EXPERIMENTAL INVESTIGATION OF BLENDS OF ESTERIFIED COCONUT OIL AND SUNFLOWER OIL IN A 4 STROKE CI ENGINE

ANURAG K B[1], AKHIL PRASAD[2], ANOOP K V[3], ABIN VARGHESE[4], ANVAR SADATH[5], Dr. G. KALIVARATHAN[6]

[1] B.Tech Student, Mechanical Engineering, NCERC, Kerala, India
[2] B.Tech Student, Mechanical Engineering, NCERC, Kerala, India
[3] B.Tech Student, Mechanical Engineering, NCERC, Kerala, India
[4] B.Tech Student, Mechanical Engineering, NCERC, Kerala, India
[5] B.Tech Student, Mechanical Engineering, NCERC, Kerala, India
[6] Professor and HoD, Mechanical Engineering, NCERC, Kerala, India

---***---

Abstract - *Out of all such mechanical means IC engines are considered as the most complex mechanical means because of its cycle to cycle variations and reciprocating motion to the piston. Vegetable oils have been used as possible alternative to diesel fuel in CI engines with the possibility of also reducing harmful exhaust gas emissions. Various blends have been reported by researches in this area as the optimum, giving higher or comparable engine performance. This project deals with two locally available but marginally utilized vegetable oils and their respective blends with diesel in CI engines. Physical properties relevant to the fuel industry were determined for the two pure vegetable oils and their respective blends with diesel. A four stroke single cylinder, fixed throttle CI engine was run on blends containing 1-sunflower oil, 2-coconut oil and diesel to measure their performance characteristics. Based on the values of engine test, comparative analysis has been carried out and the blend having highest Brake Power (BP), highest Brake Thermal Efficiency (BTE), highest Volumetric Efficiency and Minimum Brake Specific Fuel Consumption of the engine has been identified. Emission analysis of every blend has been calculated and out of all this blends, blend having minimum smoke density is identified. Based on the performance characteristics and emission analysis, the best blend is identified which has better overall performance and cause less pollution to the environment. This blend will act as a perfect alternative for the diesel in every aspect and thus reduces the consumption of diesel in engines and makes our environment much safer.*

Key Words: marginally utilized, performance characteristics, comparative analysis, engine test, emission analysis.

1. INTRODUCTION

In the face of escalating oil prices and depleting oil reserves, the search for alternative sources of fuels has been intensified more than ever before in the history of mankind. Aside energy security concerns, issues of climate change as a result of the emission of carbon dioxide (CO_2) and carbon monoxide (CO) and other harmful compounds associated with the use of fossil fuel have also been one of the driving forces in the search for alternative sources which are environmentally friendly and sustainable. Of great concern are the relatively high viscosities and the low volatilities of most of the vegetable oils and carbon deposits on the piston during the running of the engine. All these factors have been observed to have a negative impact on the performance of the engine. A possible remedy proposed by many authors is the blending of the vegetable oil and diesel in some proportions. This is expected to cut down on cost, improve the fuel properties to make it suitable for use in engines and also reduce the quantity of greenhouse gases being emitted into the atmosphere.

The other possible remedy is to modify car engines to run purely on B100 (100% vegetable oil). Consumption has been growing steadily at an annual rate of about 5%. Diesel can thus be seen as an important derivate of fossil fuel to the economy. Aside the transportation sector, the mining sector is also heavily reliant on diesel accounting for about 10% of the total consumption in the country. Replacing petroleum derived diesel with alternative sources will have a huge positive impact on the quantity of fossil fuels imported into the country and thus conserve the nation's foreign currency reserves. Aside this, an added advantage of pursing a biofuel policy is its ability to create and sustain jobs especially in the agriculture sector of the economy. Biodiesel, derived from esterified vegetable oils, appears to be the most promising alternative fuel to diesel due to the following reasons : -

- Biodiesel can be used in the existing engines without any modifications and can be obtained from vegetable sources which does not contain any sulphur, aromatic hydrocarbons, metals or crude oil residues.
- Biodiesel is an oxygenated fuel; emissions of carbon monoxide and soot tend to reduce. Unlike fossil fuels, use of Biodiesel does not contribute to global warming as the CO_2 so produced absorbed by the plants. Thus in nature CO_2 is balanced.
- The Occupational Safety and Health Administration classify biodiesel as a non-flammable liquid and the use of biodiesel can extend the life span of diesel engines because it is more lubricating than petroleum diesel fuel.
- Biodiesel is mostly obtained from renewable vegetable oils or animal fats and hence it may improve the fuel or energy security and thus leading to economy independence.

1.1 Objective Of The Project

The main objective of the project was to ascertain which of these locally available vegetable oils is most suitable to replace diesel in CI engines and to perform the CFD analysis for fluid flow pattern. The project sought to establish the best blends that gave :

- Highest brake power.
- Highest thermal efficiency.
- Minimum brake specific fuel consumption of the engine
- Minimum smoke density

To achieve these objectives, a four stroke single cylinder CI engine with fixed throttle was run at variable loads with the blends of sunflower, coconut oil and diesel oil and the parameters to be observed are :

- Brake power,
- Fuel consumption rate,
- Smoke density,
- Thermal efficiency,
- Exhaust gas temperature.

