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Experimental Investigation of single cylinder diesel engine by use of callophyllum and its blends

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Abstract

Biodiesel is a renewable fuel, which can reduce the use of petroleum based fuels and possibly lower the overall greenhouse gas emissions of internal combustion engines. Biodiesel is currently expensive but would be more cost effective if it could be produced from low–cost oils (restaurant waste, frying oils, and animal fats). These low–cost feedstocks are more challenging to process because they contain high levels of free fatty acids. The objective of this study was to investigate the effect of the biodiesel produced from high free fatty acid feedstocks on engine performance.The biodiesel is nothing but the diesel blended with the oil extracted by the various plant seeds also by fatty acids, the oil is blended in proportion of 5% to 100%. In this project we tested the diesel blended with the callophyllum oil in proportion 00, 15,30,45,60 and 100% and tested on Variable Compression Ratio (VCR) Diesel Engine as per ASTM standard. The performance test was conducted for parameters, BSFC, Break power, Break thermal efficiency.

I. INRODUCTION

The energy is the prime entity for the world. The energy is consumed for various systems functioning in day to day life can be categories as consumption of fuel used for those system and their subsystems. The energy sources available in present days are in non renewable and renewable form as the non renewable sources are in limited quantity which includes fossil fuels and natural gases are going to exhaust one day, may be after some years. The relief for these consequences is the use of alternative energy sources like alternative fuels. Diesel is one of the most used fuels for Transportation and power sectors also coal is the major fuel used by these sectors, as coal and diesel are the non renewable source the alternative fuel that is biodiesel can replace diesel partially [1].

Biodiesel and its blends with petroleum-based diesel fuel can be used in diesel engines without any significant modifications to the engines. The advantages of biodiesel are that it displaces petroleum thereby reducing global warming gas emissions, tail pipe particulate matter, hydrocarbons, carbon monoxide, and other air toxics [3].

The first use of vegetable oil in a compression ignition engine was first demonstrated through Rudolph Diesel who used peanut oil in his diesel engine. The use of oils from coconut, soy bean, sunflower, safflower, peanut, linseed, rape seed and palm oil amongst others have been attempted. The long term use of vegetable oils led to injector coking and the thickening of crankcase oil which resulted in piston ring sticking. Therefore, vegetable oils are not used in diesel engines because of endurance issues. To overcome this problem, various modifications of vegetable oils have been employed such as transesterification biodiesel is made through a chemical process called transeterification whereby the glycerin is separated from the fat or vegetable oil. The process leaves behind two products-methyl esters (the chemical name for biodiesel) and glycerin (a valuable byproduct usually sold to be used in soaps and other products). The transesterification is achieved with monohydric alcohols like methanol and ethanol in the presence of an alkali catalyst [2].

In this research work, brake power, brake specific fuel consumption, brake thermal efficiency have been tested at different blend, load on variable compression ratio engine. For the present work of experimental investigation of engine performance parameters the Laxmitaru oil has been selected. Laxmitaru is a plant as the tree has been christened here, is being promoted by horticulturists, agro-scientist, holistic health hub and practitioners of traditional Indian medicines across the country as the latest wonder tree whose edible, therapeutic and other utility values may outweigh those of common medicinal and edible herbs found in India. The tree, which first came to India from central (Latin) America in 1960, can be grown anywhere from the sea coast to elevations of 1500 feet in tropical climatic conditions. At the village level, the plant is cost effective as its farming is nearly zero-budget and completely organic.

II. BIODIESEL PRODUCTION

For production of biodiesel following steps are implemented.

2.1 Oil Extraction

In oil extraction process, the oil seeds are first crushed and then with the help of soxhelt apparatus the oil is extracted from crush. In this process, polar solvent (petroleum ether, hexane, diethyl ether) is used with given seed sample with the ratio 1:5.

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III. TRANSESETERIFICATION REACTION

This reaction is also called as alcoholysis which is the displacement of alcohol from an ester by another in a process similar to hydrolysis, except an alcohol is used in water. The reaction can be represented as follows; the general equation will be.

RCOOR' + R"OH RCOOR"+ R'OH

For transesterification process the feedstock should not have more than 5% of free fatty acid content. The major components of vegetable oils and animal fats are Triglycerides. To obtain biodiesel, the vegetable oil or animal fat is subjected to a chemical reaction termed transesterification. Following fig 1.1 shows the transesterfication process.

