Experimental Analysis On The Performance And Emission Of Diesel Engine Using Calophyllum Oil Methyl Ester

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Abstract - *For the overall development of world utilization of energy is needed. The main source of energy in the transport, agriculture, commercial, domestic, and industrial sector for generation of power is diesel fuels. The usage of these fuels on large front had lead to the serious shortage of the fossil fuel. So a consistent and a systematic approach for the alternative fuels is needed. And oils extracted from the non edible sources form one of the best alternative.The current paper the Calophyllum inophyllum biodiesel is prepared by using thermal cracking process and then transesterified. The blends of the obtained oil is prepared with diesel as 20%,40%,60%,80%.Experiments were conducted on Variable Compression ratio Engine and Performance parameters were determined like Brake Specific Fuel Consumption, Volumetric and Brake Thermal Efficiency. Also the Exhaust Emission parameters like CO, CO_2, HC and NOx were determined for biodiesel-diesel blends by incrementing load by 25% and at constant speed of 1500 rpm, injection pressure of 200 bar and injection timing of 27^0bTDC. The emissions shown by Pure Calophyllum biodiesel and B20 are much better and cleaner in comparison to diesel wherein the Carbon monoxide emission and Hydrocarbon emission reduced by 52% and 49.8%.font)*

Key Words: *Biodiesel, Calophyllum inophyllum oil, Thermal cracking ,Biodiesel Blends, VCR Diesel Engine, Performance and emission, Engine Load*

1. INTRODUCTION

In the present days the alternate fuels is the answer to the depleting fossil fuels. The best alternative source is the Biodiesel. Biodiesel is distinct as it is oxygenated, sulfur-free, biodegradable, non-toxic and eco-friendly alternative diesel oil. It can be defined as a fuel self- possessed of mono-alkyl esters or methyl esters of long chain fatty acids derived from renewable sources, for instance vegetable oil, animal fat and used cooking oil which is designated as B100 and also they meet the special requirements such as the ASTM and the European standards. The conversion of vegetable oils into biodiesel is best possible way to use in engine. There are many techniques to convert the vegetable oil into biodiesel and reduce its viscosity .There are both edible and non edible source for obtaining biodiesel. There are several works that were conducted on various edible and non edible oils. The experiments were conducted on Mahua oil methyl, ethyl, butyl ester, [1] on the soybean, sunflower, cotton seed, rapeseed, palm oil and their methyl ester[2] and on rapseed[3] on sal methyl esters [4] and on jatropa oil methyl ester[5] and many more seed like kanranja , cotton seed, cashew nut shell [6] The present work is done on Calophyllum Inophyllum from the Clusiaceae family. There are various names given in various languages like honne oil, puna oil etc. Many investigations were done on this oil by varying parameters like load, compression ratio, injection timing and pressure on both performance and emission with pure and blends with diesel. The various works done on this oil were done byB.K Venkanna et al[7] conducted a production process and for the optimum yield of Calophyllum inophyllum Llinne oil by a three stage method. The process included a pre-treatment process, alkali catalyzed transesterification and post treatment. The choices of the alkali catalyst or acid depend on the free fatty acid in raw oil. It was understood that the free fatty acid and the moisture content in the seed oil would be important parameter for the yield of the oil. Vasanthakumar Sathya Selvabala et. al. [8] developed a two step production process for the pinnai oil that is having high FFA content. The two stage methods are the esterification and transesterification processs. In esterification the pinnai oil free fatty acid was high so phosphoric acid modified b-zeolite (Pb) was used as a catalyst. Then the FFA was reduced and then the trasnsterification process was used by preheating the oil and using methol and KOH as catalyst. The optimum conditions were determined by the Response Surface Methodology (RSM), and Central Composite Design also was used for the analysis in order to get the relation between the oil to methanol ratio, amount of catalyst and temperature. Various researchers have investigated on honne oil methyl ester with varying pressure of 200 to 260 barThe brake thermal efficiency increased when the IOP was varied from 200bar to 240bar The variation of EGT was observed that H100 has highest at 200 bar but the thermal efficiency is lowest.[9]Variation of compression ratio showed that the BSFC was least at maximum compression ratio and the Brake thermal efficency was reduced for the biodiesel blendswhen compared to diesel.At higher compression ratio the CO, HC, smoke reduced. [10]

2. MATERIALS AND MEHODS

There are various process in which the preparation of Biodiesel can be possible, in this work the biodiesel is prepared by the process of thermal cracking of the crude oil and then proceeded for the transesterification process. Thermal cracking is the chemical reaction in which the lower molecular weight products are produced from the organic compound. The crude oil usually has long chains hydrocarbon molecules and also higher viscosity. The chains are broken and the the viscosity of the oil is considerably reduced in the thermal cracking process.