2. PROJECT DESCRIPTION

Fuel and energy crisis are the concern of society for the depleting world's non-renewable energy resources which led to a renewed interest in the quest for alternative fuels. One of the most promising alternatives fuel is the vegetable oils and their derivatives. Biodiesel stands as an attractive source of alternative energy. By adopting and increasing the use of biodiesel, European countries have reduced from her over-dependence on crude oil reserves. The emissions produced from biodiesel are cleaner compared to petroleum based diesel fuel. Particulate emissions, soot, and carbon monoxide are lower since biodiesel is an oxygenated fuel. This project deals with two locally available but marginally utilized vegetable oils and their respective blends with diesel in CI engines. Two vegetable oils which have been selected are sunflower oil and coconut oil. These vegetable oils have been mixed with diesel in ratios B10, B20, B30 in a certain way by undergoing various processes in the Nehru college pharmacy laboratory. Then physical properties like flash point, fire point, kinematic viscosity, density has been found from the Nehru college mechanical department lab. Each blend has undergone engine test and their Brake power, Total fuel consumption, Specific fuel consumption, Brake thermal efficiency, Brake mean effective pressure, Volumetric efficiency are found and noted.

Engine test values of the blended vegetable oils are undergone a comparative analysis. Also along with engine test, emission analysis test is been carried out. Based on the comparative analysis and the emission analysis test carried out, the best blend fuel with better performance in overall and cause less pollution to the environment can be identified. This identified blend will have highest brake power, highest thermal efficiency, minimum brake specific fuel consumption of engine and minimum smoke density. The various production processes of biodiesel are listed below : -

A) Transesterification Process

This is the most commonly used method to reduce the viscosity of vegetable oils. In this process, triglyceride reacts with three molecules of alcohol in the presence of a catalyst producing a mixture of fatty acids, alkyl ester and glycerol. The process of removing all the glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called esterification. This esterified vegetable oil is called bio-diesel whose properties are similar to diesel fuel. Transesterification process substitute alcohol for the glycerine in a chemical reaction, using a catalyst.

B) Blends

Vegetable oil can be directly mixed with diesel fuel and may be used for running of an engine. The blending of vegetable oil with diesel fuel in different proportion were experimented successfully by various researchers. Blends of biodiesel and conventional hydrocarbon-based diesel are products most commonly distributed for use in the retail diesel fuel marketplace. Much of the world uses a system known as the "B" factor to state the amount of biodiesel in any fuel mix:

- 10% biodiesel, 90% diesel is labelled as B10.
- 20% biodiesel, 80% diesel is labelled as B20.
- 30% biodiesel, 70% diesel is labelled as B30.

C) Micro – emulsification

To solve the problem of high viscosity of vegetable oil, micro emulsions with solvents such as methanol, ethanol and butanol have been used. A micro emulsion is defined as the colloidal equilibrium dispersion of optically isotropic fluid microstructures with dimensions generally in the range of 1–150 nm formed spontaneously from two normally immiscible liquids and one or more ionic or non- ionic amphiphiles.

D) Cracking

Cracking is the process of conversion of one substance into another by means of heat or with the aid of catalyst. It involves heating in the absence of air or oxygen and cleavage of chemical bonds to yield small molecules. The pyrolyzed material can be vegetable oils, animal fats, natural fatty acids and methyl esters of fatty acids.

E) Materials used in Biodiesel Production

In the laboratory scale production of biodiesel from coconut oil, the following materials were used. 1 litre of coconut oil, 200 ml of methanol, 99% pure sodium hydroxide (NaOH) scales accurate to 0.1 grams. A reaction temperature of 65°C was selected as reaction temperature for the process must be below the boiling point of alcohol. Most researchers have used 0.1 to 1.2 % (by weight of oil) of catalyst for biodiesel production. 0.8% NaOH (by weight of coconut oil) concentration was therefore selected while 20% methanol was used.

F) Washing Method

Washing can be done in two steps. In the first step, collected biodiesel after transesterification reaction was taken into a beaker. Hot water (40°C) was poured into the biodiesel slowly. Then the mixtures were shaken slowly and the solution was kept 4 hours in stable position. Then a layer of soap has formed in the bottom of beaker. Then the biodiesel was collected by a pipe followed by siphoning method. The process had been repeated 4 times and gradually soap formation was reduced. The pH of the solution was also measured after each wash .This process is known as wet wash process. In other step, an air stone was used for producing bubbles in the solution for dry wash. Dry wash confirmed the formation of glycerol and soap rest in the mixture. A heater was used which had been kept always 35°C for removing the water from biodiesel. After the process finally the biodiesel was collect and its properties were tested in the laboratory.

G) Volume of Raw Materials needed for Biodiesel Preparation

a) Biodiesel made from extraction of coconut oil

Make up solution of biodiesel needed taken as 500 ml and in ratios B10, B20, B30.

- ❖ B10 – 50 ml esterified + 450 ml diesel + 5g cyclohexane.
- ❖ B20 – 100 ml esterified + 400 ml diesel + 5g cyclohexane.
- ❖ B30 – 150 ml esterified + 350 ml diesel + 5g cyclohexane.
- ❖ Total: - 300 ml esterified + 1200 ml diesel + 15g cyclohexane.
- ➢ For undergoing transesterification of coconut oil :-
- 500 ml coconut oil (pure) + 100 ml methanol + 4g NaOH pellets + 65°C + 2 hours.

b) Biodiesel made from extraction of Sunflower Oil

Make up solution of biodiesel needed taken as 500 ml and in ratios B10, B20, B30.

