (jatrophacurca), neem (azadirachtaindia) etc.Among these, azadirachta

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

The neem oil plant is a fast growing plant with longproductive life span of 150 to 200 years, its ability tosurvive on drought and poor soils at a very hottemperature 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 transesterfication is nothing but the breaking the longer chain molecules into smaller chain molecules by means of heating the oil and some chemical reactions. The transestercation process done in this project is atwo step process, i.e., crude oil is subjected to the acid and base catalysedtransesterification process[1][2][10]. In addition to that there are some other process of transestercation process to the crude neem oil which produced less amount of yield[8][9]. After the completion of the transestercation process, it will be sujected to the analysis of performance characteristics of the bio diesel in the diesel engine [4][8]. The analysis of performance characteristics can be evaluted by changing the compression ratio operated on diesel engine[2][5]. 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[6][7] . Experimental determination of brake thermal efficiency and brake specific fuel consumption of diesel engine fuelled with biodiesel [12] without changing the compression ratio was studied. Adding to that the emission parameters such as the smoke, no_x, carbon monoxide and the unburnt hydrocarbons of the diesel engines subjected to bio diesel without changing the compression ratio[11][12] are studied. The emission parameteres are analysed by changing the compression ratio for the various blend [5][6][7] are studied.Experimental investigation of diesel engine was made with 20% (B20), 40% (B40) and 60% (B60) blending of Ziziphusjujuba oil with diesel for 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[13].Tamanu oil is considered for the alternative fuel, the engine performanceis 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 standard engine. The specific fuel consumption is lower at all load conditions [14].The effect of compression ratio on combustion and performance of variable compression ratio engine when fuelled 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 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 compression ratio of 20 at full load condition of blend B20.[15]. Break thermal efficiencies have been computed for various blends of soya and mustered oils with petrol at different engine loads in 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 break thermal efficiency compared to 15-PRS at the load of 7.5 KG also. It means that the blend 20-PRS shows the higher break thermal efficiencies compared to 15-PRS at all the three loads[16].Various proportions of Karanja oil methyl ester blends (10%, 20%, and 30%) were usedfor 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 increased in blend proportion in diesel fuel. NOx 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[17].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 & NOX 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 NOx, 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. [20].

2. BIO DIESEL PREPARATION

Two – step acid – base catalyzed transesterification

Crude neem oil when transesterified using NaOH catalyst produceda significant amount of soaps from saponification side reaction. Thiswas due to the high level of free fatty acids and small quantity ofmoisture in the crude neem oil. Therefore, a two stepprocess acidcatalyzed esterification followed by alkali catalyzedtransesterification was employed according to the method ofBerchmans and Hirata (2008).[3]

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 $H_2SO_4$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 h.
6. The pre-treated oil was separated from the methanol - water phase at the top.

Figure 1 Magnetic stirrer with the neem oil

Base catalyzed transesterification

The method of base catalysedtransesterification 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 2h.
7. The resulting mixture was poured into a separating funnel and allowed to settle under gravity for 24 h for separation of biodiesel.
8. The lower glycerol layer was tapped off.

Figure 2 Biodiesel in Seperating Funnel

3.EXPERIMENTAL INVESTIGATION

Figure 3 Variable Compression Ratio 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
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
Dynamometer arm length	145 mm

Table 1 Specifications of Engine

4. 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 neemoil 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 shows 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 thediesel, because of biodiesel has a lower calorificvalue or lower heating value and high viscosity coupled with density.

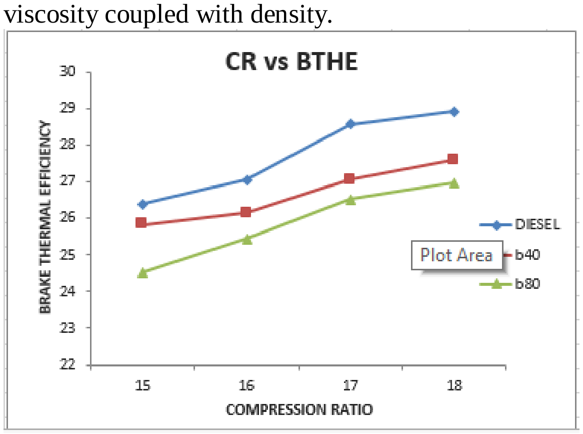

Figure 4

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.

