SYNTHESIS AND ANALYSIS OF BIODIESEL FROM VEGETABLE OILS

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ABSTRACT

Today in this fast developing World the need of various transportation system is increasing day by day, in the result of this Number of vehicles and engine are increasing, but the conventional fuel used in the vehicles (like diesel and petrol) are limited and decreasing gradually with time. So there is a requirement of various means to drive these vehicles without a heavy modification in the engine of these vehicles. This situation leads to requirement of alternative fuels for engines. Bio- diesel is the best substitute of the Diesel in the Diesel Engine. Vegetables oil is the best alternative fuel. The main advantage of vegetable oil over the conventional fuel (as diesel in the diesel engine) is of reducing the cost and able to reduce net CO2 and CO emissions to atmosphere due to their agricultural origin. The main objective of this project is to prepare the bio diesel from sun flower vegetable oil and for reduction of exhaust emissions by using bio diesel as blend with diesel in single cylinder diesel engine. In this work different percentage of bio diesel consider as a blends for diesel. From this work it is found that emissions reduce with increase in percentage of additive and increase in thermal efficiency.

KEYWORDS- *Biodiesel, Alternate Fuels, Vegetable Oils.*

I. INTRODUCTION

1.1 What is BIO-DIESEL?

Biodiesel is a domestic, renewable fuel for diesel engines derived from natural oils like vegetables oils. Biodiesel can be used in any concentration with petroleum based diesel fuel in existing diesel engines with little or no modification. Biodiesel is not the same thing as raw vegetables oils. It is produced by a chemical process which removes the glycerol from vegetable oil. Chemically, it is a fuel a mix of monoalkyl esters of long chain fatty acids. A lipid trans-esterification production process is used to convert the base oil to the desired esters and remove free fatty acids. After this processing, unlike straight vegetable oils, biodiesel has very similar uses. However, it is most often used as an additive to petroleum diesel, improving the otherwise low lubricity of pure ultra-low sulpur petro-diesel fuel. It is one of the possible candidates to replace fossil fuels as the worlds primary transport energy source, because it is a renewable fuel that can replace petro-diesel in current engines and can be transported and sold using today's infrastructure.
Biodiesel is typically produced by a reaction of vegetable oil or animal fat with an alcohol such as methanol or ethanol in the presence of a catalyst (acidic or basic) to yield mono-alkyl esters and glycerol, which is removed.

1.2 Objective of the Project

The project aims at designing and fabricating equipment for the synthesis of esters (bio-diesels) from vegetable oils. The project can be split into five stages. These are:

- Design of the equipment: The equipment needs to be flexible in nature. It must be able to accommodate a variety of oils and alcohols. Also, the 2 critical components of design are the stirring mechanism and heating mechanism. Vigorous stirring is required. The temperature needs to be maintained at the required temperature after heating it to the same.

- Fabrication of the equipment: The equipment fabrication is done according to the specification in the design stage. The material is procured and fabrication it to the same.
- Fuel production: This involves determining the stoichiometric ratio in which the reactants need to be mixed in order to get bio-diesel. Also, the reaction can be carried according to certain optimum conditions which yield the best results.
- Characterization: Fuel characterization includes finding the following properties: flash point, fire point, viscosity, density, cloud/pour point and Cetane number.
- Testing: This stage deals with testing the bio-diesel obtained from the reactor in engines so that the performance and emission characteristics can be obtained. The bio-diesel is blended with diesel and tested.

II. PRODUCTION

2.1 Steps for Production of BIO-DIESEL

- Weight 6 kg of vegetable oil (refined sunflower oil) and pour it into the reactor for preliminary heating to temperature of about 60-70°C.
- In separate container, dissolve 22.8grams of NaOH (3.8grams per liter of oil, got by 3.5grams stoichiometric equivalent and 0.3grams for neutralizing FFA) in 1.2L methanol (200ml per liter of oil) add the NaOH slowly. This combined mixture makes sodium methoxide.
- Add this to the vegetable oil. Provide rigorous mixing with the use of a stirrer.
- The cloudy looking free fatty acids, called glycerine, will sink to the bottom and the methyl ester- a translucent liquid, will remain on top.
- When the separation appears not to be advancing any more, stop mixing.
- Let the mixture settle overnight. Meanwhile another batch can be started as the reactor is not being used.
- The liquid on top is methyl ester, but before using it any remaining soaps or salts which could cause engine damage have to be removed.
- The glycerin which has sunk to the bottom can be used in production of cosmetics

