Experimental on Performance and Emission Characteristics of Diesel Engine by using Mahua and Neem Oil as Alternative Fuel

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Abstract- **Fuels derived from the renewable biological resources for the use in diesel engine are known as biodiesel. Biodiesel produced from non-edible feed stocks such as Mahua, Neem, Jatropha etc. are reported to be feasible choices for developing countries like India. In this investigation the blends of varying proportions of Neem, Mahua and diesel were prepared, analyzed and compared with the performance of diesel fuel and studied using dual cylinder diesel engine at varying loads. Raw oils of Neem and Mahua were esterified (butyl esters) before blending with pure diesel. The esterified oils of biodiesel blends satisfies the important fuel properties and it lead to an improvement in engine performance and emission characteristics without any design modifications in the engine. The brake thermal efficiency, SFC, Exhaust gas temperature, Smoke density, CO, CO2 and HC were analyzed. It is observed that fuel consumption increases and brake thermal efficiency decreases as the biodiesel in the diesel blend increases. The smoke,CO,CO2 and HC emissions of the engine were increased with blends at all the loads however MB10 gives best results when performance parameters (FC, SFC, brake thermal efficiency) and emission parameters(Smoke density,CO,CO2 and HC) were concern and found to be best alternative for the Indian perspective.**

Keywords: ***Biodiesel, CI engine, bio fuel, Mahua, Neem.***

I. Introduction

Since the very conception of the engineers have been searching for the fuel that is available forever. As we know that the amount of the conventional fuels like petrol & diesel are limited and the conversion process of biological product into petroleum oil takes thousands of years. The internal combustion engines are considered to be the biggest source of energy consumption and environmental pollution.

Bio-Diesel may be the conventional and environmental safer alternatives. Biodiesel is a variety of ester-based oxygenated fuels derived from natural, renewable biological sources such as vegetable oils. Biodiesel operates in compression ignition engines like petroleum diesel thereby requiring no essential engine modifications. Biodiesel can be made from new or used vegetable oils and animal fats. Unlike fossil diesel, pure biodiesel is biodegradable, nontoxic and essentially free of sulphur and aromatics.

Biodiesel refers to a non petroleum based diesel fuel consisting of short chain alkyl (methyl or ethyl) esters, made by transesterification of vegetable oil or animal fat (tallow) which can be used (alone, or blended with conventional petro-diesel) in unmodified diesel-engine vehicles. An engine actually run on regular diesel fuel or CNG, but in the past kerosene was used because it was far cheaper, and worked just as well. Biodiesel is more efficient, cheap, and clean alternative. Today plans are being chalked out to cultivate jatropha plants on barren land to use its oil for biodiesel production.

Now biodiesel can be used for railway engines and the plantations are recommended to plant these plants everywhere in unused areas through government sectors. It is being used experimentally to run state transport corporation buses in Karnataka.

A. Comparison of Diesel and Bio-diesel Flame:

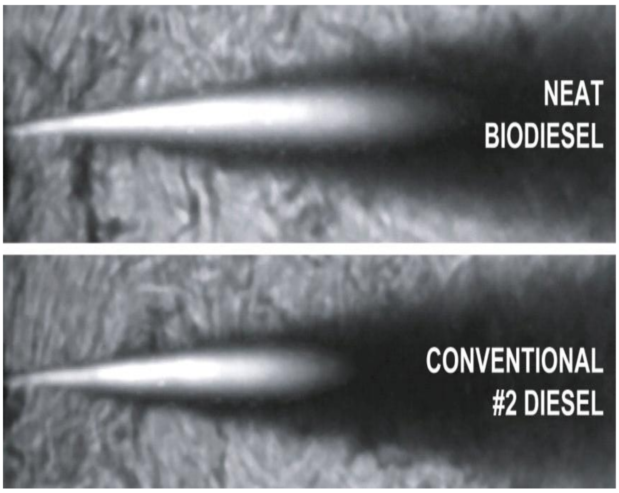

Fig.1.1 Comparison of diesel and biodiesel flame

Fig.1.1 shows superimposed images of Mie scattering from the fuel-jet core shows the liquid-penetration length, and image shows the jet spreading angle. Image pairs are shown for neat biodiesel and conventional diesel fuel. The liquid-penetration length is more than 30% longer for neat biodiesel than for diesel fuel at this condition which could lead to impingement of liquid fuel on in-cylinder surfaces. The temperature and density into which the fuel is injected are 1000 K and 14.8 kg/m3. In this paper we have carry out the Performance and Emission test on twin cylinder diesel engine for the biodiesel for different blending ratios and varying load conditions. Finally find out the optimum blending ratio with maximum power output, minimum fuel consumption, and highest thermal efficiency and with least emissions. Find out the best possible alternative fuel for the fossil fuel (diesel) in Indian perspective.

II. LITERATURE SURVEY

A. Swarna Kumari has carried out to the evaluation of the performance and emission characteristics of Neem oil blends with diesel Engine. The brake thermal efficiency values of fuels considered are very close to the diesel fuel at all the injection pressures. For B10 the brake specific fuel consumption is minimum and brake thermal efficiency is maximum at full load for the injection pressure of 225 bars. For B60 the brake specific fuel consumption is minimum and brake thermal efficiency is maximum at full load for the injection pressure of 250 bar. From the entire experimental programmed, she concluded that thermal performance of the engine with the fuels B10 is satisfactory at all the injection pressures when compared with neat diesel fuel. & the optimum injection pressure for the fuels B10 is 225 bars.

S.S.Ragit has analyzed performance and exhaust emission characteristics of diesel engine fueled with filtered Neem oil and Neem oil methyl ester compared with diesel fuel. At part load, NOME is found best fuel because it reduces NOx and UHC with improved BTE. At part load, NO gives higher percentage of CO2 emission as compare to diesel, due to complete combustion whereas NOME shows increasing trend as compare to diesel. CO emission is found to be increasing with increasing BMEP. In case of 100% filtered NO, It increases at all loads because high viscosity and poor atomization tendency of filtered NO leads to poor combustion and higher CO emission.

