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"Performance Analysis of 4 Stroke Single Cylinder Diesel Engine Using Blend Of Soya Oil with Diesel"

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Abstract: *In current scenario, there are continuously increasing the number of automobiles and correspondingly increasing the fuel consumption as well as fuel prices. In this regard, biodiesel is found as an alternative fuel derived from natural fats or vegetable oils and it is considered as an attractive alternative to replace diesel fuel.*

In this work, biodiesel prepared from soya oil by Transesterification process with methyl alcohol. Processed soya oil is blended with diesel in different proportions as B-10, B-20, B-30, B-40 and B-50. Thermodynamic analysis of 4stroke single cylinder diesel engine, By using different blends of diesel & soya oil has been carried out the effect of B-10,B-20,B-30,B-40,B-50 on the Brake Power, Thermal Efficiency, Brake Specific Fuel Consumption and Total Fuel Consumption has been absorbed. The experimental result shows that at B-40, the optimum BTE (12.09), maximum BP (1.221) and minimum BSFC (0.694).

Key word: *Soybean oil, Transesterification Process, 4-stroke Diesel engine, Biodiesel Blends.*

I. Introduction

1.1 Background

The idea of using vegetable oil as fuel for diesel engines is not a new one. Rudolph Diesel used peanut oil as fuel in his engine at Paris Exposition of 1900 [4]. Inspite of the technical feasibility, vegetable oil as fuel could not get acceptance, as it was more expensive than petroleum fuels. Later various factors as stated earlier, renewed the interests of researchers in using vegetable oil as substitute fuel for diesel engines. In recent years, systematic efforts have been made by several researchers to use vegetable oils of Sunflower, Peanut, Soyabean, Rapeseed, Olive, Cottonseed, Jatropha, Pongamia, Rubber seed, Jojoba etc as alternate fuel for diesel. Many types of vegetable oils are edible in nature. Continuous use of them causes shortage of food supply and proves far expensive to be used as fuel at present. So far few types of non-edible vegetable oils have been tried on diesel engine leaving a lot of scope in this area. Testing of diesel engines with preheating, blending with diesel and blending with preheating improves the performance and reduces the emissions compared to neat vegetable oil [1].

Biodiesel is produced by Transesterification of oil, where one mole of oil is chemically reacted with three moles of an alcohol in presence of a catalyst. In this reversible reaction, the glycerol moiety of the triglyceride molecule is replaced with an alkali radical of the alcohol used, giving alkyl based monoesters.

Biodiesel has others advantages, compared to conventional diesel fuel, such as: portability, ready availability, renewability, biodegradability, lower sulphur content, higher cetane number, flash point, cloud point and cold filter plugging point [15]. Since biodiesel comes from a renewable energy source, its production and use as a replacement for fossil fuel provides three main benefits: reduces economic dependence on petroleum oil; decreases gas emissions that cause the greenhouse effect; and diminishes the proliferation of deceases caused by the pollution of the environment [3].

To ascertain the possibility of use of modified karanja oil as fuel for compression ignition engine the performance test were conducted. The comparison of the test fuels made with diesel fuel. Test fuels' performance analyzed for esters of karanja oil, blends of karanja oil, and the diesel oil as baseline at varying loads performed at governor controlled speed. The variations in the injection parameters were analyzed to observe its influence on the engine performance with different fuels [7]. Results show that diesel engine gives poor performance at lower Injection Pressure than, esterified karanja oil and its blends with diesel. Specific energy consumption is a more reliable parameter for comparison. A comparison of physical and fuel properties of vegetable oils with those of diesel fuel indicates that the vegetable oil are quite similar in nature to diesel fuel. However, vegetable oils have exceptionally high viscosity. After esterification of karanja oil, the specific gravity reduced to 0.895 at 280°C and for diesel at the same temperature was 0.84. The calorific value of esterified karanja oil found to be 36.76 MJ/kg, which is 17.95% lower than that of diesel. The specific Energy consumption is higher for pure karanja methyl ester as well as for its blends with diesel [5].

1.2 Objectives

The aim of this work is to evaluate the performance using different blends of biodiesel with pure diesel in a CI engine. The biodiesel is treated from the soyabean oil by Transesterification process. The following are the major objectives to fulfil the aim of this work.

1. Extraction of soya oil from soya seeds.
2. Determination of physical properties of soya oil and diesel.
3. Study of effect of dilution on properties of blending of soya oil with diesel.
4. Performance evaluation of Diesel engine using different blends of soya oil with diesel.