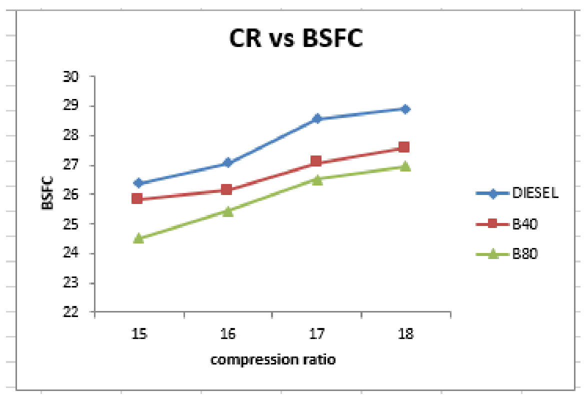

Figure 5

Exhaust Emission characteristics

CO Emissions

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

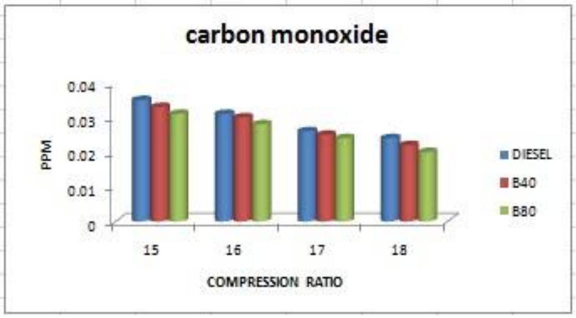

Figure 6

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 CO_2.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 highoxygen content in it. This helps for the complete combustion. Hence, carbon monoxide emission decreases with increasing biodiesel percentage in the fuel.

Unburned Hydrocarbons (HC)

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

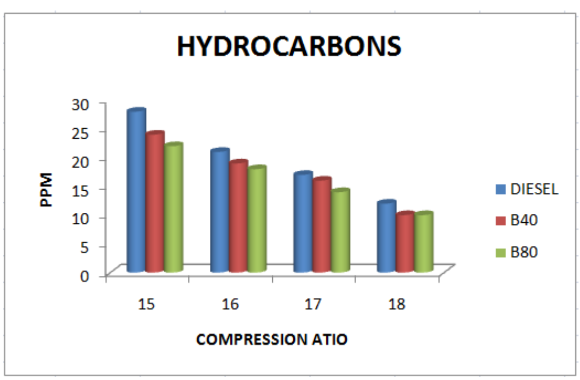

Figure 7

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 unburned HC emissions were low, may be because of increased temperature and pressure at higher compression ratios and better combustion can be ensured.

Smoke

Figure8 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.

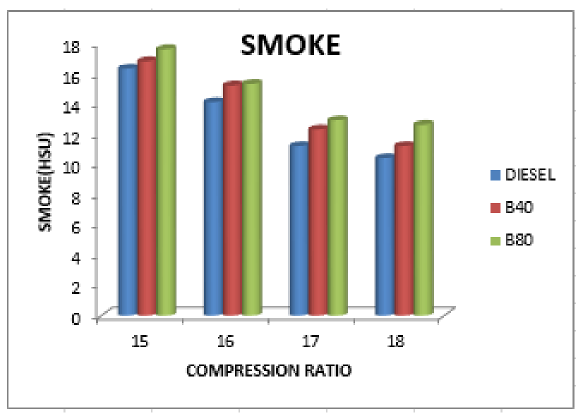

Figure 8

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.

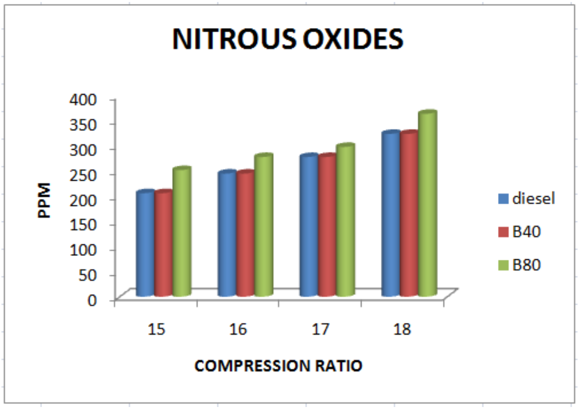

Figure 9

5. Conclusion

From the experimental observations it is concluded that

1. The brake thermal efficiency of the CI engine increases with the compression ratio butits 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 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.