2.2 Observation for Production of BIO-DIESEL

- The optimum condition for the reaction was found to be the following: for every liter of oil used, 200ml of methanol needed to be used.
- The optimum temperature for the reaction was identified to be in the range of 53°C to 58°C for methanol.
- Vigorous stirring and heating is of paramount importance for better conversion efficiency.
- The ideal time for the completion of reaction is around 3-4hrs.
- Reaction with ethanol is difficult unless 2 conditions are met – a) Requirement of anhydrous ethanol and b) Requirement of closed system to prevent ethanol from absorbing water.
- The FFA content of oil needs to be determined and appropriate quantity of Lye needs to be added in order to neutralize excess acid. This excess acid is present when the oil gets heated.
- Care must be taken to prevent the process of saponification from occurring. This can be ensured by proper heating and stirring.
- About 4.5 Liters of Biodiesel has been obtained for an input quantity of 6L oil.

2.3 Production of BIODIESEL

Fig: 1 Vegetable oil

Fig:2 After First wash

Fig:3 After Second wash

Fig:4 Pure Biodiesel

III. EXPERIMENTAL SETUP

3.1 Description

Four stroke single cylinder diesel engine is connected to the rope brake dynamo meter with the help of coupling and mounted on the rigid frame, digital RPM indicator, U-tube manometer, air filter, fuel measuring tube. And gas analyzer is also arranged.

- Four-stroke engine mounted on a test rig
- Rope brake dynamometer
- Solex fuel injector
- Throttle control mechanism
- Crypt on (290) gas analyzer
- Gasoline-alcohol fuel tank

3.2 Four-Stroke Engine

A four-stroke, single cylinder, stationary diesel engine, of specification given in appendix was used for the testing purposes. It was rigidly mounted on the test rig with air and fuel intake lines. The inlet manifold of the engine was suitably modified to handle alcohol bi-fuel mode.

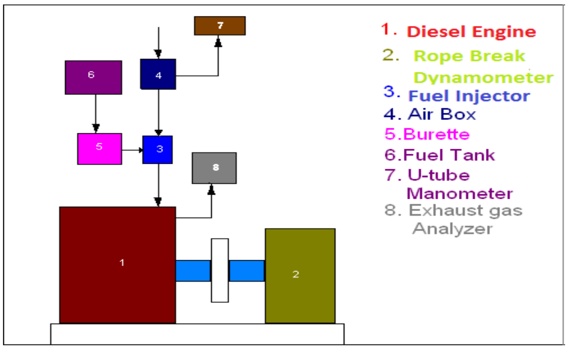


Fig :5 Experimental Setup

IV. TEST PROCEDURE, FORMULAE AND TABULATIONS

4.1 Test Procedure

1. The engine was started in neat petrol mode at no load condition.
2. The engine speed, time for 10 cc petrol consumption, exhaust temperature and Exhaust Gas analyzer values were noted
3. The above steps were repeated for 0 kg, 2kg, 4 kg, 6 kg, 8 kg and full load conditions.
4. The bio-diesel and diesel fuel substitutions are enter into the fuel tank substitution percentages are 20%,40%, 60%,80%and 100%
5. First enter the bio-diesel of 20% blended with diesel.
6. The engine speed, time for 10cc petrol consumption, exhausts temperature and Exhaust Gas Analyzer values were noted.
7. The process was repeated at no load, 2 kg, 4 kg and so on.
8. The similar procedure was followed for 40%, 60%, 80%,and 100% bio-diesel and diesel blends.
9. All the observations for the various kgs of substitutions and for the various loads were tabulated and the efficiency obtained in each case was calculated.
10. The values of efficiency exhaust temperature, total fuel consumption and, emissions were compared for bio-diesel and diesel fuels 20%, 40%, 60%,80% and 100% blends of diesel conditions.