- ❖ B10 – 50 ml esterified + 450 ml diesel + 5g cyclohexane.
- ❖ B20 – 100 ml esterified + 400 ml diesel + 5g cyclohexane.
- ❖ B30 – 150 ml esterified + 350 ml diesel + 5g cyclohexane.
- ❖ Total : - 300 ml esterified + 1200 ml diesel + 15g cyclohexane.
- ➢ For undergoing transesterification of sunflower oil :-
- 500 ml sunflower oil (pure) + 100 ml methanol + 4g NaOH pellets + 65°C + 2 hours.

c) Biodiesel made from extraction Mixture of Sunflower Oil and Coconut Oil

Make up solution of bio diesel needed taken as 850 ml and in ratios B10, B20, B30.

- ❖ B10 – 85 ml esterified + 765 ml diesel + 12.75g cyclohexane.
- ❖ B20 – 170 ml esterified + 680 ml diesel + 12.75g cyclohexane.
- ❖ B30 – 255 ml esterified + 595 ml diesel + 12.75g cyclohexane.
- ❖ Total : - 510 ml esterified + 2040 ml diesel + 38.25g cyclohexane.
- ➢ For undergoing transesterification for the mixture of sunflower oil and coconut oil :-
- 600 ml + 120 ml methanol + 4.8g NaOH pellets + 2 hours + 65°C.

d) Total Amount of Raw Materials used for Biodiesel Preparation

- 800 ml coconut oil.
- 800 ml sunflower oil.
- 4440 ml diesel.
- 68.25g cyclohexane.
- 12.8g NaOH pellets.
- 320 ml methanol.

H) Engine Specification

Specification of engine in which engine test is carried out for biodiesel in GEC college Thrissur are given below:-

Table -2.1: Specification of Engine

Mitsubishi Kubota Diesel Engine	
Single cylinder, BHP - 5	Horizontal rpm – 1500
Rope Diameter – 762 mm	Stroke of the cylinder – 110 mm
Brake Drum Diameter – 300 mm	Bore of the cylinder – 80 mm

I) Components Used

- Magnetic Stirrer
- Stir Bars
- Catalyst (NaOH)

2.1 Preparation Procedure Of Biodiesel

The detailed procedure for preparation of alternative fuel biodiesel is listed below :-

a) Transesterification of Coconut Oil

1 litre beaker is taken and 500 ml coconut oil is poured into the beaker. This is the makeup solution. 100 ml methanol and 4g NaOH pellets are added to the beaker. Now this beaker is placed on a magnetic stirrer and stirrer bar is placed inside the beaker. Magnetic stirrer is made ON. The heater is adjusted so that we get a temperature of 65°C. The temperature is adjusted and maintained at 65°C and this can by done by checking the solution temperature using a thermometer. Care should be taken that thermometer tip should not go deep in the solution because the stirrer bar will be rotating at bottom and if touched at it cause damage to the thermometer. The rotation of stirrer bar is adjusted at frequent intervals that we get continuous rotation throughout the reaction. The reaction needs 120 minutes to complete. Stirrer bar must rotate continuously during 120 minutes only then thorough mixing take place. By the completion of 120 minutes we get 3 layers in the solution where biodiesel form a layer at bottom, ethanol at the middle and glycerine at the top. The mixture of solution in the beaker is allowed to settle, only then proper 3 layer formation can be seen. Glycerine can be removed by washing method and then ethanol can be removed by separation method. Thus we get biodiesel which has been extracted from coconut oil.

Fig -2.1: Three layer formation of biodiesel at bottom, ethanol at middle and glycerin at top.

b) Transesterification of Sunflower Oil

1 litre beaker is taken and 500 ml sunflower oil is poured into the beaker. This is the makeup solution. 100 ml methanol and 4g NaOH pellets are added to the beaker. Magnetic stirrer is made ON and same procedure is repeated as done in first case. We get 3 layer formation in the solution. Glycerine at top can be removed by washing method and then ethanol at middle can be removed by separation method. Thus we get biodiesel which has been extracted from sunflower oil.

c) Transesterification of Sunflower Oil and Coconut Oil (Mixture)

1 litre of beaker is taken, 300 ml of sunflower oil and 300 ml of coconut oil is added to the beaker which constitute 600 ml of the total solution. Then we add 120 ml methanol along with the addition of 4.8g of NaOH pellets to the solution. Now this beaker is placed on a magnetic stirrer and stirrer bar is placed inside the beaker. Magnetic stirrer is made ON and same procedure is repeated as done in first case. We get 3 layers of formation in the solution. Glycerine at the top can be removed by washing method and ethanol at the middle can be removed by separation method. Thus we get biodiesel which has been extracted from sunflower oil and coconut oil.