T. Venkateswara Rao has prepared biodiesel from transesterification process. He has examined properties, performance and emissions of different blends (B10, B20, and B40) of PME, JME and NME in comparison to diesel. Results indicated that B20 have closer performance to diesel and B100 had lower brake thermal efficiency mainly due to its high viscosity compared to diesel. However, its diesel blends showed reasonable efficiencies, lower smoke, CO and HC. Pongamia methyl ester gives better performance compared to Jatropha and Neem methyl esters. Pongamia, Jatropha and Neem based methyl esters (biodiesel) can be directly used in diesel engines without any engine modifications. Brake thermal efficiency of B10, B20 and B40 blends are better than B100 but still inferior to diesel. Properties of different blends of biodiesel are very close to the diesel and B20 has given good results. Smoke, HC, CO emissions at different loads were found to be higher for diesel, compared to B10, B20, B40 blends. With properties close to diesel fuel, biodiesel from Jatropha, Pongamia pinnata and Neem seed oil can provide a useful substitute for diesel thereby promoting our economy.

K. Ambumani has studied the feasibility two non edible plant oils Mustard and Neem as diesel substitute and a comparative study on their combustion characteristics on a C.I. engine were made. Biodiesel was prepared by transesterification process in the ratio of 10:90, 15:85, 20:80, and 25:75 by volume. He found engine run at 20% blend of oils showed a closer performance to pure diesel. However, mustard oil at 20% blend with diesel gave best performance as compared to Neem oil blends in terms of low smoke intensity, emission of HC and NOx. These studies have revealed that both the oils at 20% blend with diesel can be used as a diesel substitute. Butyl ester of mustard oil at 20% blend with diesel gave best performance in terms of low smoke intensity, emission of HC and NOx. Cetane number, total fuel consumption, specific energy consumption, specific fuel consumption, brake thermal efficiency, and cylindrical peak pressure were almost equal when engine was run on pure diesel. The transesterification process is used for making biodiesel from vegetable oils. Esterified Mustard oil and esterified Neem oil as a biodiesel satisfies the important fuel properties.

M.K.Ghosal has prepared different blends of Mahua methyl ester oil with diesel fuel from 20% to 100% by volume at three fuel temperatures (30 ºC, 50 ºC and 700 ºC) and at two injection pressures (17640 kPa and 24010 kPa). The engine performance parameters studied were power output, BSFC, BThE and ExGT by using diesel fuel alone and the above mentioned blend fuels. The performance of engine with blend fuel (20% Mahua methyl ester and 80% diesel) was found to be better than the other blend fuels. But the values of power output, BSFC, BThE and ExGT in case of blend fuel B20 (20% Mahua methyl ester and 80% diesel) were observed to be respectively 3% more, 9% more, 12%more and 0.5% less than the diesel fuel at 700 ºC temperature and 24010 kPa pressure. The Mahua methyl ester (blends of B20) can be used as an alternative diesel fuel replacement with little sacrifice in brake specific fuel consumption. The performance of the engine with B20 blend fuel was found to be good as compared to the diesel fuel for short-term engine test. On an average, the values of power output, ESFC and ExGT of the blend B20 were found to 3% more, 9% more 0.5 % less than the pure diesel fuel. Mahua methyl ester can be used as a substitute for diesel fuel in compression ignition engine with lower percentage of emissions and engine wear compared to diesel.

S. Savariraj investigated the performance and emissions characteristics of diesel engine using Mahua biodiesel. In this investigation, the blends of varying proportions of Mahua biodiesel and diesel were prepared, analyzed compared with the performance of diesel fuel, and studied using a single cylinder diesel engine. He found that as the proportion of Mahua biodiesel increases in the blend, the brake thermal efficiency decreases. For B- 100, the brake thermal efficiency was 14.3% less than that of diesel at full load. More the proportion of Mahua biodiesel in the blend more is the increase in brake specific fuel consumption for any given load. The carbon monoxide emissions are doubled with neat Mahua biodiesel operation when compared to diesel mode at full load condition. At 20% load, HC emissions for Mahua biodiesel and blends are quite high. At higher loads, as the quantity of Mahua biodiesel in the blend increases HC emissions decreases. The NOx and smoke emissions are higher for neat Mahua biodiesel and blends when compared to diesel at almost all loads.

S. Prabhakar has evaluated the sound, exhaust gas temperature and smoke opacity characteristics of a single cylinder, four stroke engines fuelled with vegetable oil methyl ester and its blends with standard diesel. Tests has been conducted using the fuel blends of 20%, 40%, 60% and 80% biodiesel with standard diesel, with an engine speed of 1800 rpm. It is found that the sound, exhaust gas temperature and smoke opacity characteristics of vegetable oil methyl ester and its diesel blends closely followed those of standard diesel. He found that after trans-esterification of vegetable oil, the kinematic viscosity and density are reduced while the calorific value is increased and the experimental results such as Sound, Exhaust gas temperature and Smoke opacity characteristics of the methyl ester of vegetable oil blends are almost comparable to that of diesel fuel results.

M.V.Mallikarjun has found out the performance of the four strokes; Single cylinder C. I. engine fueled by the preheated (300C to 1350C) edible Madhuca indica oil and they found that the preheating of oil showed considerable improvements at higher loads 75% of full load without preheating 4.9 and with preheating 4.58 and at full load without preheating 5.5 and with preheating 4.38. The improvement in BSFC at 75% of full load is 6.5% and at full load is 20% was measured due to preheating. At 75% of full load 25.8% Brake thermal efficiency obtained for diesel fuel. 19.9% for Madhuca Indica oil without preheating and 21.8% efficiency with preheating. The raw MI oil without preheating has high viscosity and it affects poor spray characteristics and homogenity of air fuel mixture. In the preheating oil to participate in better combustion resulting power CO emission than raw oil by 47% at 75% of full load. The CO emission was high for advance/retard injection timing at high loads only. The reduction of HC emission is 58% at 75% of full load and 48% at full load compared to without preheating and for that of the diesel was 52% reduction at no load and 25% for full load.