4.2 Formulas

1. Mass of fuel consumption (m_f) =C.C/time * (S/1000) *3600
   Where
   S= Specific gravity of fuel
   C.C = fuel consumption in sec.
2. Brake power (B.P) = $2\pi NT$ / (60 x 1000) kW
   Where
   N= speed of the engine in rpm
   T = torque in n-m
   T= R*W*9.81

R = distance. From the centre of dynamometer shaft to center of the spring balance=0.32 m,
W=spring balance reading in kg.f

3. Frictional power (F.P) from the graph B.P Vs M_f
4. Indicated power (I.P) =B.P+F.P
5. Specific fuel consumption (SFC) = M_f /B.P kg/kw-hr
6. Mechanical efficiency (η_m) = B.P/I.P*100.
7. Brake thermal efficiency (η_{bt}) = B.P/ (M_f * C.V) *100.

Where B.P=brake power in kW
C.V= [(percentage of diesel substitution x diesel calorific value) +(Percentage of blend substitution x bio diesel calorific value)]
C.V for biodiesel=40054kj/kg
C.V for diesel = 44000 kj/kg

8. Indicated thermal efficiency ($\eta_{m)}$ =I.P/ (M_f * C.V)*100.

Density = [(percentage of petrol substitution x density of petrol) +(percentage of alcohol substitution x density of the alcohol)].
Density of bio diesel=791 kg/m^3
Density of diesel=860kg/m^3

4.3 Tabulations

Table:1 Calorific Values Of Various Blends With Diesel

% of Blending	Diesel (KJ/Kg)	% of Diesel	Diesel (KJ/Kg)	BLEND-Diesel (KJ/Kg)
20%	8010	80%	35200	43210
40%	16021	60%	26400	42421
60%	24032	40%	17600	41632
80%	32043	20%	8800	40843
100%	40054	0%	-----	40054

Table:2 Diesel with 0% Blend

S.NO	N (rpm)	W (kg.f)	T (sec)	M_f (kg/hr)	B.P (kw)	I.P (kw)	SFC (kg/kw-hr)	η_{ith} (%)	η_{mech} (%)	ηbth (%)
1	1500	0	72	0.425	0.297	1.7	1.43	6.258	17.04	5.71
2	1500	2	61	0.5016	0.862	2.272	0.58	5.240	37.94	14.06
3	1500	4	52	0.5884	1.44	2.85	0.408	4.941	50.52	20.02
4	1500	6	44	0.695	2.02	3.43	0.344	5.103	58.89	23.78
5	1500	8	40	0.765	2.6	4.01	0.294	5.125	64.83	27.80
6	1500	10	37	0.825	3.19	4.6	0.258	4.626	69.39	31.62

Table:3 Diesel with 20% Blend

S.NO	N (rpm)	W (kg.f)	T (sec)	M_f (kg/hr)	B.P (kw)	I.P (kw)	SFC (kg/kw-hr)	η_{ith} (%)	η_{mech} (%)	ηbth (%)
1	1500	0	78	0.398	0.29	1.7	1.37	3.372	17.05	6.07
2	1500	2	65	0.478	0.862	2.272	0.55	5.303	37.94	15.02
3	1500	4	56	0.555	1.44	2.85	0.38	5.382	50.52	21.16
4	1500	6	47	0.661	2.02	3.43	0.32	5.68	58.89	25.46
5	1500	8	41	0.758	2.6	4.01	0.29	5.834	64.83	28.57
6	1500	10	38	0.818	3.19	4.6	0.25	6.241	69.34	32.48

Table:4 Diesel with 40% Blend

S.NO	N (rpm)	W (kg.f)	T (sec)	M_f (kg/hr)	B.P (kw)	I.P (kw)	SFC (kg/kw-hr)	η_{ith} (%)	H_{mech} (%)	η bth (%)
1	1500	0	81	0.390	0.29	1.7	1.34	3.4	17.05	6.31
2	1500	2	66	0.478	0.862	2.274	0.554	4.58	39.94	15.30
3	1500	4	54	0.585	1.44	2.85	0.406	6.204	50.52	20.88
4	1500	6	47	0.670	2.02	3.43	0.332	4.946	58.52	25.50
5	1500	8	40	0.7902	2.6	4.01	0.303	5.556	64.83	27.92
6	1500	10	37	0.854	3.19	4.6	0.267	5.900	69.34	31.69