d) Blending Of Biodiesel Extracted From Coconut Oil

3types of blends have been planned to make . Letter C denote that biodiesel extracted from coconut oil. 3 blends made in the ratio are B10, B20, B30. From the makeup solution 50 ml esterified coconut oil is mixed with 450 ml diesel. Then cycloalkanes which are of 1% - 1.5% of total volume are added. So here cyclohexane of 1% that is 5g is added to the solution. Cyclohexane is added to improve the fuel properties. The solution obtained finally is named as C-B10. Similarly from the makeup solution 100 ml esterified coconut oil is mixed with 400 ml diesel and 5g of cyclohexane is added to it. The solution thus obtained is named as C-B20. Similarly from the makeup solution 150 ml esterified coconut oil is mixed with 350 ml diesel and 5g of cyclohexane is added to it. The solution obtained is named as C-B30.

e) Blending Of Biodiesel Extracted From Sunflower Oil

3types of blends have been planned to make. Letter S denote that biodiesel extracted from sunflower oil. 3 blends made in the ratio are B10, B20, B30. From the makeup solution 50 ml esterified sunflower oil is mixed with 450 ml diesel. Then cycloalkanes which are of 1% - 1.5% of total volume are added. So here cyclohexane of 1% that is 5g is added to the solution. Cyclohexane is added to improve the fuel properties. The solution obtained finally is named as S-B10. Similarly from the makeup solution 100 ml esterified sunflower oil is mixed with 400 ml diesel and 5g of cyclohexane is added to it. The solution thus obtained is named as S-B20. Similarly from the makeup solution 150 ml esterified sunflower oil is mixed with 350 ml diesel and 5g of cyclohexane is added to it. The solution obtained is named as S-B30.

f) Blending Of Biodiesel Extracted From The Mixture Of Sunflower Oil And Coconut Oil

3 types of blends have been planned to make. Letter C-S- denote that biodiesel extracted from the mixture of sunflower oil and coconut oil. 3 blends made in the ratio are B10, B20, B30. From the makeup solution, 85 ml of esterified mixture of coconut oil and sunflower oil is mixed with 765 ml of diesel and 1.5 % of cyclohexane that means 12.75 g of cyclohexane are added to the solution. Thus the solution obtained can be named as C-S-B10. From the makeup solution, 170 ml of esterified mixture of coconut oil and sunflower oil is mixed with 680 ml of diesel and 12.75 g of cyclohexane are added to the solution. Thus the solution obtained can be named as C-S-B20. From the makeup solution, 255 ml of esterified mixture of coconut oil and sunflower oil is mixed with 595 ml of diesel and 12.75 g of cyclohexane are added to the solution. Thus the solution obtained can be named as C-S-B30. Cyclohexane is added to improve the fuel properties.

2.2 Engine Test Calculations

Engine test is carried out in a single cylinder 4 stroke diesel engine with rope brake dynamometer. Various equations used for finding the properties of biodiesel during engine test are given below :-

1. Brake Power (B.P) = $\frac{2\pi NT}{60}$

   Where N – Speed in rpm.

   $T = (W - S) \times 9.81 \times r$

   S – Spring balance reading.

   r – Arm length in metre.

2. Total Fuel consumption (TFC) = $\frac{x \times 3600 \times \rho}{t \times 1000}$

   Where x – fuel consumption in cm.

   ρ – Density of fuel used.

   t – Time taken for 'x' cc fuel consumption.

3. Specific Fuel consumption (SFC) = $\frac{TFC}{BP}$

4. Indicated horse power (IP) = F.P + B.P

   Where F.P – Frictional Power noted from graph.

5. Brake thermal efficiency (BTE) = $\frac{B.P \times 3600 \times 100}{TFC \times Cv}$

   Where C_v – Calorific value of fuel.

6. Indicated Thermal efficiency (ITE) = $\frac{I.P \times 3600 \times 100}{TFC \times Cv}$

7. Mechanical efficiency (ME) = $\frac{B.P \times 100}{I.P}$

8. Brake Mean Effective pressure (BMEP) = $\frac{B.P \times 60 \times 2}{LAN}$

   Where L – Stroke of cylinder.

   A – Area of cylinder.

9. Indicated Mean Effective pressure (IMEP) = $\frac{I.P \times 60 \times 2}{LAN}$

10. Volumetric efficiency (VE) = $\frac{Qact \times 100}{Qth}$

    Where $Q_{act} = C_d \times a \times \sqrt{(2 \times g \times H)}$

    $Q_{th} = \frac{LAN}{60}$

    C_d – Coefficient of discharge = 0.62

a – Area of Orifice.

2.3 Values Of Engine Test Calculation

Based on the equations given above, engine test calculations were carried for the prepared 9 blends. These calculated values of prepared 9 blends are being tabulated in a table. Properties of blends were measured in nehru college, mechanical department, pampady, thrissur, kerala. The readings being tabulated in table are given below.

Table -2.2: Tested values of Flash point, Fire point, Kinematic viscosity, Density of the prepared 9 blends.

