AN EXPERIMENTAL APPROACH IN TO THE PERFORMANCE ANALYSIS OF DIESEL ENGINE USING RUBBER SEED OIL AS BIODIESEL

Pradeesh A R[1], Deepu T[2], Akshay D[3],Navaneeth P[4], Padmaraj C K[5], Surjith K[6]

[1,2]*Asst. Professor, Dept. Of Mechanical Engineering, Ammini College Of Engineering, Palakkad-678613*
[3,4,5,6]*B. Tech Scholars, Dept. Of Mechanical Engineering, Ammini College Of Engineering,Palakkad-678613*

Abstract – *In this paper, An experimental approach in to the performance analysis of diesel engine using rubber seed oil as biodiesel is discussed. A domestically produced renewable fuel called biodiesel is better for the engine and offers economic, energy security, fuel quality, and environmental benefits compared to petroleum based diesel. Biodiesel from rubber seed oil was produced by acid and alkaline esterification process used for the study on engine performance evaluation. Performance test was conducted with single cylinder water cooled diesel engine with rubber seed oil as fuel*

Key Words**:** ***Bio diesel Blend, Rubber Seed Oil, Trans esterification***

1. INTRODUCTION

The availability of energy resources places a critical role in the progress of a nation. An almost all the human energy needs are currently met from the fast depleting fossils fuel associated with serious environmental consequence. Due to the problem of fuel crisis and environmental pollution, the survival of these engines has been threatened. Bio-fuels and its blend appear to be a potential alternative "greener" energy substitute for fossil fuel.

Biodiesel is one of the alternative fuels usable in any conventional diesel engine with a little or no modification to the engine or fuel system. Increased utilization of renewable bio-fuels results in significant micro-economic benefits to both the urban and rural sectors. Also it results in a substantial reduction of unburned hydrocarbons, carbon monoxide and particulate matter. A renewable fuel can be derived from vegetable oils, used oils and animal fats. Biodiesel is not the same thing as raw vegetable oil; rather, it is produced by a chemical process which removes the glycerin and converts the oil into methyl esters. Biodiesel can be used in any concentration with petroleum- based diesel fuel with little or no modification to existing diesel engines. Dilution or blending as well as heating of vegetable oils reduce the viscosity. Different methods for reducing viscosity have been analyzed for locally available bio-fuels and found that dilution is the economic way for reducing the viscosity and improving their combustion properties. Experimental investigations revealed that local fuels such as coconut, palm and rubber seed oils are found to be alternative fuels to diesel in compression ignition engine.

The rubber seed cultivation in India is abundantly done and the availability of rubber seeds is also high. The oil obtained by crushing these seeds can be used as an alternate fuel and they are also non edible. Due to the high FFA content of the oil esterification is done before using it as alternate fuel. Also due to the high availability of rubber seed oil the impact of fossil fuel on Indian economy can be minimized. If mass production of oil is done, it will favor the agricultural sector of our country. Alternate fuels should be easily available at low cost, be environment friendly and fulfill energy security needs without sacrificing engines operational performance. For the developing countries, fuels of bio origin provide a feasible solution to the twin crises of fossil fuel depletion and environment from the point of view of protecting global environment and concerns for long - term energy security, it becomes necessary to develop alternative fuels with properties comparable to petroleum based fuels. Unlike rest of the world, India's demand for diesel fuel is roughly six times of gasoline hence seeking alternative to mineral diesel is a natural choice.

Thus the objective is to conduct a test in order to increase the efficiency of a diesel engine. This is to done by adding a certain diesel blend (here it will be rubber seed oil) in the consistent amount and verify the conditions.

In **section 2,** the production of biodiesel and the application of biodiesel were explained. The preparation of rubber seed oil and biodiesel from rubber seed. Fuel analysis and properties of various biodiesel were discussed in **section 3.** In **section 4,** the experimental set up of the diesel to carry out the performance test for diesel and various rubber seed oil blend, its testing procedure to carry out the results were explained. In **section 5,** the results and discussions of the experiments carried out. In **section 6,** contains the conclusions of the paper followed by references.