Table:5 Diesel with 60% Blend

S.NO	N (rpm)	W (kg.f)	T (sec)	M_f (kg/hr)	B.P (kw)	I.P (kw)	SFC (kg/kw-hr)	η_{ith} (%)	H_{mech} (%)	η bth (%)
1	1500	0	71	0.452	0.29	1.7	1.55	3.468	17.05	5.54
2	1500	2	62	0.517	0.862	2.272	0.599	5.678	39.94	14.41
3	1500	4	53	0.605	1.44	2.85	0.420	5.532	50.52	20.58
4	1500	6	46	0.698	2.02	3.43	0.345	5.308	58.52	25.02
5	1500	8	39	0.823	2.6	4.01	0.316	5.997	64.83	27.31
6	1500	10	31	1.035	3.19	4.6	0.324	5.614	69.34	26.65

Table:6 Diesel with 80% Blend

S.NO	N (rpm)	W (kg.f)	T (sec)	M_f (kg/hr)	B.P (kw)	I.P (kw)	SFC (kg/kw-hr)	H_{ith} (%)	H_{mech} (%)	bth (%)
1	1500	0	72	0.453	0.297	1.7	1.52	3.538	17.05	5.77
2	1500	2	62	0.526	0.869	2.272	0.64	5.294	37.94	14.44
3	1500	4	49	0.665	1.44	2.85	0.461	5.643	50.52	19.08
4	1500	6	43	0.758	2.02	3.43	0.375	5.413	58.89	23.48
5	1500	8	38	0.858	2.6	4.01	0.33	6.117	64.83	26.70
6	1500	10	34	0.959	3.19	4.6	0.30	5.727	69.34	29.31

Table:7 Diesel with 100% Blend

S.NO	N (rpm)	W (kg.f)	T (sec)	M_f (kg/hr)	B.P (kw)	I.P (kw)	SFC (kg/kw-hr)	H_{ith} (%)	H_{mech} (%)	bth (%)
1	1500	0	70	0.473	0.297	1.7	1.59	3.538	17.05	5.64
2	1500	2	59	0.561	0.862	2.272	0.65	5.294	37.94	13.81
3	1500	4	48	0.69	1.44	2.85	0.479	5.643	50.52	18.75
4	1500	6	42	0.78	2.02	3.43	0.386	5.413	58.89	23.27
5	1500	8	38	0.87	2.6	4.01	0.334	6.117	64.83	26.86
6	1500	10	36	0.92	3.19	4.6	0.288	5.727	69.34	31.16

4.3.2 Emissions of Diesel Engine with Blends

Table:8 Diesel with 0% Blend

S.No	CO %	CO_2 %	HC (PPM)	NOx (PPM)	O_2 %	A %
1	0.05	2.68	26	102	17.16	….
2	0.04	3.16	32	150	16.37	4.548
3	0.04	3.79	34	210	15.71	3.87
4	0.03	4.44	37	328	14.76	3.316
5	0.03	4.95	39	450	14.13	2.971
6	0.03	5.07	40	486	13.97	2.907

Table:9 Diesel with 20% Blend

S.No	CO %	CO_2 %	HC (PPM)	NOx (PPM)	O_2 %	A %
1	0.04	1.86	12	88	18.19	
2	0.04	2.16	19	124	17.71	
3	0.03	2.54	21	178	17.08	
4	0.04	3.04	24	269	16.42	4.77
5	0.03	3.39	25	403	15.83	4.18
6	0.02		28			

Table:10 Diesel with 40% Blend

S.No	CO %	CO_2 %	HC (PPM)	NOx (PPM)	O_2 %	A %
1	0.05	2.03	18	87	17.09	
2	0.05	2.55	20	142	16.97	
3	0.04	3.17	24	225	16.25	4.55
4	0.04	3.67	25	317	15.64	3.93
5	0.03	4.31	27	465	14.76	3.38
6	0.03	4.64	28	541	14.29	