1.3 Biodiesel

Biodiesel is a non-petroleum based diesel fuel which consists of the mono alkyl esters of long Chain fatty acids derived from renewable lipid sources. Biodiesel is typically produced through the reaction of a vegetable oil or animal fat with methanol in the presence of a catalyst to yield glycerine and biodiesel (chemically called methyl esters). Biodiesel is registered with the US Environmental Protection Agency as a pure fuel or as a fueladditive and is a legal fuel for commerce. Biodiesel is an alternative fuel which can be used in neat form, or blended with petroleum diesel for use in compression ignition (diesel) engines. Its physical and chemical properties as it relates to operation of diesel engines are similar to petroleum based diesel fuel. The specification for biodiesel is approved by the American Standards for Testing and Materials (ASTM) under code number 6751.

Biodiesel is a domestically produced, renewable fuel that can be manufactured from new and used vegetable oils, animal fats, and recycled restaurant grease. Biodiesel's physical properties are similar to those of petroleum diesel, but the fuel significantly reduces greenhouse gas emissions and toxic air pollutants. It is a biodegradable and cleaner-burning alternative to petroleum diesel.

II. Literature Review

S. KIRANKUMAR [1] have presented an experimental investigates of the bio-diesel preparation from vegetable oil i.e. Soya oil by using the Trans esterification process. In the initial stage tests are to be conducted on the four stroke single cylinder direct ignition diesel engine and base line data is generated. Further in second stage the test was conducted on the same engine at same operating parameters by using the diesel blended with the soy esters with different blending ratios such as S10, S20, S30 and the performance parameters (Brake Thermal Efficiency, Brake Specific Fuel Consumption) and also emission parameters (CO, HC, NOx, CO2, unused oxygen and smoke density) are evaluated. Among all the blends S30 has shown the better performance in the parameters and also in the emissions. So S30 is taken as the optimum blend. Finally the performance and emission parameters obtained by the above test are compared with the base line data obtained earlier by using diesel.

Jiantong Song al.[2] have investigated the power and fuel economies performances of a diesel fuelled with soybean biodiesel Experimental results show that, compared with diesel fuel, with increase in the biodiesel in the blends, the brake power and torque and the brake specific energy consumption increase, the smoke density under free acceleration decreases except B10, the NO_x emissions increase. The trade-off relationship is clear between the NO_x and smoke densities when the diesel engine fuelled with different biodiesel percentage in the blends. From the trade-off relationship between NO_x and smoke density, the optimum blend ratio is B20 in the experimental study.

K. Dilip Kumar. al. [3] have of the engine performance and exhaust emission characteristics for various blends. Experiment set up was developed to carryout engine performance and emission characteristic studies on selected fuel blends at different load conditions. The present work has resulted in giving a good insight into the performance and emission characteristics of the C.I. engine using ethanol, biodiesel, diesel fuel blends. As fuel property point of view density and pour point of all the fuel blends are under the standard limits for diesel fuel. Heat of combustion of all blends is found to be lower than that of diesel fuel alone. D70B20E10 give lower CO and HC emission and slightly higher thermal efficiency than other blends

III. Experimentation

3.1 Transesterification

Trans-esterification also called alcoholysis is the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis. This process has been widely used to reduce the viscosity of triglycerides. The transesterification reaction is represented by the general equation, which is the key reaction for bio-diesel production.

RCOOR' + R"OH ⟶ RCOOR" + R'OH

If methanol is used in the above reaction, it is termed methanolysis. The reaction of triglyceride with methanol is represented by the general equation.

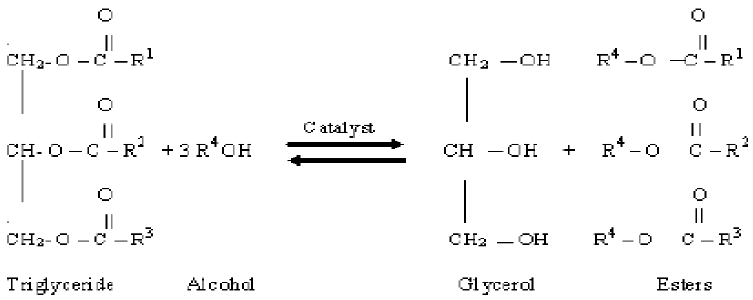

Fig.1 Flow diagram of preparation of bio-diesel

3.2 Contents of Biodiesel

- NaOH 150ml
- Methanol 250ml
- Soabean oil 1 lit.