2. PRODUCTION OF BIODIESEL

Rubber seed oil is vegetable oil produce from the seed of *Heveabrasiliensis.*Rubber seed as a waste product from rubber plantations, Rubber (*Heveabrasiliensis*) tree starts to bear fruits at four years of age. Each fruit contain three or four seeds, which fall to the ground when the fruit ripens and splits. Each tree yields about 800 seeds (1.3 kg) twice a year. A rubber plantation is estimated to be able produce about 800- 200 kg rubber seed per ha per year, and these are normally regarded as waste. According to a study conducted by the rubber board, on an average, a healthy tree can give about 500 g of useful seeds during a normal year and this works out to an estimated availability of 150 kg of seeds per hectare produced mostly in kerala (southernmost state of India), the processing of rubber seeds is concentrated in Tamilnadu (another southern state).The production and utilization of these oils are low at present because of their limited end usage.

Biodiesel refers to a vegetable oil- or animal fat-based diesel fuel consisting of long-chain alkyl (methyl, ethyl or propyl) esters. Rubber seeds are collected. These kernels are crushed and oil is extracted by screw pressing and then filtered. The rubber seed oil varies in colour from light yellow to brown, depending on the Free Fatty Acids (FFA) content. Hence the amount of FFA must be reduced to its minimum by acid esterification before alkaline esterification. The common method for the biodiesel production is the Transesterification. It consist on the reaction of fat with methanol with the presence of an alkaline (NAOH) to remove glycerin from oil.

Fig-1: Rubber Seed

Triglyceride + Methanol = Glycerol +Methyl Ester

Fig-2: Rubber Seed Oil

2.1 Biodiesel Blends

Much of the world uses a system known as the “B” factor to state the amount of biodiesel in any fuel mix. The different type of biodiesel blends are;

- 20% biodiesel, 80% diesel is labeled B20
- 25% biodiesel, 75% diesel is labeled B25
- 30% biodiesel, 70% diesel is labeled B30
- 35% biodiesel, 65% diesel is labeled B35

3. PREPARATION OF BIODIESEL

3.1 Determination Of Free Fatty Acid (FFA) Content In Raw Oil

Step1: Preparation of 0.1Normal (0.1N) NaOH solution:

4 grams of NaOH is weighed & transferred into the conical flask containing 1 liter of water. Dissolve NaOH completely by constant stirring then the solution we get iscalled 0.1N NaOH solution. (With NaOH the molecular weight is 40 so a 0.1N solution contains 4g per liter)

Step2: Titration and calculation of free fatty acid content in raw oil:

Take 25ml of 0.1N NaOH solution in the burette and then take 10 grams of Rubber seed oil, in a conical flask, add 50ml of Isopropyl alcohol into the conical flask and also add 5-6 drops of Phenolphthalein as indicator and shake well. This is titrated against the 0.1N NaOH solution until it turns pink color, this is the indication of end point and by using the formula we can find FFA content in the oil.

Step3: FFA calculation

$$\text{FFA Content} = \frac{\mathbf{28.2 \times \textit{Normality of NaOH} \times \textit{Titration value}}}{\mathbf{\textit{weight of the oil}}}$$

If the value of the FFA is less than 2% we can directly go to transesterification or we need to do esterification and then reduce the FFA content till it lower than 2%.

3.2 Esterification

In the Esterification process the excess free acid gets reacted. The remaining acid content in the oil undergoes transesterification. So this method is effective for oils that contain high free fatty acid (FFA) content. So the selection of acid catalyst is very important. The aim of esterification reaction is to remove water during processing otherwise seriously hurt the reaction conversions. The esterification reaction is shown below:

$$\underset{\text{(FFA)}}{R-COOH} + \underset{\text{+ (METHANOL)}}{CH_3OH} \xrightarrow{H_2SO_4\,\text{(CATALYST)}} \underset{\text{(FATTY ACID ESTER)}}{R-CO-OCH_3} + \underset{\text{+ (WATER)}}{H_2O}$$

During the process take 150ml of methanol and 4ml of H_2SO_4 is taken. Take 1L Rubber seed oil and heated till 65°c, after oil attains 65°c pour the above mixture into the 3 neck flask and make necessary water circulation arrangement. Then agitate the mixture in the reaction vessel (3-Neck flask) at 65°C for 1.5hrs. Transfer the mixture to the separating funnel and allow it to settle for at least 2 to 3 hours. Acid layer will rise to the top as black layer as shown in the figure. Separate the bottom layer to 3-Neck flask. Drain the top acid layer. Take the sample of the bottom layer from the 3-Neck flask and measure the new FFA.