Items	Flash Point °C	Fire Point °C	Kinematic Viscosity (mm^2/s)	Density Kg/m^3
C – B10	75	81	1.968	790
C – B20	80	86	2.532	841.32
C – B30	85	92	3.243	910.42
S – B10	50	55	2.967	890
S – B20	55	59	3.536	923.17
S – B30	60	65	4.324	988.63
C – S – B10	62	70	1.965	787.14
C – S – B20	50	55	2.765	872.47
C – S – B30	75	80	3.876	948.53

Based on the comparative analysis carried out flash point, fire point, kinematic viscosity and density of prepared 9 blends comes in closer value to that of diesel. Diesel has a flash point of 52°C, and fire pint of 56°C. Kinematic viscosity of diesel is $2.7 mm^2/s$ and density is 810 Kg/m^3. Out of all 9 blends, blend C-S-B20 shows much closer value to diesel in terms of flash point, fire point, kinematic viscosity and density. Most compromising value of flash point, fire point, kinematic viscosity, density coming closer to the value of diesel is C-S-B20. Now we have to carry out engine test and emission test. Based on the engine test values and emission test values only we can be sure of predicting which all blends can be used as a replacement for diesel fuel. The engine test is carried out and the result is shown below.

Table -2.3: Engine load test Values

	B.P (Kw)	TFC Kg /h	SFC Kg/Kwh	BTE (%)
C-B10	0.81	0.355	0.44	19.49
C-B20	0.97	0.348	0.359	25.08
C-B30	1.29	0.345	0.267	35.52
S-B10	0.88	0.308	0.351	21.83
S-B20	1.11	0.305	0.275	26.72
S-B30	1.45	0.315	0.216	31.99
C-S-B10	1.27	0.236	0.186	37.98
C-S-B20	1.78	0.229	0.129	48.16
C-S-B30	1.69	0.255	0.151	42.54
DIESEL	0.83	0.351	0.422	19.37

Table -2.4: Engine load test Values

	BMEP N/m^2	VE (%)	F.P (Kw)	I.P (Kw)	ITE (%)
C-B10	116.9	30.6	1.8	2.61	62.89
C-B20	140.3	31.9	1.9	2.87	74.20
C-B30	187	33.1	2.5	3.79	104.2
S-B10	126.9	34.3	1.8	2.68	66.6
S-B20	160.3	37.7	2	3.11	74.9
S-B30	210.4	38.8	2.4	3.85	84.7
C-S-B10	183.7	40.3	2.3	3.57	106.7
C-S-B20	257.2	45.1	2.7	4.48	121.3
C-S-B30	243.8	43.7	2.75	4.44	111.9
DIESEL	120.2	31.2	1.8	2.63	61.3

Table -2.5: Engine load test Values

	ME (%)	C_v (Kj /Kg)	IMEP (N/m^2)
C-B10	30.997	42000	377.17
C-B20	33.805	40000	415
C-B30	34.102	38000	548.52
S-B10	32.783	47000	387.19
S-B20	35.669	49000	449.51
S-B30	37.751	52000	557.45
C-S-B10	35.586	51000	516.27
C-S-B20	39.717	58000	647.59
C-S-B30	38.014	56000	641.46
DIESEL	31.603	44000	380.51

In the case of engine test value readings of 9 blends, C-B10 has lower value of B.P, BTE, VE, M.E than that of diesel and the fuel consumption is also higher than that of diesel. So blend C-B10 cannot be used as a fuel for running the engine. Whereas all other 8 blends shows better value of performance in B.P, BTE, VE, M.E than that of diesel. Fuel consumption of these 8 blends are also very less than that of diesel. So these 8 blends namely C-B20, C-B30, S-B10, S-B20, S-B30, C-S-B10, C-S-B20, C-S-B30 can be used as a fuel instead of diesel for running of engine. Of all these 8 blends, based on comparative analysis carried out the best blend showing is C-S-B20 which exhibits better performance of values in all respects than diesel and other remaining 7 blends. So we can use C-S-B20 as an alternative fuel for diesel in running of engines.

Now to use C-S-B20 as an alternative fuel for diesel in engines the other factor to be considered is emission analysis. Based on the emission analysis only it could be completely sure about using C-S-B20 as an alternative fuel for diesel. In the emission analysis test, to be considered is the amount of emission of gases like CO, HC, CO_2, NO_x coming out from the vehicles and causing pollution to the environment. While using diesel as a fuel the emission values of the gasses are CO - 0.05 % volume, HC - 14 ppm volume, CO_2 - 1.7 % volume, NO_x - 85 ppm volume.

Table -2.6: Emission test values

	CO(% volume)	HC (ppm volume)	CO_2 (% volume)	NO_x (ppm volume)
C-B10	0.064	15	1.83	83
C-B20	0.082	15.8	2.1	80.2
C-B30	0.09	16.3	2.4	79.8
S-B10	0.05	14	1.9	82
S-B20	0.045	13.3	1.7	79.4
S-B30	0.04	12.9	1.65	76.6
C-S-B10	0.37	12.1	1.7	72.8
C-S-B20	0.02	11.4	1.45	65.3
C-S-B30	0.026	11.6	1.51	66.4
DIESEL	0.05	14	1.7	85

Based on the emission analysis test carried out it is found that those 8 blends of biodiesel considered, can be used as an alternative fuel to diesel by the comparative analysis, after undergoing emission test, readings prove that all of 8 blends cannot be used as a good alternative to diesel. Because some of the blends like C-B20, C-B30 their emission values are higher than that of diesel. S-B10 is having similar emission values to that of diesel whereas S-B20 is showing a slight lower value of emission than that of diesel but it is close to the emission values of diesel. So they cannot be used as an alternative. In the case of S-B30, C-S-B10 their HC, NO_x values are lower but CO_2 emission value is closer to that of diesel. So they cannot be used. Now C-S-B20 and C-S-B30 is showing considerable lower value of emission of gases than that of diesel and they both can be used as an alternative to diesel. Of these blends C-S-B20 showing the most least value of emission and thus C-S-B20 can be used as alternative to diesel in every aspects.