3.3 Preparation of Bio-Diesel from Soya Oil

For the trans-esterification of mustard oil, Dr. Peeper's style has been followed in our work. First 250ml (90% pure) methanol was mixed with 150ml NaOH. This mixture was swirled in a glass container until NaOH is fully dissolved in methanol. As this is an exothermic reaction, so the mixture would get hot. This solution is known as methoxide, which is a powerful corrosive base and is harmful for human skin. So, safety precautions should be taken to avoid skin contamination during methoxide producing. Next, methoxide was added with I liter of mustard oil, which was preheated about 55 degree Celsius. Then the mixture was jerked for 5 minutes in a glass container. After that, the mixture was left for 24 hours for the separation of glycerol and ester. This mixture then gradually settles down in two distinctive layers. The upper more transparent layer is 100% bio-diesel and the lower concentrated layer is glycerol. The heavier layer is then removed either by gravity separation or with a centrifuge. In some cases if the soyabean oil contains impurities, then a thin white layer is formed in between the two layers. This thin layer composes soap and other impurities.

Figure1: crop of Soya Bean

3.4 Specification of Test Rig

1. ENGINE-The engine is water cooled single cylinder four stroke constant speed diesel engine 5 HP Make Kirloskar.

Figure 2: Engine

Table3.4.1: Engine Specifications

Sr. no.	Items	Specifications
1	Model	KIRLOSKAR, AV1
2	Compression ratio	19:1
3	Method of starting	Hand starting
4	Type, no. of cylinders	Vertical – 4 stroke, 1 cylinder
5	Bore x stroke(mm)	87.5x110
6	Cubic capacity	624
7	Maximum power	5 Hp
8	Nominal speed	1500 rpm
9	Cooling system	Water-cooled
10	Fuel filter	Present
11	Lube oil filter	Present

2. Rope Brake Dynamometer-A rope brake dynamometer is supplied with the engine coupled with the flywheel of engine.

3. Load indicator-It indicates the load in kg range 0-20 kg Make Harrison.

4. M.S. Base Frame-The engine and the dynamometer are mounted on a solid M.S. Channel Base Frame.

5. Instrumentation for measuring various inputs/outputs- All instrumentation is incorporated on a control panel. The various factors to be measured are as follows:

(a) Fuel measurement: This is done by using burette mounted on the control panel. The fuel tank is mounted on panel. The fuel is supplied to engine using fuel line to fuel injection system. The amount of fuel consumed is determined by the change in the readings shown on the burette. A three –way cock is used both to fill the burette and to allow the fuel to flow to the engine.

(b) Air flow measurement: Air flow is measured using an air box Orifice fixed in the inlet of air box. Suction pressure difference across the orifice is read on the U-tube manometer mounted on the panel. The outlet of the air suction box goes to the engine through the flexible hose for air suction.

(c) Temperature measurement: For heat balance analysis the PT-100 sensors are connected at exhaust gas calorimeter and engine cooling.

(d) Tachometer: It is measured the RPM of crank shaft

Figure 3: Tachometer

(e) Pensky Martins: This is used for measuring the flash point of biodiesel

Figure 4: Pensky Martins

(f) Stopwatch: It is used to measure the time when fuel is consumed in the engine

Figure 5: Stopwatch

(f) Pycnometer: It is used to measure the density of biodiesel & different blends

Figure 6: Pycnometer

3.5 Testing and inspection of experiment setup

After settling all the instruments, observation is about to start but before starting any experiment on the setup it is very necessary to inspect all the places where care should be taken to avoid any danger during the observation process. The step of inspection of experiment setup is completed by checking all the important places of experiment setup in a regular time interval during whole process of taking observation. The way of inspection is described here.

a. Tightening all nuts on foundation structure coupled with engine frame.
b. Checking the level of oil in the tank to maintain proper level of oil on burette.
c. Checking the level of cooling water in water jacket.
d. Checking the leak points of oil in various gate valves where pipes are connected
e. Insure all switches kept off in electrical load panel before starting the engine.
f. Check and control speed of engine by adjusting the fuel supply before taking the observation.

3.6 Measurement of required variables in different locations-

3.6.1 Measurement of fuel consumption

Experiment starts from first step of measurement of fuel consumption by filling the fuel in the burette. As the fuel is filled in the burette time is started in the stop watch from 0 to 20 ml fuel consumed in the burette. In this way fuel consumption in terms of ml/sec in noted from no load to maximum load (2 to 10 Kg). Same process is repeated for number of observations taken at different load condition.