For the purpose of preparation of biodiesel, a three necked flask packed with the column and then a condenser is used as a reactor for crude oil. An amount of 200ml oil is filled in the flask and 1 ml of HCl is used as anti foaming agent. As crude oil has the capability to form foams which can be affected by possible impurities present in it. A heating metal is used for heating the crude oil for a maximum temperature of 250^o C. Porcelain bites were introduced into the flask in order to retain the uniform temperature inside the flask. Glass wool is used for the insulation purpose in order to reduce the heat loss to the surrounding [11].The condensed vapors were collected. The so obtained oil is further transesterified .In the present research the 1 litre of thermally cracked oil was made to react with the 180 ml of methanol and 5 gm of potassium hydroxide in a round bottomed flask. A magnetic stirrer was also placed inside the oil for the equal distribution of the temperature. The round bottomed flask is inserted in a water bath in one container and the whole setup was placed on the magnetic stirrer with hot plate. A temperature of about 65^{0}C was maintained for 2 hours. Then the entire solution is was taken in separating funnel and allowed to settle for an hour then Calophyllum oil Methyl Ester and glycerol will be formed separately. Carefully the Methyl ester was separated. The one litre of obtained Calophyllum oil Methyl Ester was mixed with one litre of distilled water and shaked vigously then the saponified water and washed methyl ester can be obtained. The process was continued till the complete absence of the saponified water. Then the blends of B20 (20% of Calophyllum Oil Methyl Ester with 80% of diesel by volume), B40, B60, B80 were prepared

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Table 1: Property Table of Biodiesel

PROPERTY	B100
Viscosity *mm^2/sec*	4.3
Flash Point ^0C	152
Fire Point ^0C	158
Net heating Value *MJ/kg*	38.690

3. EXPERIMENTAL SETUP

Experimentation was conducted on Diesel Engine test rig having single cylinder four stroke, D.I. water cooled type diesel engine with Eddy current loading for diverse fuel blends. The engine is a variable compression ratio engine.

3.1 Experimental methodology:

The testing observations were recorded at constant Engine speed 1500 rpm, injection pressure of 200 bar and injection timing of 27^{0}bTDC. Readings signify the engine parameters recorded were the variation in load and compression ratio with respect to all blends of Diesel-Biodiesel. The measurands are Thermal Performance and Exhaust emissions for different Blends of Bio diesel and the Diesel. The gas analyser used was 5-way in nature that can measure oxides of nitrogen, carbon (like CO and CO_2,) hydrocarbons in PPM or % basis

Table 2: Engine Specification and setup

Make and Model	Rocket Engineering Model VRC -1
Type	4-stroke single cylinder, water Cooled, VCR diesel engine
Standard Dimensions of Cylinder	80mm bore diameter and 110mm length of stroke
Speed	1500rpm Constant
Exhaust Gas Analyser Make	Indus Scientific Pvt.Ltd.
Measureable Gases	CO, CO2, NOx and HC