CH_2OCOR''' | CH_2OH | R'''COOR

CH_2OH R''' + 3ROH → (Catalyst) CH2OH + R''COOR

COOR | CH2OH | R''COOR

(Oil or fat) (Alcohol) (Glycerine) (Biodiesel)

Figure 1: Transesterification Process

3.1 Filtering Transesterification Reaction

Filter the vegetable oil to remove solid particles from it. You may have to warm it up a bit first to get it to run freely; 35°C should be enough. A Cartridge filter is used for the same

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3.2 Removing the Water Transesterification Reaction

Heat the oil first to remove the water content. Vegetable oil will probably contain water, which can slow down the reaction and causes saponification (soap formation). Raise the temperature to 100°C, hold it there and allow water contents to boil off. Run the agitator to avoid steam pockets forming below the oil and exploding, splashing hot oil. Or drain water puddles out from the bottom as they form, you can save oil that comes out with the water later. When boiling slows, raise the temperature to 130°C for 10 minutes and allow cool to it.

IV. EXPERIMENTAL TEST RIG

A single cylinder, four stroke, vertical, water cooled, constant speed, variable compression ratio engine was used for tests. The compression ratio of the engine was varied by raising the bore and head of the engine. Different blends of biodiesel were prepared as B15, B30, B45, B60, & B100 where used as fuel in the engine. So that they can be conveniently used during the experiment.fig 2 shows photograph of experimental setup.

Figure 2: Photograph of VCR experimental test rig.

Table 1: Engine specification

Parameters	**Specification**
Engine manufacturer	Kirloskar oil engines Pvt. Ltd. India.
Engine type	VCR Diesel Engine
Number of cylinders	1
Number of Strokes	4
Fuel	H.S. Diesel
Rated power	3.5 kW @1500 RPM
Cylinder Diameter	87.5 mm
Stroke Length	110 mm
Connecting Rod Length	234 mm
Compression ratio Variation	12-18.1

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V. EXPERIMENTAL PROCEDURE

Test was carried out on the engine initially using diesel as a fuel in order to provide base line data. Before the actual test was carried out the engine was checked for lubrication and fuel supply. During this trial the speed of engine was kept almost constant at 1500 rpm and the load on the engine is given as3kg, 6kg, 9kg & 12kg. First the compression ratio of the engine was kept as 17.5:1 and then blends of Calophyllum B15, B30, B45, B60, & B100 where used as fuel in the engine.

During test the fuel consumption, engine speed, calorimeter inlet and outlet temperature measured. The entire test was carried out in same way at different compression ratios for diesel, and biodiesel blended fuels. Test summery is given in table no.1.

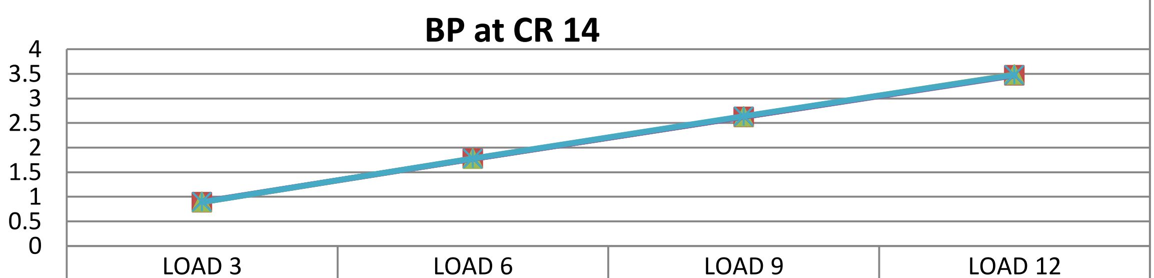
Table 2: Set of experiments

Sr. No.	Fuel	Compression Ratio		Load Steps (Kg)
		14	17.5	
1	Diesel	√	√	3, 6, 9, 12.
2	B00	√	√	
3	B15	√	√	
4	B30	√	√	
5	B45	√	√	
6	B60	√	√	
7	B100	√	√	

VI. RESULT & DISCUSSION

The experiments were carried out by operating the engine with pure diesel fuel and Biodiesel blended fuels with varying compression ratio of 16 and 17.5. For each test the engine was run for fifteen minutes. During the test the speed of the engine was kept almost constant i.e. 1500 rpm. The parameters were measured during these tests at steady state working condition. The performance parameters like Brake Power. Brake Specific Fuel Consumption, Brake Thermal Efficiency.