3.6.2 Measurement of engine shaft speed-

Speed of the engine is measured in terms shaft speed as RPM (Revolution per minute). In the experiment speed of flywheel is measured which is mounted on crank shaft. For measuring the speed of flywheel a digital tachometer is used which is directly subjected to the rotating flywheel. A small reflecting strip is attached to outer side of the flywheel which reflects red rays coming from digital tachometer and counts the number of revolutions per minute of the flywheel. Hence the speed of crank shaft is estimated.

Abbreviations:

T_1=Exhaust gas temperature at inlet of the calorimeter
T_2=Exhaust gas temperature at outlet of the calorimeter
T_3=Temperature of water at the inlet of calorimeter
T_4=Temperature of water at the outlet of calorimeter
T_5=Temperature of water at the inlet of engine housing
T_6=Temperature of water at the outlet of engine housing

IV. Calculation

The basic performance parameters that were determined for performance evaluation of engine are:

- Brake Power
- Brake thermal efficiency
- Brake specific fuel consumption
- Total fuel consumption

Various formulae that were used for performance evaluation are listed below:

The brake power is calculated by measuring load on dynamometer and engine speed and then putting these values in,

$$BP = \frac{(W-s)\times\pi(D+d)N}{60\times1000}\ KW \text{----- (i)}$$

Where,

D =Dia. of drum = 340mm
d =Dia. of rope = 20mm
W =Weight applied on spring balance
(W-S) =Net load reading
N =rpm of Crank Shaft

C.V. of diesel = 44000kJ/Kg[1]
C.V. of Biodiesel = 38400 kJ/Kg[1]

The fuel consumption rate is noted for each loading and then brake specific fuel consumption is calculated as,

$$BSFC = \frac{TFC}{BP} \times 3600\ \ kg/kw\text{-}hr \text{ ---- (ii)}$$

The brake thermal efficiency of the engine is calculated as,

$$BTE = \frac{BP}{TFC\times CV} \times 100 \qquad \text{------- (iii)}$$

Total fuel consumption,

$$TFC = \frac{cc(ml)}{time} \times \frac{(specific gravity)}{1000}\ kg/_{sec} \text{ ---- (iv)}$$

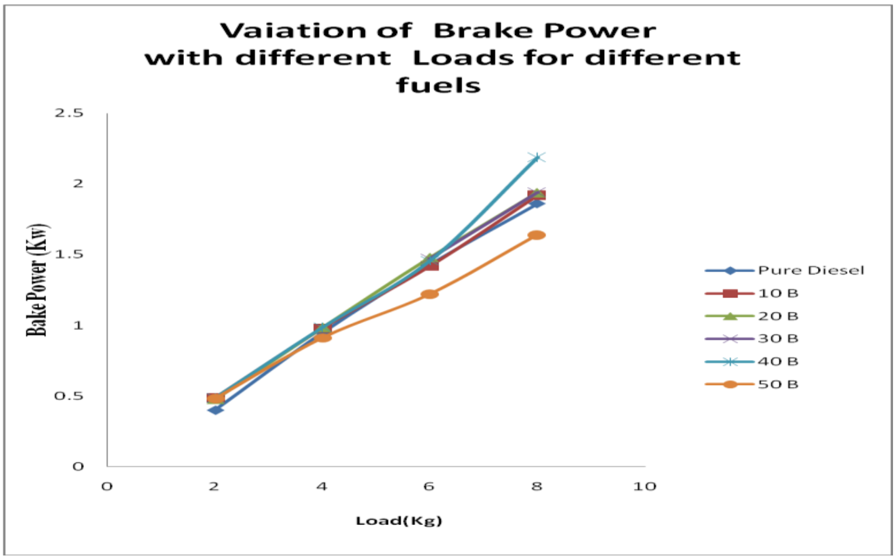

Figure 4.1: Variation of Brake Power with Different loads for different fuels

FIGURE 4.1, Depicts the variation in BP with Different loads for different blends. From the curve it is observed the BP is increasing from B10 to B40, after that as blending ratio increases, decrease in the BP, So that the maximum BP achieved at B 40.