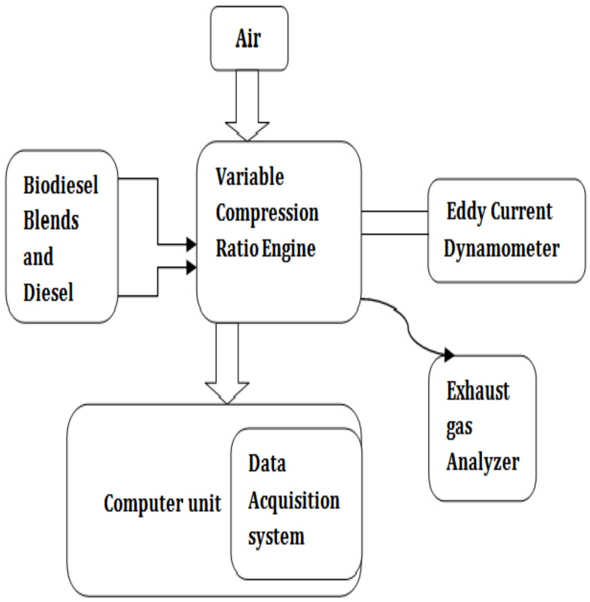

Fig1. Schematic representation of experimental procedure

4. RESULTS AND DISCUSSION:

4.1 Load Variation: Engine Performance:

The below experimental study reveals the variations observed when the load was altered for the blends.

4.1.1 Brake Power:

Chart No 1. Illustrates the effect brake power derived from Callophyllum biodiesel to the load that is incremented by 25%. Brake power of an engine is directly proportional to the load applied and hence the BP for all blends shows a linear variation. Also output power is found maximum for B20 Blend which contains 20% vol. Calophyllum methyl ester. The Brake power also derives the knowledge that the actual power delivered or obtained at the crankshaft reminding which is useful observation while considering a alternate fuel for current diesel engines without any high modifications.

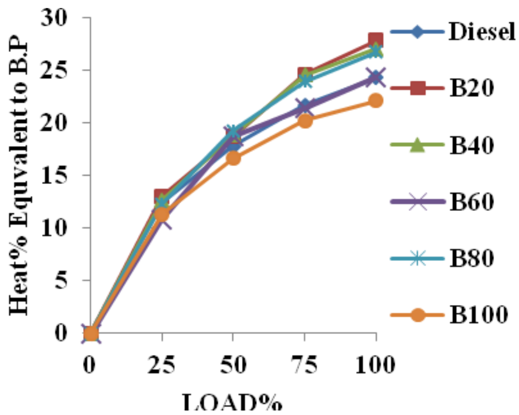

Chart -1. Variation of Brake power to load

4.1.2. Brake Mean Effective Pressure

Brake mean effective pressure is a factor of turbulence occurring due to effective burning inside the cylinder recurring to greater BMEP .The Chart No 2 signifies that as the load increases the brake mean effective pressure rises almost linearly. Effective Pressure for diesel is very low in comparison to other mixtures. As the percentage of Calophyllum Methyl ester increases in the blend, relative increase in BMEP is found. The Effective pressure of B100 (Calophyllum oil methyl ester) was maximum than all other the blends of biodiesel-diesel. The BMEP of Diesel has increased by 52.5% on average with conventional fuel.

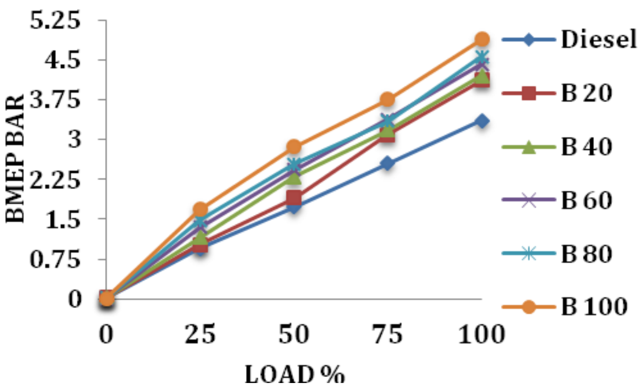

Chart- 2 Variation of Brake mean Effective Pressure to load

4.1.3 Exhaust Gas Temperature

The exhaust gas expelled after the Power stroke contains some amount of heat or temperature which is allowed to the atmosphere. The chart-3 plotted below mentioned shows that as the load are altered on the output shaft the expelled gas temperature also increases. The amount of Heat released is directly proportional to exhaust gas temperature and also the heat release is important which is based on burning of fuel or which is also called as complete combustion. The trend observed for all the blends is the same but B20 is increased by 2.4%. The compression ratio 17.5, Injection pressure 200 bar and timing of 27⁰bTDC were constant during observation. It is inferred from the graph that the B100 pure biodiesel is giving maximum exhaust gas temperature as the load is incremented.