We know that the economy of India depends to a large extent on the wheels of transport. However, because of a high investment cost and a heavy infrastructure, only fifty percent of the biogas production is upgraded, and the natural gas replacement is very low. This renewable energy is already used for heat and electricity production, but the best Upgrading solution of this clean energy should be the injection into the natural gas grid or the production of vehicle fuel. Biogas containing more than 45% carbon dioxide caused harsh (rough or unpleasant to the senses) and irregular running of the engine. Similar results were obtained by others, in which increased exhaust emission of the unburned fuel was found in the region of 45-50% carbon dioxide [3]. The large quantity of CO_2 present in biogas lowers its calorific value, flame velocity and flammability range compared with natural gas. The self-ignition temperature of biogas is high and hence it resists knocking which is desirable in SI engines. Thus biogas has a high anti-knock index and hence biogas engine can use high compression ratios, which can lead to improvements in thermal efficiency

Biogas cannot be used to run an IC engine directly on account of its high self ignition temperature. However, it can be utilized in an IC engine with the dual fuelling approach. The dual fuel engine is basically a modified IC engine. In this case, a mixture of air and biogas or other gaseous fuel is sucked into the engine, compressed and then ignited by a spray of fuel with a low self-ignition temperature like diesel, vegetable oil or biodiesel, which is called a pilot fuel [4]. Dual fuel operation always needs a small amount of pilot fuel for ignition.

III. ALTERNATIVE FUELS

A. Neem

Table 3.1 Properties of Neem oil [4]

Sr. No.	Fuel property	Diesel	Neem oil
1	Calorific value (Mj/kg)	42.3	39.1
2	Flash point(°c)	60	100
3	Fire point (°c)	65	109
4	Density (g/cm3)	0.830	0.920
5	Cloud point (°c)	-12	19
6	Pour point (°c)	-16	10
7	Viscosity (cst)	4.7	35.83
8	Cetane number	45-55	31

B. Mahua

Table 3.2 Properties of Mahua oil [6]

Sr. no.	Fuel property	Diesel	Mahua
1	Calorific value (Mj/kg)	42.3	39.7
2	Flash point (°C)	72	174
3	Fire point (°C)	80	185
4	Density (g/cm3)	0.830	0.8812
5	Cloud point (°C)	-3	12
6	Pour point (°C)	-18	4
7	Viscosity (Cst)	4.56	5.58
8	Cetane number	50.6	51.4

C. Chemical Analysis and Cost Estimation of Biodiesel

Table 3.3 Chemical analysis of Neem and Mahua biodiesel

Sr. No.	Test Parameters (%)	Neem	Mahua
1	Carbon	84.80	84.91
2	Hydrogen	8.70	8.82
3	Oxygen	4.82	5.82
4	Nitrogen	0.63	-
5	Sulphur	0.07	0.072

D. Cost estimation of Neem Biodiesel per Liter:

Cost of raw Neem oil: 80
Biodiesel processing (transesterification) cost: 12
Profit (Producer): Dealer’s margin: 5
Dealer’s margin: 3
Sale price of Neem Biodiesel: 100

E. Cost estimation of Mahua Biodiesel per Liter:

Cost of raw Mahua oil: 100
Biodiesel processing (transesterification) cost: 12
Profit (Producer): 3
Dealer’s margin: 5
Sale price of Mahua Biodiesel: 120

IV. EXPERIMENTAL ANALYSIS FOR PERFORMANCE AND EMISSION TEST

A. Specification of the Engine

Table 4.1: Specification of the Engine

Maker’s name	Gangadhar industries, Aji vashahat,80-feet road,Rajkot-3
Type of engine	Dual cylinder, Vertical, four stroke cycle, Water cooled, Cold start oil engine, Direct injection
Bore and stroke	80 mm and 110mm
Brake power and RPM	7.35 kw and 1500 RPM
Specific fuel consumption	250gm/kwhr
Lubrication oil	Servo 20W40
Fuel	High speed diesel
Governing	Class B1
Dynamometer	Electrical type
Compression ratio	16:1

Engine – Multicylinder vertical water cooled self governed diesel engine developing 10 H. P. at 1500 rpm. Lubricating oil type is 20w/40. Lubricating Oil quantity required are 7 Ltrs.
Dynamometer 6 KVA capacity alternator coupled to the engine with load arrangement.

Measurement 6 KVA capacity alternator coupled to the engine with load arrangement
Calibrated Burette for fuel intake measurement.
Orifice meter - Fitted to the air inlet tank with water
Manometer for air intake measurement.
Multichannel digital temperature for measurement of temperature at various points.
Exhaust gas calorimeter to measure heat carried away by exhaust gas.
Measure the water flow rate of engine jacket and calorimeter.

B. Experimental Set up and Procedure

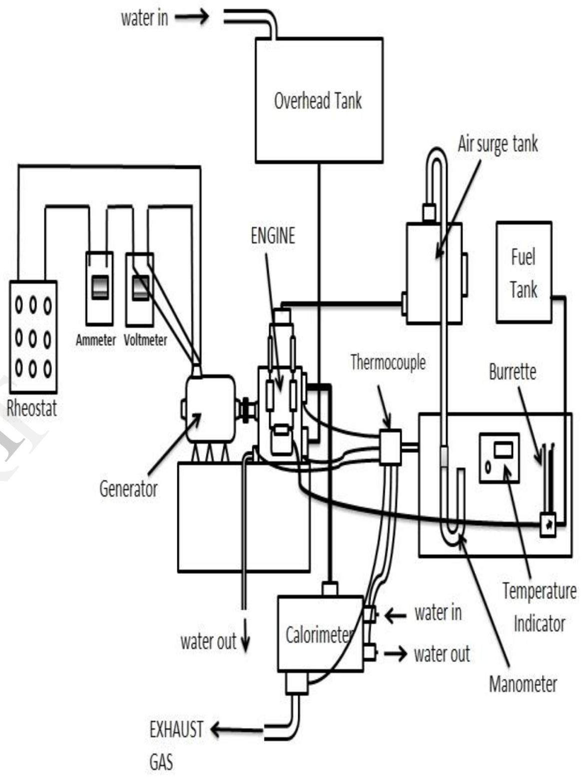

Fig 4.1 Experimental setup

Diesel engines are widely used for various applications. Before the engine is put to services, they are required to be tested to estimate their performance. Various types of loadings are used for testing the engines. The ‘DYNAMIC’ company apparatus consists of a multicylinder diesel engine coupled to electrical dynamometer. Various other measurements are provided so that performance of the engine can estimated at various loads.