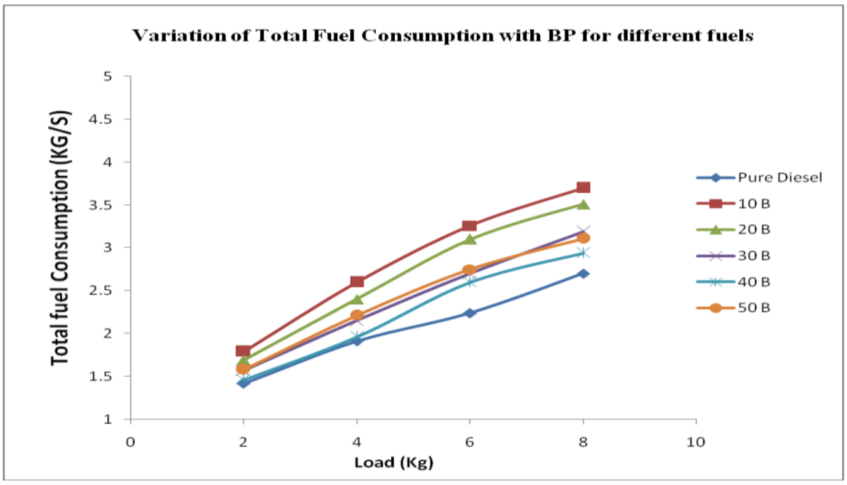

Figure 4.2: Variation of Total Fuel Consumption with different loads for different blends

FIGURE 4.2, Depicts the variation in total fuel consumption with different loads for different blends. From the curve it is observed that Total Fuel Consumption decreases from B10 to B40, after that as blending ratio increases, increase in the total fuel consumption.

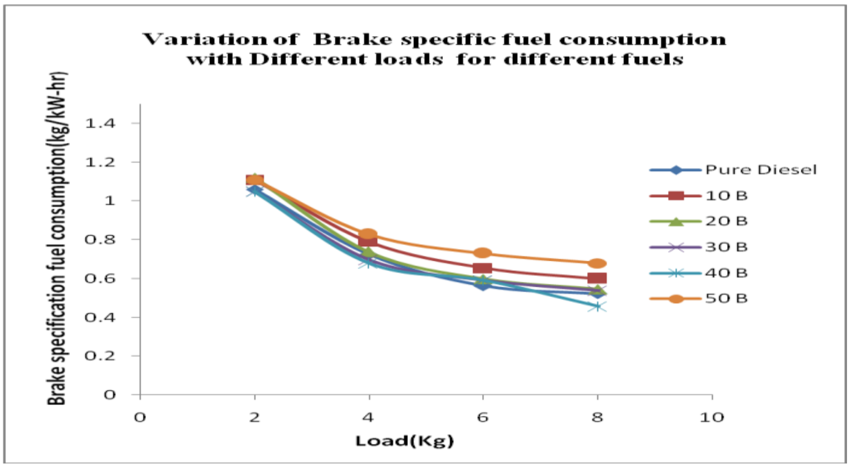

Figure 4.3: Variation of Brake specific fuel consumption with Different loads for different fuels

FIGURE 4.3, Depicts the variation in Brake specific fuel consumption with Different loads for different fuels. From the curve it is observed that the Brake specific fuel consumption decreases from B10 to B40, after that as the blending ratio increases, increase in the Brake specific fuel consumption.

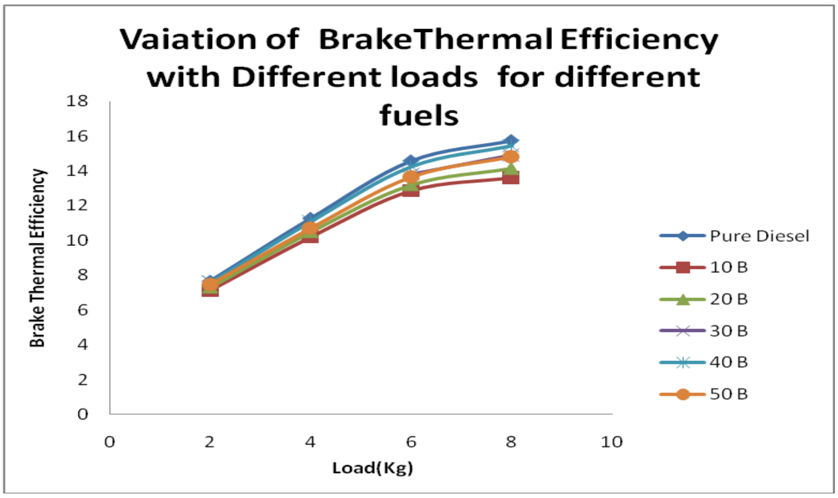

Figure 4.4: Variation of Brake Thermal Efficiency with Different loads for different fuels

FIGURE 4.4, Depicts the variation in Brake thermal efficiency with Different loads for different fuels. From the curve it is observed that the Brake thermal efficiency increases from B10 to B40, after that as blending ratio increases, decrease in the Brake thermal efficiency.