2.4 Performance Characteristic Graphs

Based on the tabulated values of prepared 9 blends, performance characteristic graphs are being plotted for better understanding of performance and analysis of prepared 9 blends when compared to diesel. Various performance characteristic graphs of blends are shown below :

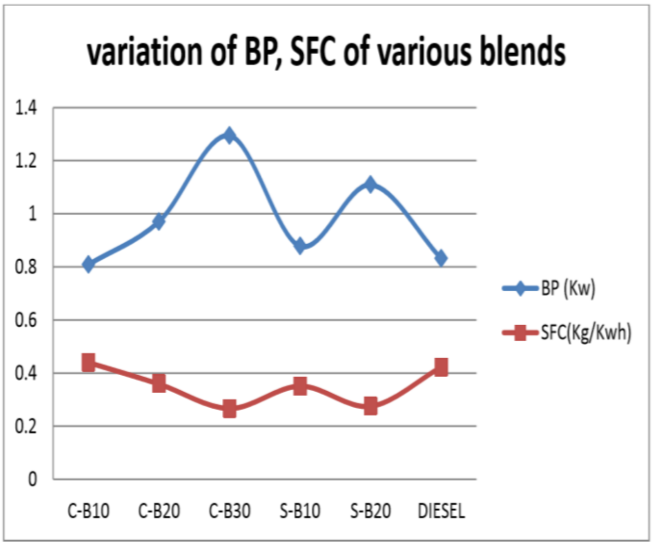

Chart -2.1: Variation of BP, SFC of various blends

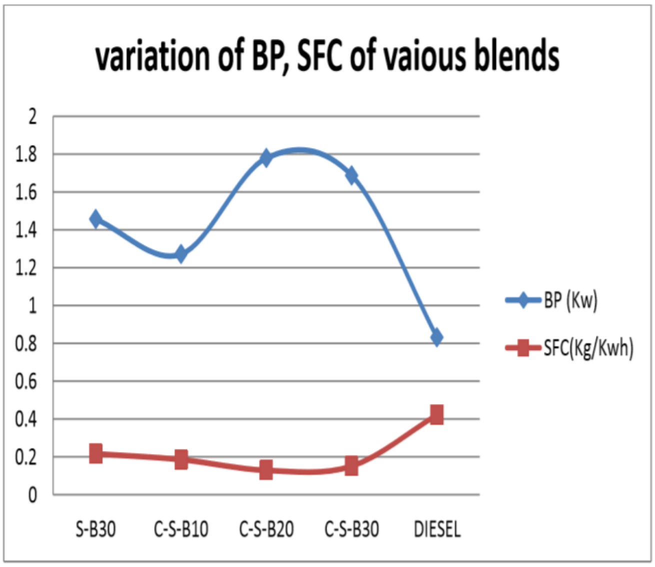

Chart -2.2: Variation of BP, SFC of various blends

By analysing of these graphs, it can be said that the best blend showing maximum BP, minimum SFC and can be used to replace diesel in every manner is C-S-B20.