References

1. Pradeep Kr Vishnoi et al, Production of neem oil ethyl ester (NOEE) or neem oil biodiesel by two step esterification of filtered neem oil. MATRIX Academic International Online Journal of Engineering and Technology.
2. YogeshTamboli Feasibility Testing of VCR Engine using various blend of Neem Oil, International Journal of Innovations in Engineering and Technology
3. Awolu and Layokun, optimization of two step transesterification production of biodiesel from neem oil International Journal of Energy and Environmental Engineering, a springer open journal, 2013
4. S. S. Saddu, Dr S. B. Kivade, The Status of Biodiesel as an Alternative fuels Amoora, Surahonne and other oils used for Diesel Engine - An Overview, International Journal of Science and Research. 2014
5. Kuldeep Singh et al, Performance Study of aVCRDiesel Engine Fueled with Diesel and Low Concentration Blend of Linseed oil biodiesel, International Journal of Emerging Technology and Advanced Engineering,2014.
6. R. Anand et al, The performance and emissions of a variable compression ratio diesel engine fuelled with bio-diesel from cotton seed oil, ARPN journal of engineering and applied sciences, 2009
7. Ajay V. Kolhe et al, Performance, Emission And Combustion Characteristics Of A Variable Compression Ratio Diesel Engine Fueled With Karanj Biodiesel And Its Blends, International Journal of Applied Engineering and Technology, 2014
8. A.V. Kulkarni et al, Performance Analysis and Investigation of Emissions of C.I. Diesel Engine Using Neem Oil as Blending Agent: Review, International Journal of Innovative Research in Science, Engineering and Technology, 2014
9. Aransiola EF et al, Production of biodiesel from crude neem oil feedstock and its emissions from internal combustion engines, African Journal of Biotechnology, 2012
10. T. Sathya et al, Biodiesel production from neem oil using two step transesterification, International Journal of Engineering Research and Applications, 2013

11. Vikas Kumar et al, Production of Bio-Diesel to Neem oil and its performance and emission Analysis in two stroke Diesel Engine, International Journal of Engineering Science and Technology, 2013
12. A.V. Krishna Reddy et al, Experimental Determination Of Brake Thermal Efficiency And Brake Specific Fuel Consumption Of Diesel Engine Fuelled With Biodiesel, International Journal Of Engineering And Technology, 2010
13. K.Naveen et al, Experimental Investigation of Variable Compression Ratio Diesel Engine using ZiziphusJujuba oil, International Journal of Innovative Research in Science, Engineering and Technology, 2014.
14. Mohan T Raj et al, Tamanu oil - an alternative fuel for variable compression ratio engine, International Journal of Energy and Environmental Engineering, 2012
15. s.nagaraja et al , combustion and performance analysis of variable compression ratio engine fuelled with preheated palm oil – diesel blends, Indian journal of chemical technology,2013
16. Dr. D. R. Prajapati et al, Study of Brake Thermal Efficiencies of Blend Fuels Using CVCRM Engine Test Rig, International Journal of Engineering and Innovative Technology, 2012
17. P. L. Naik et al, Performance Analysis of CI Engine using PongamiaPinnata (Karanja) Biodiesel as an Alternative Fuel, International Journal of Science and Research (IJSR), 2013
18. Amaramma et al, Extraction of Simarouba Biodiesel and Experimental Investigation of its Suitability as Fuel for CI Engine, International Journal Of Innovative Research & Development, 2014.
19. ShaileshGolabhanvi et al, performance, emission and combustion characteristics of a single cylinder diesel engine operating on simirouba biodiesel and diesel fuel, International Journal of Emerging Trends in Engineering and Development, 2014.
20. Nithyananda B. S et al, Performance Study on Diesel Engine Using Different Blends of Neem Biodiesel, International Journal of Engineering Research and Applications, 2013.