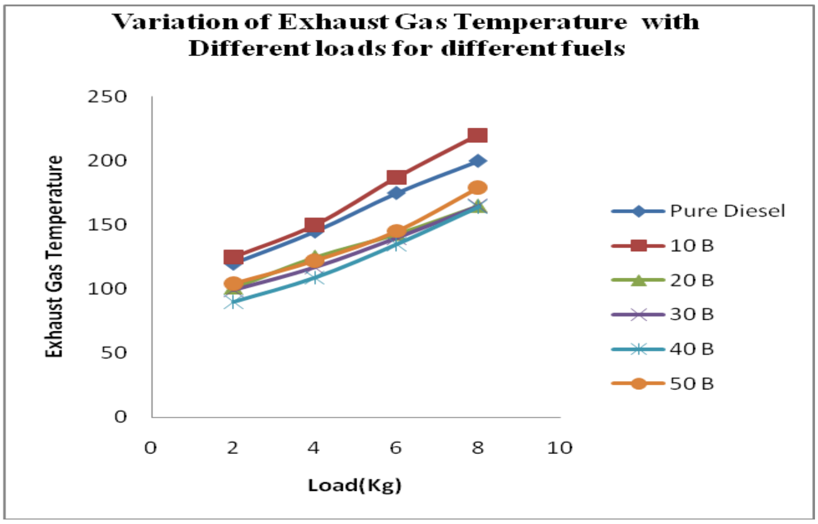

Figure 4.5: Variation of Exhaust gas temperature with Different loads for different Blends

FIGURE 4.5, Depicts the variation in Exhaust gas temperature with Different loads for different fuels. From the curve it is observed that the Exhaust gas temperature decreases from B10 to B40, after that as blending ratio increases, increase in the Exhaust gas temperature.

4.1 Performance Analysis

Table 4.1.1: Performance Analysis for calorific values of different composition of blends

Vegetable oil Blend	Calorific Value (KJ/kg)
Pure Diesel	44000
10 B	38400
20 B	40890
30 B	40480
40 B	39970
50 B	39540

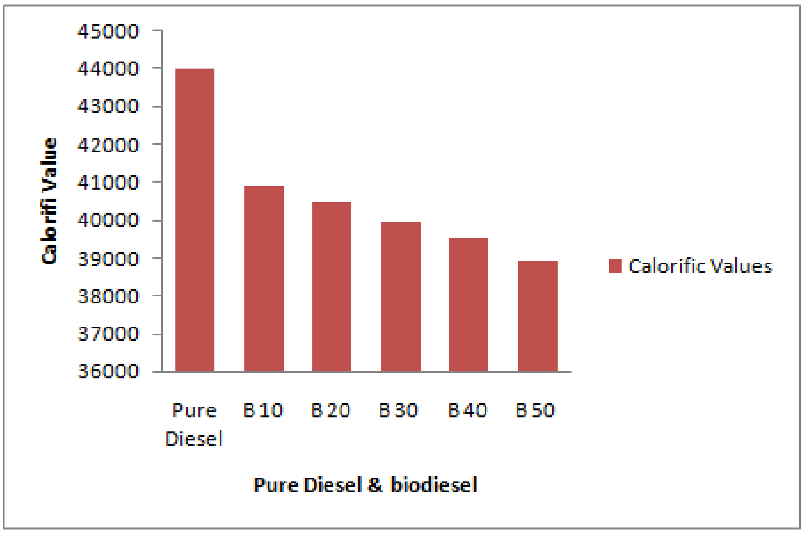

Figure 4.6 Graphical representation of Calorific value of different fuel

RUNNING COSTOF ENGINEWITH DIFFERENT BLENDS

Fuel	Cost (Rs./lr.)
Diesel	63.01
Biodiesel	70.22
B10	63.7
B20	64.4
B30	65.1
B40	65.8
B50	65.5

V. Conclusion

Biodiesel is an alternating fuel, currently available in tremendous amount in the form of human producible domestic natural sources. There are many edible oils, such as palm oil, Ghee, neem oil, caster, sunflower oil, coconut oil, mustered oil and soya bean oil etc. These varieties of bio lipids can be used to produce biodiesel. These types of alternative source of energy can helpful in future as a working fluid for conversion of energy.