Fig-3: Esterified oil

3.3 Transesterification

Transesterification also called alcoholysis is the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis, except that an alcohol is employed instead of water. Suitable alcohols include: methanol, ethanol, propanol, butanol and amyl alcohol. Methanol and ethanol are utilized most frequently. This process is widely used to reduce the viscosity of triglycerides, thereby enhancing the physical properties of fuel and improve engine performance. Thus fatty acid methyl ester (also known as biodiesel) is obtained by Transesterification. 100ml of methanol and 5g of NaoH is added to the 1L of esterified oil. After settling it for 3-4 hours, we get separate layers of Rubber seed oil biodiesel and glycerine in top and bottom respectively

Fig-4: Transesterified Biodiesel

3.4 Washing Process

Methyl esters are then washed to remove the entrained impurities and glycerol. Take some water and heated up to 50°C and pour into the settling chamber. Then impurities will be settle down. After that remove the water.

Fig-5: Washed Oil

3.5 Heating Process

After washing process the bio diesel heated up to 120 °C to remove the moisture content in the oil

Fig-6: Biodiesel

4. EXPERIMENTAL SETUP

After preparation of various blends of biodiesel it is tested in engine to check the performance of engine. The kirloskar make single cylinder diesel engine was used for experimentation. The technical details of engine are given in table. The filter of the diesel engine was disconnected from its diesel tank and connected directly to fuel measuring unit.

Sl No.	Parameter	Details
1	Make	Kirloskar
2	Type of engine	Single cylinder, 4 Stroke
3	No. of cylinders	1
4	Power	6 HP (6×736 watts)
5	Rated speed	650 rpm
6	Bore Diameter	114 mm
7	Stroke length	140
8	Starting	Cranking
9	Type of Loading	Rope Brake Loading
10	Type of Cooling	Water Cooling
11	Type of Ignition	Compression Ignition
12	Dia. of Drum	382 mm
13	Belt Thickness	6 mm

Table-1: Technical specification of diesel engine

Fig-7: Diesel Engine

4.1 Test Procedure

At first the diesel engine with the particular specifications are set to be conduct the experiment. The diesel engine is cleaned thoroughly and made ready. The engine started taking following precautions.

- Check the fuel level.
- Check the lubricating oil level.
- Check the cooling water circulation.
- Check whether the engine is on no load

5. RESULTS AND DISCUSSIONS

5.1 Performance Of 20% Rubber Seed Oil And 80% Diesel

Sl No.	Load W_1	W_2	Net load	Time For 10 cc Fuel Consumption (t)	BP	TFC	SFC	Brake MEP	Imep	BTE	Mech. Efficiency	ITE
	Kg	Kg	Kg	sec	w	Kg/hr	Kg/Whr	N/m²	N/m²	%	%	%
1	0	0	0	112	0	0.268971	-	0	193923.7	0	0	41.678339
2	5	1	4	84	526.16	0.358629	0.000682	68023.27	195057.4	10.96475	25.96833	42.22355
3	10	2	8	69	1052.328	0.436591	0.000415	136047.6	196191.2	18.01366	41.23012	43.69052
4	15	3	12	58	1578.49	0.519393	0.000329	204071.1	197324.9	22.71284	51.27481	44.2963
5	20	4	16	47	2104.65	0.640953	0.000305	272094.4	198458.6	24.54027	58.38708	42.03031
6	24	4	20	38	2630.82	0.792758	0.000301	340118.9	199529.4	24.80141	63.6876	3.9423
7	34	4	30	36	3946.36	0.8368	0.000212	510195.2	202427	35.2452	72.4586	48.6419