Table:11 Diesel with 60% Blend

S.No	CO %	CO_2 %	HC (PPM)	NOx (PPM)	O_2 %	A %
1	0.06	2.33	20	77	17.36	
2	0.06	2.91	22	135	16.60	4.95
3	0.05	3.37	20	226	15.98	4.23
4	0.04	3.95	21	350	15.16	3.59
5	0.03	4.70	21	504	14.26	3.108
6	0.03	5.07	21	604	13.76	2.90

Table:12 Diesel with 80% Blend

S.No	CO %	CO_2 %	HC (PPM)	NOx (PPM)	O_2 %	A %
1	0.06	2.41	17	98	17.36	
2	0.06	3.02	21	118	16.41	4.737
3	0.05	3.78	15	236	15.45	3.844
4	0.04	4.43	14	377	14.63	3.302
5	0.02	4.94	12	529	14.03	2.9
6	0.02	5.63	12	731	13.05	2.66

Table:13 Diesel with 100% Blend

S.No	CO %	CO_2 %	HC (PPM)	NOx (PPM)	O_2 %	A %
1	0.06	2.64	9	86	16.95	
2	0.05	3.19	13	150	16.34	
3	0.04	3.79	10	240	15.50	
4	0.03	4.46	8	389	14.65	3.286
5	0.02	5.17	6	536	13.90	2.893
6	0.02	5.27	5	580	13.58	3.744

4.4 Model Calculation

(DIESEL WITH 40% BLEND AT 6 KG.F LOAD)

The following values were found by measurement
Calorific value of diesel = 44000 kj/kg.
Calorific value of methanol at 40% = 42950 kj/kg
Speed, N = 1500 rpm,
Time taken for 10 cc of fuel consumption = 47 sec.
Mass of fuel consumption (m_f) =C.C/time * (S/1000) *3600
= 10/16*(0.874/1000)*3600
=0.67kg/hr.
Torque T = R*W*9.81 N-m =0.32*6*9.81
=18.835
Brake power B.P = 2πNT/ (60*1000) KW
= 2*π*1500*8/ (60*1000)
= 2.02 KW
Friction power (F.P) from graph B.P Vs Mf
F.P= 1.41 KW
Indicated power (I.P) =B.P+F.P =2.958+1.35 =3.43 KW
Specific fuel consumption (SFC) of petrol with methanol = M_f /B.P kg/kw-hr
= 0.67/2.02
= 0.332 kg/kw-hr
Indicated thermal efficiency ($\eta_{m)}$ =I.P/ (M_f * C.V) *100.
=3.43/ (0.67*42421)
= 4.946%

Mechanical efficiency (η_m) = B.P/I.P*100.
=2.02/3.43*100
=58.52%

Brake thermal efficiency η_{BT} = BP/ (SFC*CV)
= 2.02/ (0.332*42421)
= 25.5%.

V. RESULTS & DISCUSSION

5.1 Exhaust Emissions Characteristics

Emission characteristics are improved for additive of methanol compared to petrol except NOx which is slightly higher than gasoline. This indicated that the combustion efficiency high for additive gasoline

Results of the experiments in the form of carbon monoxide (CO), Nitrogen oxides (NOx) and Hydrocarbons (HC) for different load conditions for various percentage of methanol compare with the gasoline in the form of graphs.

5.1.1 Carbon Monoxide

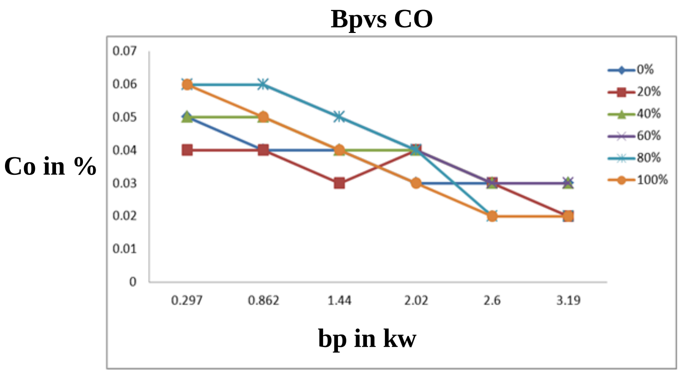


FIG:6 B.PVs CO AT VARIOUS ADDITIVES AND LOAD.