In the above experimental work different blends of soya bean tranesterified oil (TES) with diesel such as B10, B20, B30, B40 and B50 used as an alternative fuel and investigated different performance parameter such as Brake Thermal Efficiency (BTE), Brake Power (BP), Total Fuel Consumption (TFC) and Brake Specific Fuel consumption (BSFC) at different load. . From the first set of results it can be conclude that the blend B40 has given the performance near to diesel in the sense of brake thermal efficiency, brake specific fuel consumption, Brake Power and Total fuel consumption. Conclusions extracted from the investigation are as follows:-

- Soya bean oil is transesterified in the presence of methyl alcohol. By this process physical property of soya oil has been changed as in table no.
- It has been observed that Brake Power increases from B10 to B40, further increase in blend ratio, decreases the BP. So that the maximum BP achieved at B 40.
- It has been observed that Total Fuel Consumption decreases from B10 to B40, further increase in blend ratio, increases the total fuel consumption. So that minimum TFC achieved at B40.
- It has been observed that the Brake specific fuel consumption decreases from B10 to B40, further increase in blend ratio, increases the BSFC. So that minimum BSFC achieved at B40.
- It has been observed that brake thermal efficiency increases from B10 to B 40, further increase in blend ratio, decreases the BTE. So that the maximum BTE achieved at B40.
- It has been observed that exhaust gas temperature decreases from B10 to B 40, further increase in blend ratio, increases the exhaust gas temperature which is lower than the diesel exhaust gas temperature. This concluded that the TES at B40 giving less emission in the environment as compared to Diesel.

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APENDIX

Table 1: PROPERTIES OF DIESEL, BIODIESEL AND ITS BLENDS

Fuel	Density(Kg/m^3)	Calorific value(KJ/Kg)	Flash Point(^{0}C)	Fire Point(^{0}C)
Diesel	830	44000	60	62
Biodiesel	856	38400	156	158
B 10	833.50	40890	58	64
B 20	835.20	40480	62	67
B 30	837.80	39970	64	70
B 40	840.40	39540	66	73
B 50	843	38940	68	76

Table 2: Data obtained From Experimental Setup Using Pure Diesel

Sr. No.	LOAD W(kg)	Spring Load (kg)	N (RPM)	FUEL (ml)	TIME (sec)	T_1 (^{O}C)	T_2 (^{O}C)	T_3 (^{O}C)	T_4 (^{O}C)	T_5 (^{O}C)	T_6 (^{O}C)
1.	2	0.2	1466	20	117	100	57	28	30	28	38
2.	4	0.4	1464	20	87	124	66	28	30	28	40
3.	6	0.6	1454	20	78	159	80	28	31	28	41
4.	8	0.9	1444	20	57	191	94	28	32	28	43
5.	10	2.4	1432	20	50	228	109	28	33	28	46

Table 3: Data obtained From Experimental Setup Using B 10

Sr. No.	LOAD W(kg)	SPRING LOAD (kg)	N (RPM)	FUEL (ml)	TIME (sec)	T_1 (^{O}C)	T_2 (^{O}C)	T_3 (^{O}C)	T_4 (^{O}C)	T_5 (^{O}C)	T_6 (^{O}C)
1.	2	0.1	1464	20	109	138	55	18	20	19	32
2.	4	0.2	1450	20	77	157	62	19	22	19	35
3.	6	0.4	1442	20	64	192	72	20	23	20	40
4.	8	0.6	1430	20	52	232	84	20	24	20	50
5.	10	0.8	1422	20	40	260	92	20	24	20	54

Table 4: Data obtained From Experimental Setup Using B 20

Sr. No.	LOAD W(kg)	SPRING LOAD (kg)	N (RPM)	FUEL (ml)	TIME (sec)	T_1 (^OC)	T_2 (^OC)	T_3 (^OC)	T_4 (^OC)	T_5 (^OC)	T_6 (^OC)
1.	2	0.2	1470	20	113	101	50	19	21	19	30
2.	4	0.4	1460	20	83	125	56	20	22	20	32
3.	6	0.5	1450	20	67	143	61	20	22	20	35
4.	8	0.6	1438	20	56	165	68	20	23	20	36
5.	10	0.8	1428	20	50	184	75	20	24	20	38

Table 5: Data obtained From Experimental Setup Using B 30

Sr. No.	LOAD W(kg)	SPRING LOAD (kg)	N (RPM)	FUEL (ml)	TIME (sec)	T_1 (^OC)	T_2 (^OC)	T_3 (^OC)	T_4 (^OC)	T_5 (^OC)	T_6 (^OC)
1.	2	0.2	1472	20	117	108	50	21	23	21	35
2.	4	0.3	1464	20	86	124	55	21	23	21	35
3.	6	0.4	1448	20	69	148	65	21	24	21	37
4.	8	0.6	1438	20	57	179	75	21	26	21	39
5.	10	1.2	1410	20	48	205	85	21	27	21	42