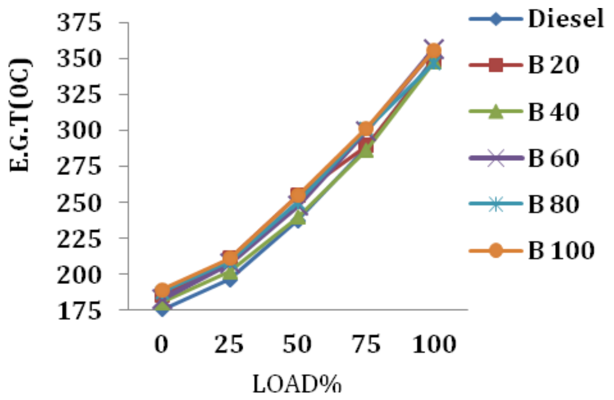

Chart-3. Variation of Exhaust Gas Temperature to load

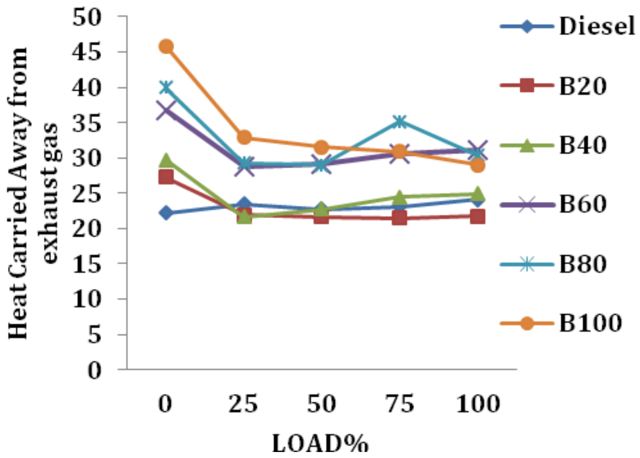

Chart-4 Variation of Heat carried away from exhaust gas to load

4.1.4. Brake Thermal Efficiency

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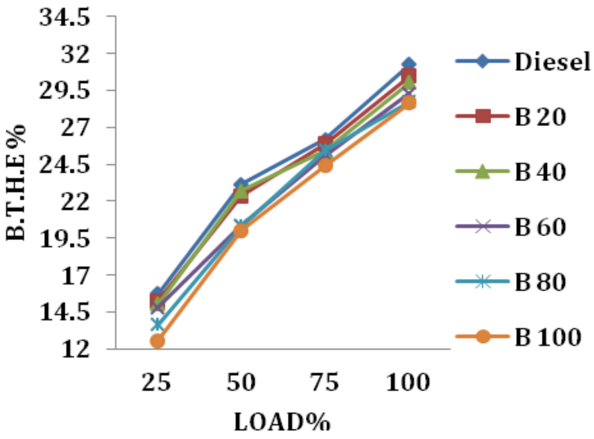

Chart-5. Variation of Brake Thermal efficiency to load

Brake thermal efficiency (%) is the ratio of output power to heat supplied. The chart-5 shows that the brake thermal efficiency for diesel is highest as the calorific value of diesel is higher than the other fuels. The brake thermal efficiency of all fuels used in the study is showing an increasing trend to load variation. The heat input provided is given by the mass of fuel consumed and the calorific value of the fuel. The bthe of B20 is almost same at lower loads but as the load increases, the average reduction is 3% with comparison to diesel. In the case of B100 the bthe reduces on a average load of 11%. The brake thermal efficiency of B100 is lowest and fossil diesel is highest.