B. Other Equipments

Exhaust Gas analyzer: For the measurement of content of exhaust gases of diesel and diesel blends like CO, CO_2, O_2 and HC .
Bomb Calorimeter: For the measurement of CV of the diesel and diesel blends.
Viscometer: for the measurement of the viscosity of the diesel and diesel blends.
Smoke Meter: for the measurement of the smoke density

C. Mathematical Modeling

1) Brake Power:

$$\frac{V \times I}{1000}$$

Brake power can be measured by a dynamometer.

Load of dynamometer = KW

Where,

V = voltmeter in volts

I = Current in Amps.

Assuming dynamometer efficiency 70% brake power of the engine

2) Fuel Consumption:

$$\frac{100}{tf} \times \frac{3600}{1000} \times 0.84$$

Fc =

$$= \frac{149400}{tf} Kg/hr$$

Where, tf = Time required for 100 ml fuel (sec.)

Specific Fuel consumption:

$$SFC = \frac{Fc}{B.P.} Kg/KW.hr$$

3) Heat Supply by Fuel:

$Hf = Fc \times$ Calorific value of Diesel

4) Indicated Power

The power developed inside the cylinder by combustion of gases is called indicated power

IP = BP + FP KW

5) Heat Equivalent to BP:

$$H_{BP} = BP \times 3600 KJ/hr$$

6) Heat Equivalent to IP:

$$H_{IP} = IP \times 3600 KJ/hr$$

7) Efficiency

It is desirable that the power produced by the engine should be fully (100%) utilized. But it is not possible as power losses are inevitable. It is due to losses of two factor viz.

Mechanical losses due to friction and Thermal losses

Hence power produced inside the cylinder is not fully transferred to the crankshaft. The relationship between power produced and the power utilized can be expressed in terms of efficiency.

8) Mechanical efficiency:

Mechanical efficiency relates the power produced inside the cylinder (ihp) and the power actually available at the crankshaft (bhp).

$$\eta_m = \frac{BP}{IP} \times 100\%$$

9) Brake thermal efficiency

$$= \frac{H_{BP}}{H_f} \times 100$$

As the power output may be indicated power or brake power, therefore thermal efficiency may be expressed as indicated thermal efficiency or as brake thermal efficiency.

$$\eta_{ith} = IP \frac{3600}{m_{fb} \times CV}$$

Where,

m_{fb} = brake specific fuel consumption (BSFC) in Kg/Kw.hr

CV = calorific value in Kg/Kg of fuel

10) Indicated thermal efficiency

$$\eta_{th} = \frac{3600}{m_i \times CV}$$

Where, m_i = indicated specific fuel consumption

11) Correction Factor

Standard condition of engine

Pr = 750 mm of Hg = 1bar = Standard pressure of engine

Tvα= 270C = Standard temperature of engine

RH = 60% = ϕv = 0.6 = standard humidity of engine

Site condition of engine

Pbx = 744 mm of Hg =Pressure at site condition of engine

Pbx = = = 0.992 bar

Td = 340C = Dry bulb temperature (at site condition)

Tw = 240C = Wet bulb temperature

Pbx = 0.992 bar =

Psw = 0.02983 bar at Tw = 240C from steam table

Pvx = Psw –

Pvx = 0.02982 -

Pvx = 0.02345 bar

Psx = 0.05335, at Td = 340C from steam Table,

Pvx = Psw -

Φx = Pvx / Psx = 0.02345/0.05335 = 0.4395

Psr = 0.03564 at Tstd = 270C from steam table

K = [x ( )0.75]

K = x 0.75

K = 0.9897 = Correction factor

α = K- 0.7 (1-K)(1/0.8-1)

α = 0.9897-0.7(1-0.9897)(0.25)

α = 0.9879

α = 0.9879 = correction factor

β = 1.0018 = correction factor

V. RESULTS AND DISCUSSION

Table 5.1 Observation Table for Diesel

Sr. No.	Voltmeter (V) Volt	Ammeter (I) Amp.	Speed (N) RPM	Time for 100 CC fuel Consumed (t_f) sec.	Mano-meter Difference (h_w) mm	Cooling Water temp.				Exhaust gas Temp. at calorimeter (°C)		Time in sec 1 lit. Of Water through	
						Engine Jacket		Calorimeter				Eng. Jacket	Calorimeter
						Inlet (°C)	Outlet (°C)	Inlet (°C)	Outlet (°C)	Inlet (°C)	Outlet (°C)	(T_1) sec	(T_2) Sec
1	245	0	1500	332.0	13.2	33	38	33	43	179	92	7	45
2	245	4.2	1440	305.6	12.9	33	40	33	45	181	104	7	45
3	245	7.8	1380	268.3	12.2	34	43	34	51	216	119	7	45
4	245	11.6	1340	248.7	12.1	34	44	34	54	232	132	7	45
5	245	14.4	1290	207.9	12.0	34	46	34	63	256	140	7	45

Table 5.2 Result Table for Diesel

Sr no	BP (kw)	Corrected BP (kw)	Fuel consumed. (kg/hr)	Corrected FC (kg/hr)	SFC (kg/kwhr)	Corrected SFC (kg/kwhr)	IP (kw)	Mechanical. Efficiency (%)	Brake thermal efficiency. (%)	Indicated thermal efficiency (%)
1	0	0	0.9	0.912	-	-	3.2	-	-	29.58
2	1.47	1.49	0.977	0.9879	0.665	0.663	4.69	31.91	12.83	40.21
3	2.73	2.76	1.113	1.123	0.408	0.407	5.96	46.54	20.85	44.92
4	4.0	4.05	1.2	1.210	0.3	0.299	7.25	56.25	28.45	50.62
5	5.11	5.17	1.437	1.448	0.281	0.280	8.37	63.4	30.38	48.82