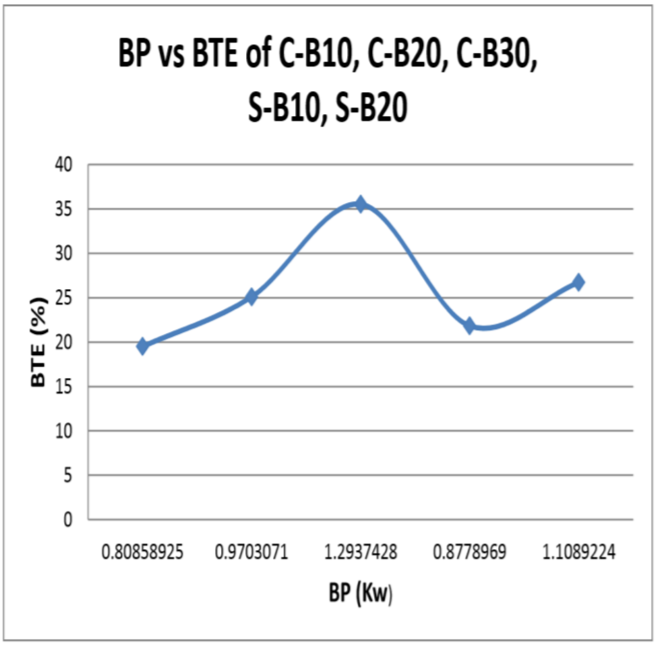

Chart -2.3: Graph for BP vs BTE of various blends

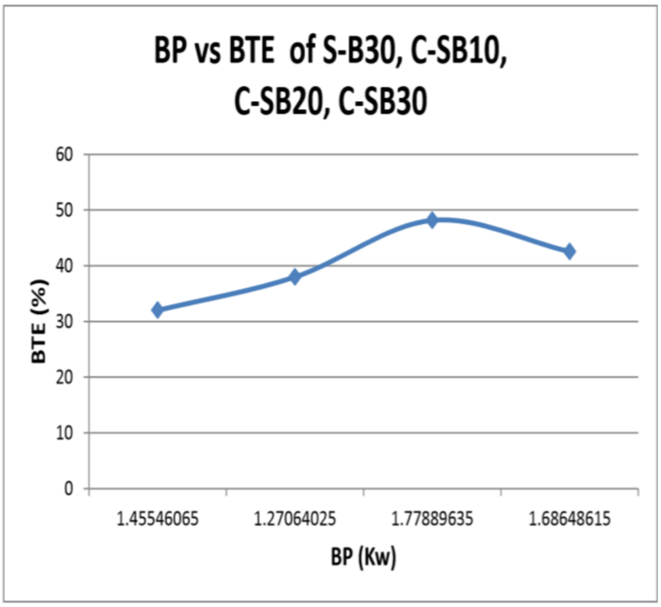

Chart -2.4: Graph for BP vs BTE of various blends

Based on the emission analysis test, the values being noted in the emission analysis table is used to draw the performance emission characteristic graphs. These emission performance characteristic graphs of various blends are given below :

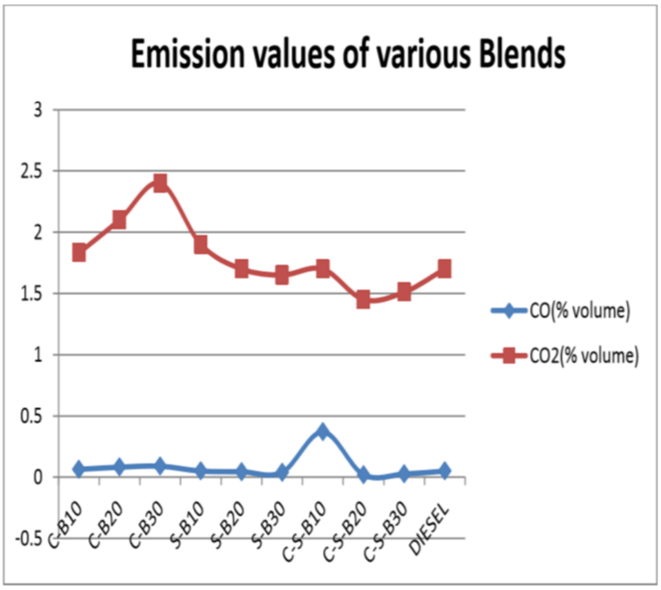

Chart -2.5: Emission test values of various blends

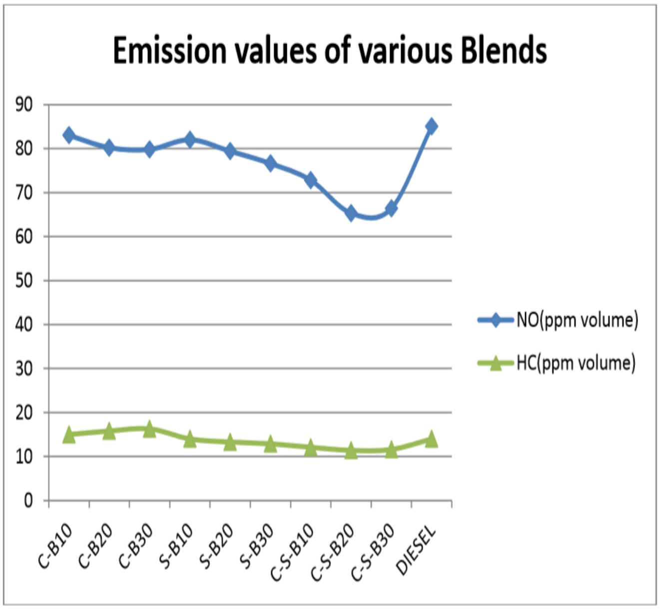

Chart -2.6: Emission test values of various blends

From the emission performance characteristic graphs it can be said that the best blend showing lowest emission of NO_x, HC, CO_2, CO gases to the atmosphere than the diesel is C-SB20. So a new blend fuel C-SB20 can be used as an alternative fuel for diesel because it gives highest brake power 1.78 Kw, highest brake thermal efficiency 48.16 %, lowest specific fuel consumption 0.129 Kg/Kwh, lowest emission of CO 0.02 % volume, lowest emission of HC 11.4 ppm volume, lowest emission of CO_2 1.45 % volume and lowest emission of NO_x 65.3 ppm volume whereas diesel gives only, brake power 0.83 Kw, brake thermal efficiency 19.37 %, specific fuel consumption 0.42 Kg/Kwh, emission of gases CO 0.05 % volume, HC 14 ppm volume, CO_2 1.7 % volume and NO_x 85 ppm volume. So in every aspects of property and other manner, diesel can be replaced by the blend C-SB20 and can be used as a fuel for running of engine.

3. RESULTS AND DISCUSSION

Experiment investigation is completed successfully and alternate fuel for diesel has been made. Total 9 blends have been made. They are three blends of biodiesel obtained from the extraction of coconut oil. They are C-B10, C-B20, C-B30. Three blends of biodiesel obtained from the extraction of sunflower oil. They are S-B10, S-B20, S-B30.Three blends of biodiesel obtained from the extraction of mixture of coconut oil and sunflower oil. They are C-S-B10, C-S-B20, C-S-B30. Cycloalkanes are added to the blended solution to improve the fuel properties. Variation in the amount of cycloalkanes added in the blended solution will result in variation in properties. Cycloalkanes of 1% or 1.5 % are added usually in blends. Each volume has unique characteristics and depending on that fuel properties vary.