6.1 Effect of Load on Brake Power



	LOAD 3	LOAD 6	LOAD 9	LOAD 12
B00	0.8951	1.7731	2.6272	3.4779
B15	0.8897	1.7743	2.6255	3.471
B30	0.8917	1.7765	2.6323	3.4847
B45	0.8975	1.7743	2.6272	3.4688
B60	0.8922	1.7765	2.6375	3.4779

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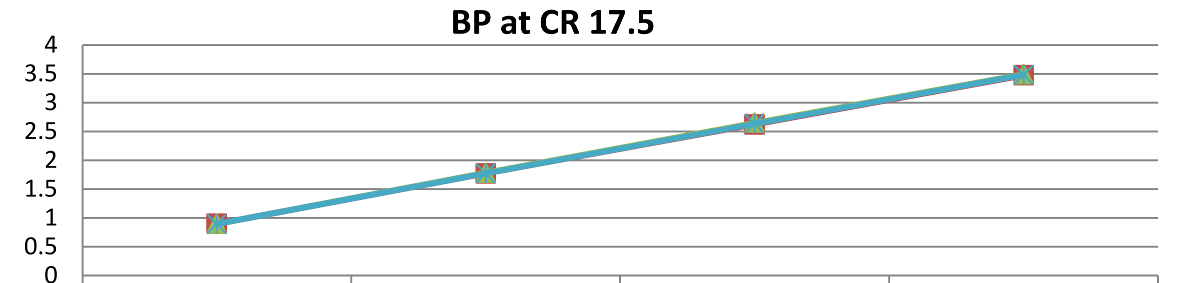
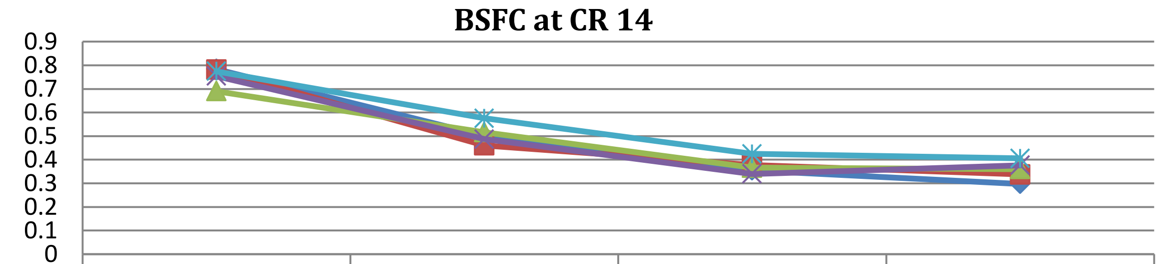
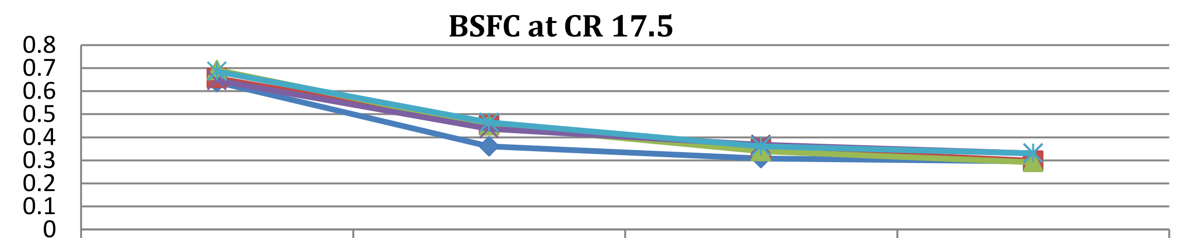


	Load 3	Load 6	Load 9	Load 12
B00	0.899	1.78	2.64	3.49
B15	0.8939	1.77	2.62	3.47
B45	0.8923	1.77	2.64	3.48
B30	0.8951	1.78	2.65	3.49
B60	0.893	1.77	2.63	3.48

6.2 Effect of Load on Brake specific fuel consumption



	LOAD 3	LOAD 6	LOAD 9	LOAD 12
B00	0.7842	0.5014	0.3549	0.2981
B15	0.7809	0.4605	0.377	0.3381
B30	0.6903	0.5167	0.3665	0.3605
B45	0.7541	0.487	0.3398	0.3767
B60	0.7746	0.5755	0.4244	0.4057



	LOAD 3	LOAD 6	LOAD 9	LOAD 12
B00	0.63911	0.36	0.3081	0.296
B15	0.6564	0.4515	0.3503	0.2978
B30	0.6918	0.451	0.3396	0.2919
B45	0.6455	0.4365	0.3681	0.3301
B60	0.6853	0.4643	0.3601	0.3303