Table 5.3 Observation Table for NB 10

Sr. No.	Voltmeter (V) Volt	Ammeter (I) Amp.	Speed (N) RPM	Time for 100 CC fuel Consumed (t_f) sec.	Mano-meter Difference (h_w) mm	Cooling Water temp.				Exhaust gas Temp. at calorimeter (°C)		Time in sec 1 lit. Of Water through	
						Engine Jacket		Calorimeter				Eng. Jacket	Calorimeter
						Inlet (°C)	Outlet (°C)	Inlet (°C)	Outlet (°C)	Inlet (°C)	Outlet (°C)	(T_1) sec	(T_2) Sec
1	245	0	1580	329	13.4	33	39	33	48	192	97	7	45
2	245	4.2	1574	305	13.3	33	40	33	54	218	115	7	45
3	245	7.8	1532	264	13.1	34	45	34	61	252	132	7	45
4	245	11.6	1492	242	12.9	34	47	34	70	298	146	7	45
5	245	14.4	1486	205	12.7	34	52	34	76	318	158	7	45

Table 5.4 Result Table for NB 10

Sr no	BP (kw)	Corrected BP (kw)	Fuel consumed. (kg/hr)	Corrected FC (kg/hr)	SFC (kg/kwhr)	Corrected SFC (kg/kwhr)	IP (kw)	Mechanical. Efficiency (%)	Brake thermal efficiency. (%)	Indicated thermal efficiency (%)
1	0	0	0.922	0.934	-	-	3.2	-	-	29.37
2	1.47	1.49	0.995	1.006	0.677	0.675	4.69	31.91	12.70	39.96
3	2.73	2.76	1.150	1.156	0.420	0.419	5.96	46.54	20.46	44.20
4	4.0	4.05	1.254	1.259	0.313	0.312	7.25	56.25	27.47	49.36
5	5.11	5.17	1.480	1.484	0.290	0.289	8.37	63.4	29.60	48.35

Table 5.5 Observation Table for NB 20

Sr. No.	Voltmeter (V) Volt	Ammeter (I) Amp.	Speed (N) RPM	Time for 100 CC fuel Consumed (t_f) sec.	Mano-meter Difference (h_w) mm	Cooling Water temp.				Exhaust gas Temp. at calorimeter (°C)		Time in sec 1 lit. Of Water through	
						Engine Jacket		Calorimeter				Eng. Jacket	Calorimeter
						Inlet (°C)	Outlet (°C)	Inlet (°C)	Outlet (°C)	Inlet (°C)	Outlet (°C)	(T_1) sec	(T_2) Sec
1	245	0	1582	320	13.5	33	42	33	48	195	101	7	45
2	245	4.2	1540	298	13.3	33	43	33	55	220	117	7	45
3	245	7.8	1506	258	13.4	33	45	33	62	252	134	7	45
4	245	11.6	1490	235	13.2	33	48	33	72	300	147	7	45
5	245	14.4	1460	195	13.0	33	54	33	76	322	162	7	45

Table 5.6 Result Table for NB 20

Sr no	BP (kw)	Corrected BP (kw)	Fuel consumed. (kg/hr)	Corrected FC (kg/hr)	SFC (kg/kwhr)	Corrected SFC (kg/kwhr)	IP (kw)	Mechanical. Efficiency (%)	Brake thermal efficiency. (%)	Indicated thermal efficiency (%)
1	0	0	0.957	0.960	-	-	3.2	-	-	28.79
2	1.47	1.49	1.028	1.040	0.700	0.698	4.69	31.91	12.37	38.95
3	2.73	2.76	1.187	1.197	0.455	0.434	5.96	46.54	19.90	43.01
4	4.0	4.05	1.303	1.316	0.326	0.325	7.25	56.25	26.58	47.59
5	5.11	5.17	1.571	1.576	0.307	0.305	8.37	63.4	28.32	45.88

Table 5.7 Observation Table for NB 30

Sr. No.	Voltmeter (V) Volt	Ammeter (I) Amp.	Speed (N) RPM	Time for 100 CC fuel Consumed (t_f) sec.	Mano-meter Difference (h_w) mm	Cooling Water temp.				Exhaust gas Temp. at calorimeter (°C)		Time in sec 1 lit. Of Water through	
						Engine Jacket		Calorimeter				Eng. Jacket	Calorimeter
						Inlet (°C)	Outlet (°C)	Inlet (°C)	Outlet (°C)	Inlet (°C)	Outlet (°C)	(T_1) sec	(T_2) Sec
1	245	0	1552	315	13.2	33	41	33	49	198	104	7	45
2	245	4.2	1520	288	13.1	33	43	33	56	222	120	7	45
3	245	7.8	1490	251	13.0	33	46	33	64	256	136	7	45
4	245	11.6	1486	228	12.9	34	49	34	74	305	150	7	45
5	245	14.4	1480	184	12.7	34	55	34	78	330	168	7	45

Table 5.8 Result Table for NB 30

Sr no	BP (kw)	Corrected BP (kw)	Fuel consumed. (kg/hr)	Corrected FC (kg/hr)	SFC (kg/kwhr)	Corrected SFC (kg/kwhr)	IP (kw)	Mechanical. Efficiency (%)	Brake thermal efficiency. (%)	Indicated thermal efficiency (%)
1	0	0	0.995	1.005	-	-	3.2	-	-	27.72
2	1.47	1.49	1.088	1.099	0.740	0.738	4.69	31.91	11.79	37.45
3	2.73	2.76	1.249	1.255	0.457	0.455	5.96	46.54	19.13	41.34
4	4.0	4.05	1.375	1.385	0.343	0.342	7.25	56.25	25.38	45.57
5	5.11	5.17	1.704	1.711	0.333	0.331	8.37	63.4	26.14	42.61