Performance characteristics and combustion analysis of 9 blends are calculated. From the comparative study of engine test and emission analysis of all blends the best blend showing is C-S-B20 which exhibits best performance and least emission of gases. So by all means C-S-B20 can replace diesel.

4. CONCLUSION

Various blends of biodiesel has been prepared as an alternative fuel for diesel and the engine test was carried out. Among these 9 blends of biodiesel, blend showing better overall performance and less pollution to the environment is C–S–B20 which has highest brake power, highest thermal efficiency, highest mechanical efficiency, minimum brake specific fuel consumption and minimum smoke density. This experimental investigation is carried out for a sustainable development strategy in IC engine operation towards better performance, less economical optimization. With the concern for environment growing every day, the project carried out is not only relevant for the protection of our environment but also for our energy security. A new fuel C–S–B20 biodiesel blend can be used which can successfully replace diesel in every manner and cause less harm to the environment.

ACKNOWLEDGEMENT

Our endeavor stands incomplete without dedicating our gratitude to everyone who has contributed a lot towards the successful completion of our project work. First of all, we offer our sincere thanks to our parents for their valuable blessings. We are indebted to God Almighty for blessing us with his grace and thanking our endeavor to successful culmination. We would like to thank our guide, Prof. and **HoD Dr. G. Kalivarathan** for his guidance and thereby steering us to complete this project successfully. We also thank **Mr. Dipin D** and **Mr. Aby Kurian** for all his support to complete our project. We finally, thank all our friends and well-wishers who supported us directly and indirectly during our project work.

REFERENCES

1. Gaurav Dwivedi, Siddharth Jain, M.P. Sharma (2013) 'Diesel Engine Performance And Emission Analysis Using Biodiesel From Various Oil Sources – Review' – JMESCN, - ISSN : 2028-2508.

2. Sundarapandian S (2015) 'Theoretical Analysis Of The Performance And Emission Of Vegetable Oil Ester Operated C.I Engine For Various Injection Timing' - National Conference On Recent Trends And Developments In Sustainable Green Technologies (NCRTDSGT), - Page 308, ISSN: 0974-2115.

3. George Varghese, P Mohanan, Nithesh Naik (2015) 'The Effect Of Cyclo-Alkane Additives In Waste Cooking Oil B20 Fuel On A Single Cylinder DI Diesel Engine' - International Journal of Materials, Mechanics and Manufacturing, - Vol. 3, No. 1.

4. K Anbumani and Ajit Pal Singh (2010) 'Performance Of Mustard And Neem Oil Blends With Diesel Fuel In C.I. Engine' – ARPN Journal of Engineering and Applied Sciences, - VOL. 5, NO. 4, ISSN 1819-6608.

5. Nithyananda B S, Anand A, G V Naveen Prakash (2013) 'Experimental Investigation Of Neem And Mixed Pongamiacoconut Methyl Esters As Biodiesel On C.I Engine' - International Journal of Mechanical Engineering and Technology (IJMET), - Volume 4, Issue 4, ISSN 0976.

6. Oguntola J Alamu, Opeoluwa Dehinbo, Adedoyin M Sulaiman (2010) 'Production and Testing of Coconut Oil Biodiesel Fuel and its Blend' – Leonardo Journal of Sciences, - Issue 16, ISSN 1583-0233.

7. M. Canakci, J. H. Van Gerpen (2003) 'Comparison Of Engine Performance And Emissions For Petroleum Diesel Fuel, Yellow Grease Biodiesel, And Soybean Oil Biodiesel' - American Society of Agricultural Engineers, - Vol. 46, ISSN 0001–2351.

8. C. A. Harch, M. G. Rasul, N. M. S. Hassan, M. M. K. Bhuiya (2013) 'Modelling of Engine Performance Fuelled with Second Generation Biodiesel' - Procedia Engineering, - Vol. 90.

9. Abdullah Abuhabaya, John Fieldhouse, Rob Brown (2011) 'The Effects of Using Bio-diesel as Fuel on Compression Ignition (CI) Engine and Its Production from Vegetable Oils' - International Conference on Environmental, Biomedical and Biotechnology, - vol.16.

BIOGRAPHIES

1. Anurag K B pursuing B.Tech in mechanical engineering at Nehru College Of Engineering And Research Centre.

2. Akhil Prasad pursuing B.Tech in mechanical engineering at Nehru College Of Engineering And Research Centre.

3. Anoop K V pursuing B.Tech in mechanical engineering at Nehru College Of Engineering And Research Centre.

4. Abin Varghese pursuing B.Tech in mechanical engineering at Nehru College Of Engineering And Research Centre.

5. Anvar Sadath P pursuing B.Tech in mechanical engineering at Nehru College Of Engineering And Research Centre.

6. Dr. G. Kalivarathan, M.E, Ph.D., is working as Prof. and HoD in the department of mechanical Engineering of NCERC pampady, Kerala. He is specialized in Thermal engineering, having 23 years of teaching experience, received ISTE national award, SAE international award, CII best innovative award, NASA online contest award, Kerala government engineering design award, published 106 papers.