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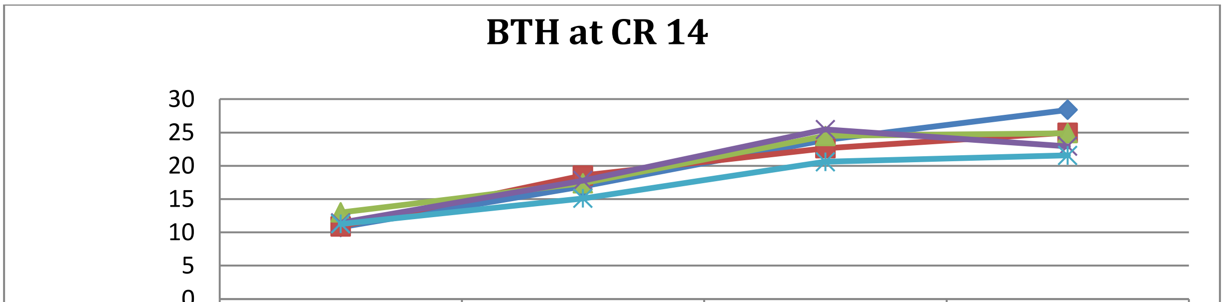
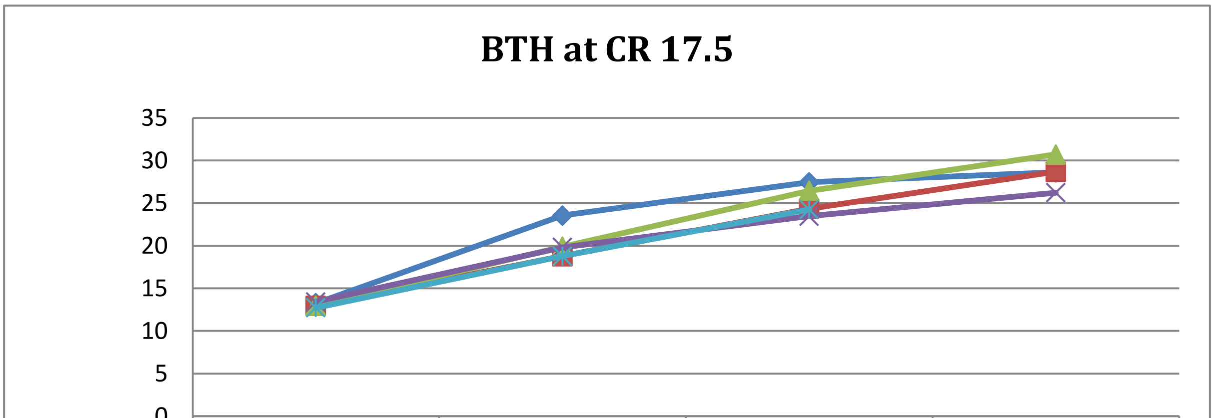
6.3 Effect of Load on Brake Thermal Efficiency



	LOAD 3	LOAD 6	LOAD 9	LOAD 12
B00	10.8	16.9	23.88	28.41
B15	10.92	18.54	22.63	24.98
B30	13.01	17.38	24.5	24.9
B45	11.45	17.8	25.44	22.92
B60	11.28	15.1	20.6	21.57



	LOAD 3	LOAD 6	LOAD 9	LOAD 12
B00	13.25	23.54	27.44	28.61
B15	12.97	18.77	24.34	28.67
B30	12.97	19.89	26.45	30.7
B45	13.42	19.8	23.47	26.23
B60	12.72	18.77	24.25	

VII. CONCLUSION

Based on the results of this investigation following conclusion can be drawn;

- The biodiesel blends performance found better at higher compression ratios. At these compression ratios higher BTE and lower BSFC found. While lower value can be occurred.
- As the percentage of biodiesel in blends increases the BTE reduces while BSFC increases.

- For same operating conditions performance of the engine reduced with increasing biodiesel percentage in blended fuels.
- Significant improvement in combustion parameter can be observed by existing diesel engine operated with neat Calophyllumoil and its blends.
- From the thermo physical properties and engine tests it can be established that for blends B00, B15, B30, B45& B60 the optimized compression ratio is 17.5.
- From engine test results, it has been established that Calophyllum biodiesel can be substituted for existing diesel in CI engine without any major modifications.
- Higher viscosity is a major problem in using vegetable oil as fuel for diesel engines. Significant reduction in viscosity is achieved by heating the oil and dilution of vegetable oil (Calophyllum) with diesel in varying proportions.
- Calophyllum biodiesel along with diesel reduces the environmental impacts of transportation, dependency on crude oil imports and offers business possibilities to agriculture enterprises for period of excess agricultural production.
- As we tested the parameters on single cylinder diesel engine we conclude that the blend B30 is our best blend.

VIII. ABBREVIATIONS AND ACRONYMS

BTE: Brake Thermal Efficiency
EGT: Exhaust Gas Temperature
BSFC: Brake specific fuel consumption
CR: Compression Ratio

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