Table-2: Performance of 80% Diesel & 20% Biodiesel

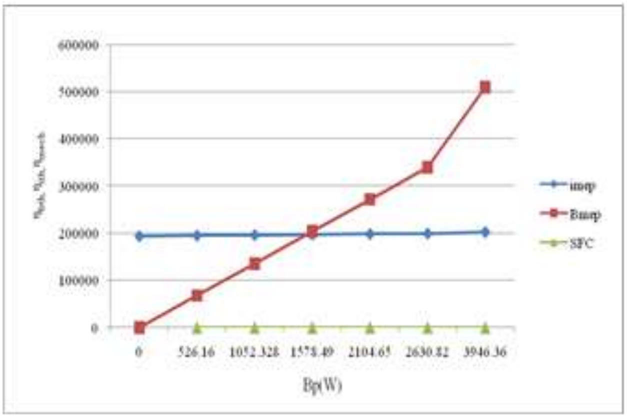

Chart -1: Bp Vs h_{bth},h_{ith},h_{mech}

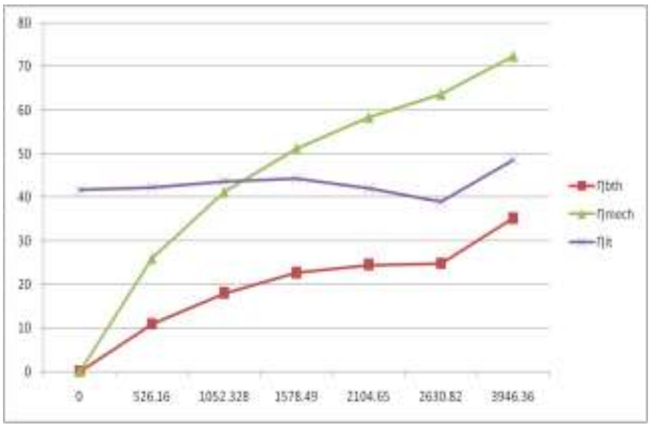

Chart -2: Bp vs imep, bmep, SFC

6. Comparison

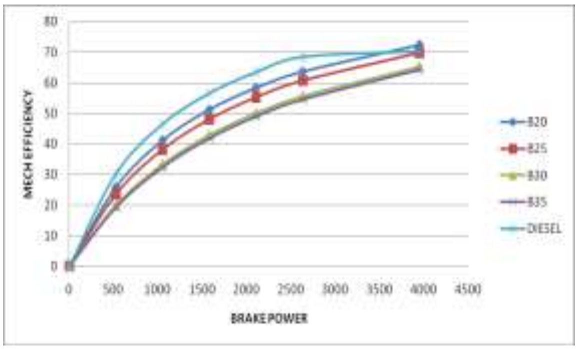

Chart -3: Brake Power Vs Mechanical Efficiency

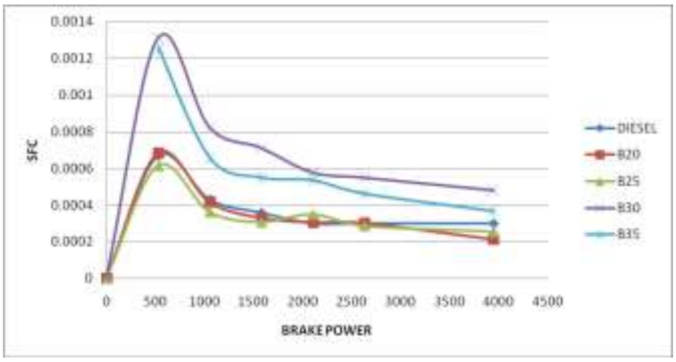

Chart -4: Brake Power Vs Sfc

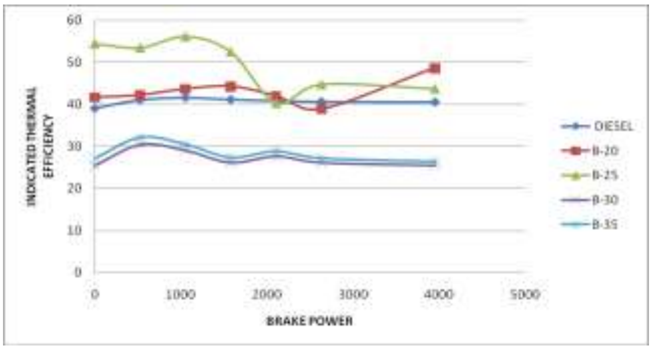

Chart -5: Brake Power Vs Indicated Thermal Efficiency

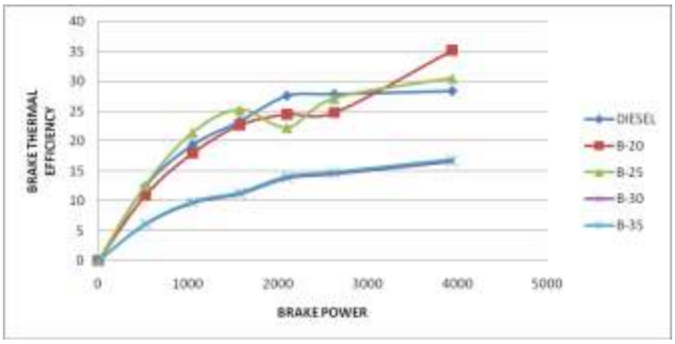

Chart -6: Brake Power Vs Brake Thermal Efficiency

7. ADVANTAGES

- Produced from sustainable renewable biological sources
- Eco-friendly and oxygenated fuel.
- Sulphur free, less carbon (co) and HC, particulate matter and aromatic compound emissions
- Income to rural community.
- Biodiesel provides better engine lubrication than Low Sulphur diesel.
- Fuel properties similar to the conventional fuel
- Used in existing unmodified diesel engines
- Reduce expenditure on oil imports.
- Nontoxic, biodegradable and safety to handle
- Less Global Warming.
- Fuel cost can be reduced.
- Diesel engine efficiency increases

8. CONCLUSIONS

The recent work has show that the Rubber seed oil can be used as a good alternative to diesel without any engine modificatons. Various performance characteristics were also plotted. Comparing the plots it was noticed that the 20:80 biodiesel blend gives more efficiency than the diesel engine and the engine performance is smooth. The engine performance with biodiesel has almost that of diesel fuel. Brake thermal efficiency, Indicated thermal efficiency and mechanical efficiency are found to be increasing, which may be assumed to be due to the lubricating effect of rubber seed oil. The Specific Fuel Consumption decreases with increase in load due to fact that the ratio of increase in brake power is more as compared to increase in fuel consumption. The biodiesel blend and mixture have higher SFC value compared to diesel due to lower calorific value. From all the above points it can be concluded that produced Rubber seed oil Methyl Ester by proper esterification and transesterification is safer and can certainly be considered as a potential alternative fuel.