Table 5.9 Observation Table for MB 10

Sr. No.	Voltmeter (V) Volt	Ammeter (I) Amp.	Speed (N) RPM	Time for 100 CC fuel Consumed (t_f) sec.	Mano-meter Difference (h_w) mm	Cooling Water temp.				Exhaust gas Temp. at calorimeter (°C)		Time in sec 1 lit. Of Water through	
						Engine Jacket		Calorimeter				Eng. Jacket	Calorimeter
						Inlet (°C)	Outlet (°C)	Inlet (°C)	Outlet (°C)	Inlet (°C)	Outlet (°C)	(T_1) sec	(T_2) Sec
1	245	0	1586	330	13.4	34	40	34	48	190	95	7	45
2	245	4.2	1580	305	13.2	34	41	34	53	220	110	7	45
3	245	7.8	1570	266	13.1	34	44	34	64	250	130	7	45
4	245	11.6	1564	245	13.0	34	48	34	74	300	150	7	45
5	245	14.4	1552	206	12.8	34	52	34	77	320	162	7	45

Table 5.10 Result Table for MB 10

Sr no	BP (kw)	Corrected BP (kw)	Fuel consumed. (kg/hr)	Corrected FC (kg/hr)	SFC (kg/kwhr)	Corrected SFC (kg/kwhr)	IP (kw)	Mechanical. Efficiency (%)	Brake thermal efficiency. (%)	Indicated thermal efficiency (%)
1	0	0	0.915	0.928	-	-	3.2	-	-	29.51
2	1.47	1.49	9.990	1.002	0.673	0.672	4.69	31.91	12.73	40.00
3	2.73	2.76	1.135	1.139	0.416	0.413	5.96	46.54	20.72	44.80
4	4.0	4.05	1.233	1.237	0.308	0.305	7.25	56.25	28.07	50.12
5	5.11	5.17	1.466	1.469	0.287	0.283	8.37	63.4	30.24	48.84

Table 5.11 Observation Table for MB 20

Sr. No.	Voltmeter (V) Volt	Ammeter (I) Amp.	Speed (N) RPM	Time for 100 CC fuel Consumed (t_f) sec.	Mano-meter Difference (h_w) mm	Cooling Water temp.				Exhaust gas Temp. at calorimeter (°C)		Time in sec 1 lit. Of Water through	
						Engine Jacket		Calorimeter				Eng. Jacket	Calorimeter
						Inlet (°C)	Outlet (°C)	Inlet (°C)	Outlet (°C)	Inlet (°C)	Outlet (°C)	(T_1) sec	(T_2) Sec
1	245	0	1572	325	13.2	33	40	33	48	195	98	7	45
2	245	4.2	1562	298	13.1	33	42	33	53	225	112	7	45
3	245	7.8	1558	260	12.9	33	46	33	65	252	132	7	45
4	245	11.6	1540	238	12.8	33	49	33	76	310	154	7	45
5	245	14.4	1536	192	12.7	33	53	33	80	325	165	7	45

Table 5.12 Result Table for MB 20

Sr no	BP (kw)	Corrected BP (kw)	Fuel consumed. (kg/hr)	Corrected FC (kg/hr)	SFC (kg/kwhr)	Corrected SFC (kg/kwhr)	IP (kw)	Mechanical. Efficiency (%)	Brake thermal efficiency. (%)	Indicated thermal efficiency (%)
1	0	0	0.938	0.950	-	-	3.2	-	-	29.08
2	1.47	1.49	1.023	1.034	0.696	0.694	4.69	31.91	12.41	39.09
3	2.73	2.76	1.172	1.185	0.430	0.428	5.96	46.54	20.12	42.47
4	4.0	4.05	1.281	1.291	0.320	0.319	7.25	56.25	27.00	48.37
5	5.11	5.17	1.588	1.597	0.310	0.309	8.37	63.4	27.27	45.14

Table 5.13 Observation Table for MB 30

Sr. No.	Voltmeter (V) Volt	Ammeter (I) Amp.	Speed (N) RPM	Time for 100 CC fuel Consumed (t_f) sec.	Mano-meter Difference (h_w) mm	Cooling Water temp.				Exhaust gas Temp. at calorimeter (°C)		Time in sec 1 lit. Of Water through	
						Engine Jacket		Calorimeter				Eng. Jacket	Calorimeter
						Inlet (°C)	Outlet (°C)	Inlet (°C)	Outlet (°C)	Inlet (°C)	Outlet (°C)	(T_1) sec	(T_2) Sec
1	245	0	1582	318	13.4	34	41	34	49	200	102	7	45
2	245	4.2	1562	288	13.2	34	45	34	55	230	115	7	45
3	245	7.8	1532	252	13.0	34	49	34	67	255	135	7	45
4	245	11.6	1512	231	12.9	34	53	34	79	315	158	7	45
5	245	14.4	1486	190	12.7	34	57	34	83	330	170	7	45

Table 5.14 Result Table for MB 30

Sr no	BP (kw)	Corrected BP (kw)	Fuel consumed. (kg/hr)	Corrected FC (kg/hr)	SFC (kg/kwhr)	Corrected SFC (kg/kwhr)	IP (kw)	Mechanical. Efficiency (%)	Brake thermal efficiency. (%)	Indicated thermal efficiency (%)
1	0	0	0.967	0.979	-	-	3.2	-	-	28.33
2	1.47	1.49	1.068	1.080	0.727	0.725	4.69	31.91	11.95	37.64
3	2.73	2.76	1.221	1.228	0.447	0.445	5.96	46.54	19.47	42.08
4	4.0	4.05	1.332	1.344	0.333	0.332	7.25	56.25	26.10	46.75
5	5.11	5.17	1.620	1.633	0.317	0.316	8.37	63.4	27.43	44.42

A. Performance Test

1) Effect of BP on Fuel Consumption for Different Blending Ratios

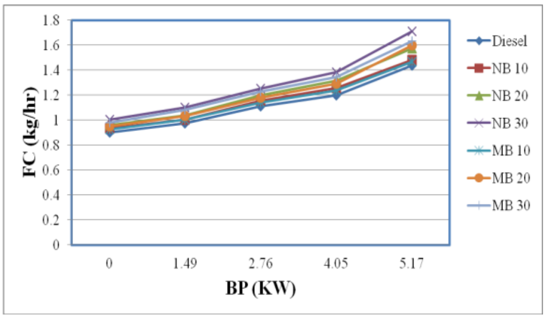

Fig 5.1 Variation in FC (kg/hr) Vs BP (kw)

Fig 5.1 shows that FC increases as brake power increases for all blending ratios. FC for MB 10 is very nearer same as that of neat diesel for all loads and higher FC is for the NB 30.