4.1.5 Brake Specific fuel Consumption

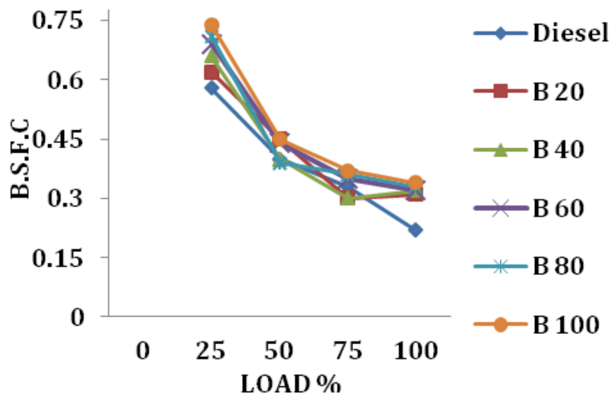

Chart-6 Variation of Brake Specific Fuel to Consumption to load

The BSFC shows the amount of fuel consumed for obtaining 1kW of output power. The chart 6 describes the variation of the B.S.F.C with the load in all the biodiesels .The fact that conventional having higher heating value gives least BSFC which is good and as the blend percentage of Callophyllum biodiesel increases the BSFC Also increases which is disadvantage when such fuels are considered. The BSFC of B20 blends shows the same as diesel and for B100 the Specific fuel consumption is maximum. The bsfc for 100% biodiesel is 24.3% more than that of diesel fuel.

4.1.6 Volumetric efficiency

The chart 7 indicates the variation of the volumetric efficiency with the load for calophyllum-diesel blends. -The volumetric efficiency is the ratio of actual air taken in to the theoretical air sucked inside the cylinder. The Vol efficiency is highest for B20 blend and lowest for conventional fuel or diesel. For B60 blend it first rises and gradually falls

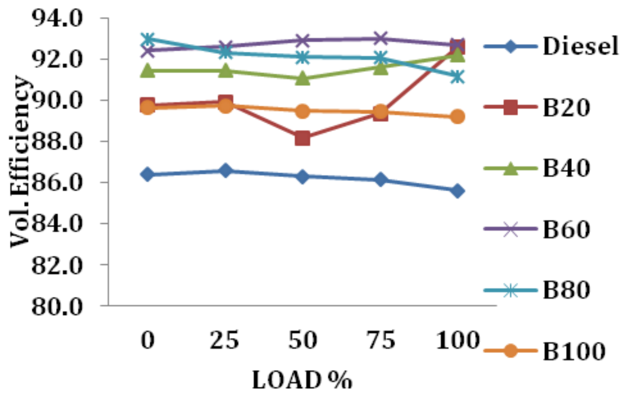

Chart-7. Variation of Volumetric efficiency to load

4.2Exhaust Emission:

4.2.1 CO_2 emission

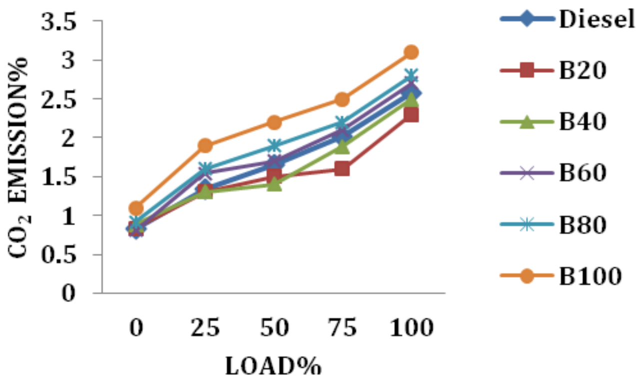

Chart-8. Variation of CO_2 to load

The chart-8 shows the emission of CO_2 with the load incrementation for all the blends. Release of carbon dioxide emission is a sign of cleaner emission. As the amount of the biodiesel percentage increases the CO_2 levels also increases which is good sign for alternate fuel. Even diesel doesn't show the the above statement. When load is increased the fuel consumption increases , the carbon dioxide emmision also shows the result in a linear progressive fashion. The CO_2 emission for B100 is highest and least for diesel. The increase in carbon dioxide emissions for B100 and B20 is 13.5% and 3.8% respectively to diesel.

4.2.2 Carbon-Monoxide Emission

The chart-9 depicts the variation of CO with the increase in load. The load is incremented by 25% i.e. 0, 3, 6, 9, 12 kg's. The CO forms when incomplete burning of fuel takes place. Also flame quenching CO emission Also these emissions required the following reasons like oxygen content is lesser than theoretical or time shortage for combustion is lesser.