REFERENCES

[1] Pradeesh A. R. ; Deepu T ; Vishnu Viswanath K ; Monish M ; Ratheesh P ; Anuraj M," *Performance Optimization and Emission Reduction on Diesel Engine using Diesel Blend"* International Journal of Engineering Research & Technology (IJERT) ISSN: 2395-0072 Vol. 3 Issue 4, Apr – 2016.

[2] Comparison Study of Rubber Seed Shell and Kernel (*Heveabrasiliensis) as Raw Material for Bio-Oil Production*

[3] Jayshri S. Patil, Shanofar A. Bagwan, Praveen A. Harari ,ArunPattanashetti," *Rubber Seed Oil As An Alternative Fuel For CI Engine: Review"Vol-1 Issue-5 2015 IJARIIE-ISSN (O)-2395-4396* 148

[4] S.N.A.M. Hassana,b,*, M. A. M. Ishakb, K. Ismaila, S. N. Alib, M. F. Yusop, "*Comparison Study Of Rubber Seed Shell And Kernel (HeveaBrasiliensis) As Raw Material For Bio-Oil Production*"

[5] S.Senthil Kumar, K. Purushothaman, P. K. Devan, "*Performance And Emission Characteristics Of A Diesel Engine Using Rubber Seed Oil And Its Diesel Blends*", International Journal of ChemTech Research, Volume-8, Number-2, Pages 669-675, 2015

BIOGRAPHIES

He is an Assistant Professor at Ammini College of Engineering, Palakkad. He received his BE and M.Tech in Mechanical Engineering 1996 and 2006 respectively. He has 7 years of industrial experience at HAL Bangalore and 9 years of teaching experience.

He is an Assistant Professor at Ammini College of Engineering, Palakkad. He received his B.Tech and M.Tech in Mechanical Engineering in 2013 and 2015 respectively. He has Presented and Published a paper in National conference on Emerging Trends in Manufacturing, organized by department of mechanical engineering, NSS college of engineering, Palakkad.

He is Pursuing B.Tech in Mechanical Engineering at Ammini College of Engineering, Palakkad.

He is Pursuing B.Tech in Mechanical Engineering at Ammini College of Engineering, Palakkad.

He is Pursuing B.Tech in Mechanical Engineering at Ammini College of Engineering, Palakkad.

He is Pursuing B.Tech in Mechanical Engineering at Ammini College of Engineering, Palakkad.