From fig.6 it is observed that CO increases with increasing load for all the percentage of methanol. If percentage of additive increases CO reduces. This is due to the batter combustion of gasoline when methanol used as an additive.

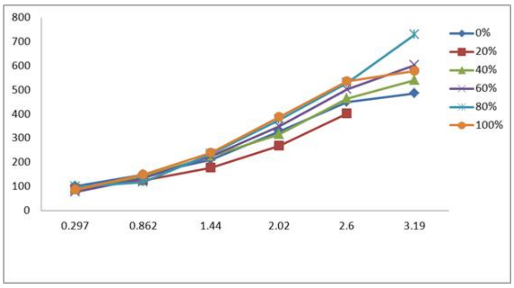
The concentration of CO decreases with the increase in percentage of methanol in the fuel. This may be attributed to the presence of O_2 in methanol, which provides sufficient oxygen for the conversion of carbon monoxide (CO) to carbon dioxide (CO_2).

5.1.2 Nitrogen Oxide

From fig.7 Show that NOx decreases with increasing load for all the percentage of methanol. If percentage of additives increases, NOx increases. The comparison of NOx emissions for gasoline and additives are shown in Fig.7. It can be seen that NOx emissions increase with increase in percentage of methanol in the petrol The NOx increase for additive of methanol may be associated with the oxygen content of the methanol, since the fuel oxygen may augment in supplying additional oxygen for NOx formation. Moreover, the higher value of peak cylinder pressure and temperature for methanol when compared to petrol may be another reason that might explain the increase in NO_X formation.

B.p. vsNOx

Nox in %



bp in kw

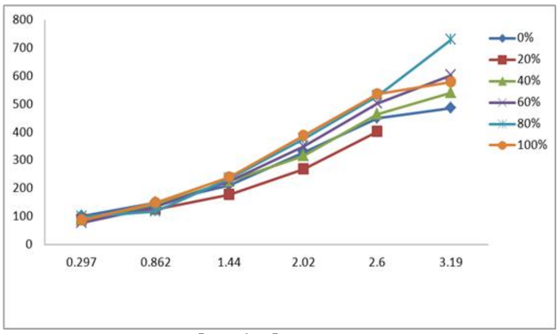
FIG :7 B.P VsNOx at various additives and load

5.1.3Hydro Carbons

From fig. 8 It is observed that hydro carbon (HC) decreases with increasing load for all the percentage of methanol. If percentage of additive of methanol increases, HC reduces. The hydrocarbon emissions are inversely proportional to the percentage of methanol added in the fuel. The petrol fuel operation showed the slightly higher concentrations of HC in the exhaust at all loads. Since methanol is an oxygenated fuel, it improves the combustion efficiency and hence reduces the concentration of hydrocarbon emissions (HC) in the engine exhaust. Blending 10% additive with gasoline greatly reduces HC emissions especially at all load condition.

B.p. vsHc

Hc



b.P in kw

FIG:8 B.P Vs HC AT VARIOUS ADDITIVES AND LOAD

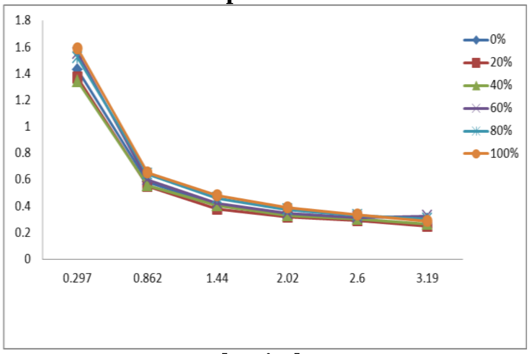
5.2 Performance Analysis

Results of the experiments in the form of brake power, brake thermal efficiency, specific fuel consumption for different load conditions for various additives of methanol with the gasoline.