2) Effect of Bp on Specific Fuel Consumption with Different Blending Ratios

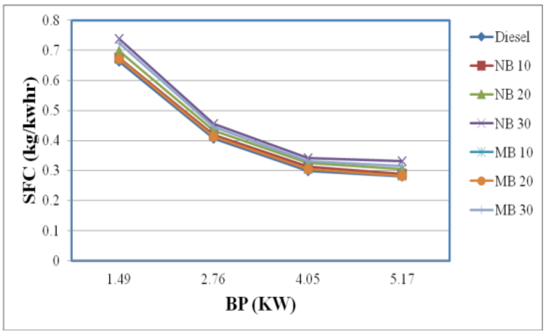

Fig 5.2 Variation in SFC (kg/kw.hr) Vs BP (kW)

Fig 5.2 shows that SFC of neat diesel is nearly similar to that of SFC of all blending ratios and it decreases with the increase in Brake Power.

3) Effect of BP on Brake Thermal Efficiency for Different Blending Ratios

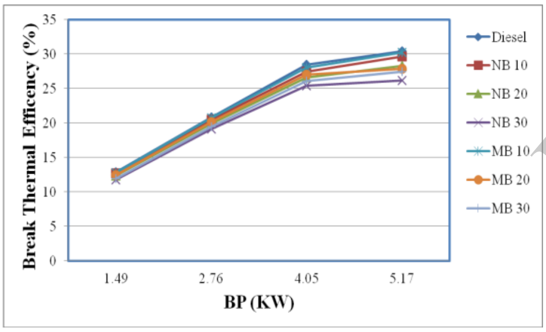

Fig 5.3 Variation in Brake Thermal Efficiency (%) Vs BP (kW)

Fig 5.3 shows that Brake thermal efficiency of the neat diesel is very nearer to the all blending ratios and it increases with increase in load (Brake Power). Brake thermal efficiency of MB 10 is similar to neat diesel for all loads.

B Emission Test

Table 5.15 Emission Test Results for Diesel

Sr No.	Load	Smoke density	CO	CO_2	O_2	HC
	kw	%	%	%	%	ppm
1	0	12.4	0.09	2.1	20.89	42
2	1.49	13.1	0.08	2.8	20.89	48
3	2.76	20.9	0.07	3.2	20.90	52
4	4.05	35.6	0.06	3.5	20.90	66
5	5.17	41.5	0.07	4.4	20.90	81

Table 5.16 Emission Results Test for NB10

Sr No.	Load	Smoke density	CO	CO_2	O_2	HC
	kw	%	%	%	%	ppm
1	0	7.0	0.07	2.0	20.89	39
2	1.49	13.5	0.08	2.6	20.89	62
3	2.76	24.2	0.08	3.4	20.89	73
4	4.05	36.0	0.06	3.8	20.98	56
5	5.17	48.0	0.06	4.6	20.89	60

Table 5.17 Emission Test Results for NB20

Sr No.	Load	Smoke density	CO	CO_2	O_2	HC
	kw	%	%	%	%	ppm
1	0	8.8	0.09	2.3	20.91	40
2	1.49	12.4	0.08	2.5	20.89	72
3	2.76	24.2	0.07	3.2	20.89	73
4	4.05	35.0	0.07	3.7	20.90	60
5	5.17	47.7	0.05	4.6	20.90	76

Table 5.18 Emission Test Results for NB 30

Sr No.	Load	Smoke density	CO	CO_2	O_2	HC
	kw	%	%	%	%	ppm
1	0	10.6	0.08	2.3	20.91	43
2	1.49	11.2	0.07	2.5	20.90	70
3	2.76	23.9	0.06	3.2	20.90	68
4	4.05	33.4	0.06	3.5	20.90	70
5	5.17	46.7	0.05	4.2	20.90	72

Table 5.19 Emission Test Results for MB 10

Sr No.	Load	Smoke density	CO	CO_2	O_2	HC
	kw	%	%	%	%	ppm
1	0	10.5	0.07	2.4	20.89	34
2	1.49	12.4	0.05	2.5	20.89	65
3	2.76	24.2	0.06	2.9	20.90	76
4	4.05	32.4	0.05	3.0	20.90	62
5	5.17	41.3	0.05	3.7	20.90	51

Table 5.20 Emission Test Results for MB 20

Sr No.	Load	Smoke density	CO	CO_2	O_2	HC
	kw	%	%	%	%	Ppm
1	0	12.1	0.07	2.0	20.89	37
2	1.49	13.6	0.06	2.3	20.90	64
3	2.76	24.5	0.05	2. 6	20.90	47
4	4.05	34.3	0.05	3.2	20.89	65
5	5.17	43.2	0.05	4.4	20.90	78

Tale 5.21 Emission Test Results for MB 30

Sr No.	Load	Smoke density	CO	CO_2	O_2	HC
	kw	%	%	%	%	ppm
1	0	13.7	0.06	1.9	20.89	37
2	1.49	14.5	0.06	2.5	20.89	41
3	2.76	28.3	0.06	3.1	20.90	53
4	4.05	37.0	0.05	3.4	20.90	59
5	5.17	48.6	0.05	4.6	20.90	68

1) Effect of BP on Smoke Density for Different Blending Ratios

Fig 5.5 shows that as the load increases on the engine smoke density goes on increase continuously. MB 10 has minimum smoke density and MB 30 as well as NB 10 has maximum smoke density with the increase in load.