Table 6: Data obtained From Experimental Setup Using B 40

Sr. No.	LOAD W(kg)	SPRING LOAD (kg)	N (RPM)	FUEL (ml)	TIME (sec)	T_1 (^OC)	T_2 (^OC)	T_3 (^OC)	T_4 (^OC)	T_5 (^OC)	T_6 (^OC)
1.	2	0.2	1474	20	118	90	43	19	21	20	31
2.	4	0.3	1460	20	90	109	50	19	22	20	33
3.	6	0.5	1457	20	70	135	60	19	23	20	36
4.	8	1.2	1436	20	60	164	70	20	24	20	40
5.	10	1.6	1410	20	54	190	85	20	24	20	44

Table 7: Data obtained From Experimental Setup Using B 50

Sr. No.	LOADW (kg)	SPRING LOAD (kg)	N (RPM)	FUEL (ml)	TIME (sec)	T_1 (^OC)	T_2 (^OC)	T_3 (^OC)	T_4 (^OC)	T_5 (^OC)	T_6 (^OC)
1.	2	0.2	1462	20	113	104	53	24	26	24	34
2.	4	0.6	1464	20	80	122	59	24	36	24	38
3.	6	1.4	1460	20	67	145	68	24	27	24	40
4.	8	1.8	1452	20	54	179	81	24	27	24	44
5.	10	2.4	1448	20	50	197	87	24	28	24	45

Table 8: Brake Power& different Loads of Different blending ratio with Diesel

	Diesel	B-10	B-20	B-30	B-40	B-50
Load (kg)	**BP (kW)**	**BP (kW)**	**BP (kW)**	**BP (kW)**	**BP (kW)**	**BP (kW)**
2	0.4	0.483	0.474	0.483	0.483	0.479
4	0.948	0.978	0.984	0.99	0.984	0.91
6	1.43	1.419	1.479	1.47	1.457	1.22
8	1.86	1.92	1.939	1.94	1.96	1.64

Table 9: Total Fuel Consumption &Different loads for Different blending Ratio with Diesel

	Diesel	B-10	B-20	B-30	B-40	B-50
Load (Kg)	**TFC kg/s**	**TFC kg/s**	**TFC kg/s**	**TFC kg/s**	**TFC kg/s**	**TFC kg/s**
2	1.42	1.52	1.48	1.42	1.42	1.48
4	1.92	2.15	2.02	1.92	1.86	2.1
6	2.24	2.58	2.46	2.42	2.4	2.48
8	2.7	3.2	2.94	2.9	2.78	3.1

Table 10: BSFC & Different loads of different blending ratio with Diesel

	Diesel	B-10	B-20	B-30	B-40	B-50
Load(kg)	**BSFC (kg/kW-hr)**	**BSFC (kg/kW-hr)**	**BSFC (kg/kW-hr)**	**BSFC (kg/kW-hr)**	**BSFC (kg/kW-hr)**	**BSFC (kg/kW-hr)**
2	1.06	1.11	1.12	1.05	1.05	1.11
4	0.725	0.791	0.791	0.698	0.680	0.83
6	0.563	0.654	0.599	0.592	0.592	0.73
8	0.522	0.6	0.545	0.538	0.457	0.680

Table 11: BTE &Different loads of different blending ratio with Diesel

	Diesel	B-10	B-20	B-30	B-40	B-50
Load (Kg)	**BTE**	**BTE**	**BTE**	**BTE**	**BTE**	**BTE**
2	7.68	7.15	7.3	7.48	7.59	7.47
4	11.28	10.20	10.50	10.75	11.10	10.70
6	14.58	12.85	13.20	13.80	14.25	13.65
8	15.74	13.60	14.15	14.90	15.45	14.82

Table 12: Exhaust Gas Temperatures &Different loads of different blending ratio with Diesel

	Diesel	B-10	B-20	B-30	B-40	B-50
Load(Kg)	Temperature (°C)	Temperature (°C)	Temperature (°C)	Temperature (°C)	Temperature (°C)	Temperature (°C)
2	120	125	101	99	90	104
4	145	150	125	117	109	122
6	175	187	143	140	135	145
8	200	220	165	165	164	179