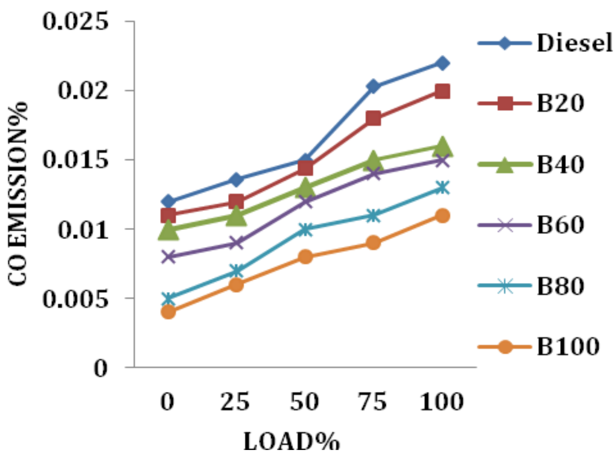

Chart-9 Variation of CO emission to Load.

At constant injection timing of 27^{0}bTDC, the CO emissions of Diesel fuel is highest and is measured in %. The B100 blends show a reduction by 52% than that of diesel and B20 by 12% for all loads.

4.2.3 Hydrocarbon emission

The hydrocarbon emission (HC) is consequential of partial burning. As the load is varied, the HC emission grows. The chart-10 given below indicates the variation in the HC with load in as the blend. The hydrocarbon emission for conventional fuel diesel is found maximum. As the amount of biodiesel increases in the fuel hydrocarbon emission reduces significantly. B20 shows a reduction of HC emission by 13.5% and B 100 by 49.8%.

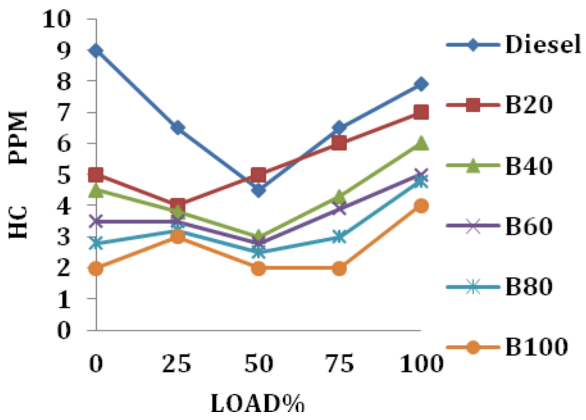

Chart-10. Variation of Hydrocarbon emission to Load

4.2.4 Nitrogen Oxides emission

The variation of Nitrogen Oxides with respect to load is plotted graphically in chart 11. The nitrogen oxides (NOx) emission is a direct function of burning temperature of the fuel in the combustion chamber inside the engine. The fluctuation of load and Oxides of nitrogen is showing a linear trend. The NOx produced by B100 is highest as combustion is found to be complete as due to the chemical structure of biodiesel has oxygen impregnated in it and which is absent in diesel. The NOx emission of B100 increased by 23% in comparison to diesel

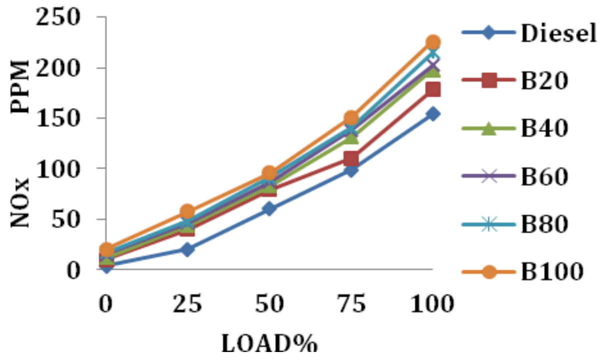

Chart-11 Variation of nitrogen oxide emission to Load.

5. CONCLUSION:

The experimental analysis of biodiesel derived from from calophyllum oil is compared to diesel with the variation of engine load incrementing by 25% and then with the variation of compression ratio observes the following points.

- The Brake thermal efficiency reduced by 3% and 12% for B20 and B100 in comparison of diesel with the variation of load and the brake specific fuel consumption increased by 24.3% for B100 with that of diesel which is a negative point when mileage concept is considered.
- The Brake Mean Effective pressure raised by 52% for B100 which adds to point of higher combustion efficiency.
- The Hydrocarbon and Carbon monoxide emissions reduced by 49.8 % and 52% which proves a cleaner fuel but the NOx increased by 23% for B100 with reference to the load variation.

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