5.3 Specific Fuel Consumption

B.p. vssfc

sfc



b.p in kw

FIG:9 B.P Vs SFC OF VARIOUS ADDITIVES

The variation of SFC with brake power for different percentage of additives of methanol with the gasoline as shown in fig 9
The additive of methanol shows lower SFC compare to gasoline because of it has oxygen content so complete combustion takes place in combustion chamber. However SFC is lower for all the other additives. The SFC decreases with the increasing loads. It is inversly praportional to the thermal efficiency of the engine.

5.4 Brake Thermal Efficiency

B.P vsbth

bth

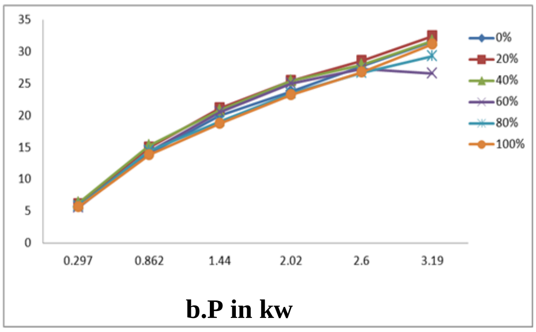


FIG:10 B.P Vs BTH of various additives

The variation of BTE with brake power for different percentage of additives of methanol with the gasoline as shown in fig 10.The additive of methanol shows The BTE is higher than the gasoline. The BTE is higher for various additives because of improve combustion efficiency.
The brake thermal efficiency is based on B.P and calorific value. of the engine . Brake thermal efficiency gradually increases with increase in percentage of additives. It is observed that brake thermal efficiency is low at low values of B.P and is increasing with increase of I.P for all additives of fuel. For a additive of 3% the brake thermal efficiency is high at highr power values when compared with other additives of fuel and is slightly higher than the petrol at high values of brake power.

5.4 Mechanical Efficiency

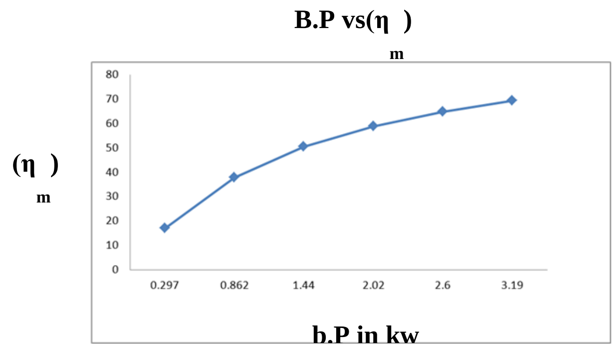


FIG:11 Mechanical Efficiency

The variation of mechanical efficiency with brake power at different loads as shown in fig 11 Mechanical efficiency SI engine is constant. Because brake power and frictional power are constant at various load conditions and additives of methanol why because speed of engine is set as constant.

VI. CONCLUSION & FUTURE SCOPE

This study has demonstrated that biodiesel production can be initiated with relatively little capital investment. It can be assumed that petroleum fuel prices will continue to rise in the future; making it likely that biodiesel will become the least cost alternative to petroleum diesel at a later date.
Experiment has been conducted on single cylinder diesel engine with different percentage of biodiesel as blend to diesel. It is concluded that, the percentage of blends increases the emission characteristics improved expect NOx and CO_2.
It is observed that the emission values of The HC and CO are decreased when compared with diesel. But The NOx emissions are increased due to presence of oxygen content in the biodiesel and also the combustion temperature is high.
The engine performance indicating parameters like brake power, indicated power, indicated thermal efficiency, brake thermal efficiency, mechanical efficiency, etc., have been observed for various additives at different loads.
The brake thermal efficiency increases with increase in percentage of blends. It is observed that 60% blend is suggested in efficiency and emissions point of view. And 40% blend is best in cost point of view. Thus biodiesel may be used as a blending for diesel in future. And we can do further experiments for different vegetable oils to get improved results.

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