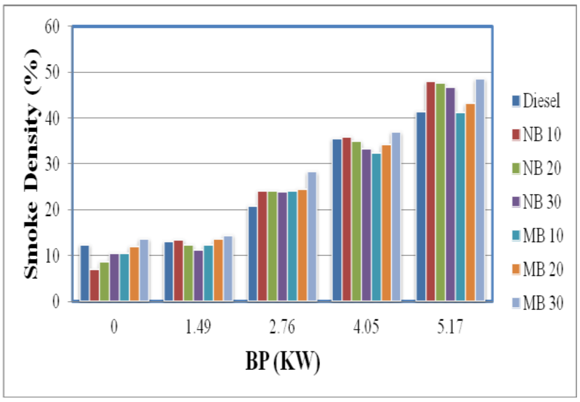

Fig 5.5 Variation in Smoke Density (%) Vs BP (kW)

2) Effect of BP on CO for Different Blending Ratios

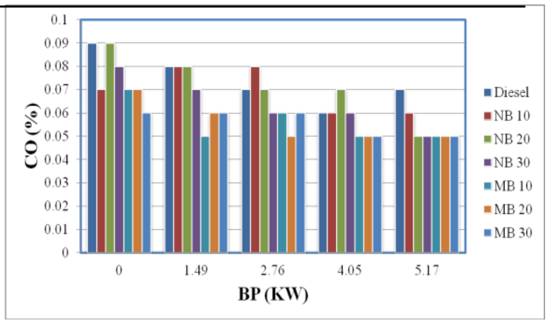

Fig 5.6 Variation in CO (%) Vs BP (kW)

Fig 5.6 shows that CO decreases with increase in blending ratio and load. MB 10 and MB 20 produced minimum CO emissions as compare to other blends and diesel at all load conditions.

3) Effect of BP on CO_2 for Different Blending Ratios

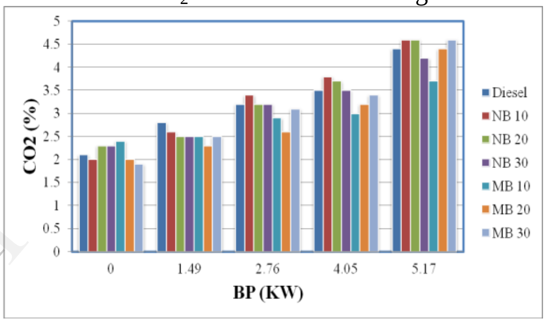

Fig 5.7 Variation in CO2 (%) Vs BP (kW)

Fig 5.7 shows that CO2 increase with increasing blending ratio at same load conditions and also increasing with higher load conditions. MB 10 produced minimum CO2 emissions as compare to other blends and diesel at all load conditions.

4) Effect of BP on HC for Different Blending Ratios

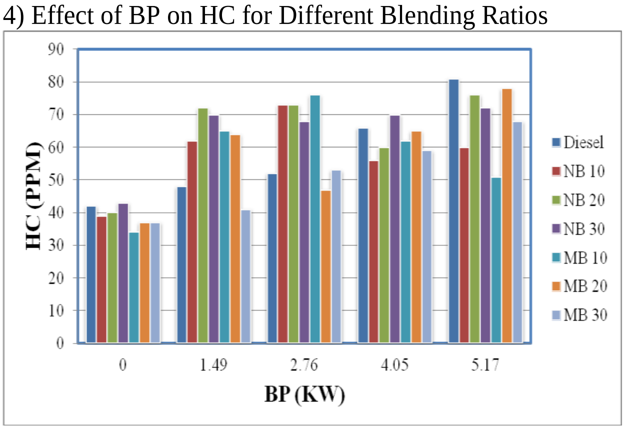

Fig 5.8 Variation in HC (PPM) Vs BP (kW)

Fig 5.8 shows that HC emissions decrease with increasing blending ratio at same load conditions and also increase with higher load conditions as compared to diesel. CB 20 produced minimum HC emissions as compare to other blends and diesel at all load conditions.

VI. CONCLUSION

- FC increases with the increase in blending ratio and load.
- BSFC for all biodiesel blends are nearly same to neat diesel fuel.
- BSFC increases with the increase in blending ratio.
- Mechanical efficiency increases with increase in load and it is lower than diesel for all biodiesel blends.
- The exhaust gas temperature increases with increase in load and biodiesel blending. It is higher for diesel as compared to the biodiesel blends.
- The brake thermal efficiency and indicated thermal efficiency for the all diesel blends were marginally similar when compared with neat diesel fuel.
- Smoke density is higher than the neat diesel for all blending ratio and increases with increase load and blending ratio.
- CO decreases with increase in load.
- HC and CO2 were increase with increase in load for all blending ratio.

MB10 gives best results when performance parameters (FC, SFC, brake thermal efficiency) and emission parameters (Smoke density, CO, CO2 and HC) were concern and found to be best alternative for the Indian perspective.

VII. REFERENCE

1]. L.M.Das and P.K. Sahoo "Combustion analysis of jatropha,Karanja and Polanga based biodiesel as fuel in diesel engine"Fuel,vol.88,pp.994-999,[2009]
2]. L.M.Das,P.K.Kumar and T.S.Varayani "Comparative evaluation of performance and emission characteristics of jatropha,Karanja and polanga based biodiesel as a fuel in tractor engine" Fuel vol.88, pp.1698-1707, [2009].
3]. Poonam Singh and Anoop Singh "production of liquid bio fuels from renewable resources"Production in energy combustion science, vol.37, pp 52-68,[2011].
4]. G. Prabhakar Rao and K. Hema Chandra Reddy T.Venkateswara Rao, "Experimental investigation of pongamia, jatropha and neem methyl esters as biodiesel on C.I. Engine"," jordan journal of mechanical and industrial engineeringl, vol. 2, pp.117-122,june,[2008]
5]. Saroj K. Padhi and R. K. singh, "Non-edible oils as the potential source for the production of biodiesel in India: A review", Journal of Chemical and Pharmaceutical Research, vol. 2, pp. 39-49, [2011].
6]. Modi A.J.and Gosai D.C. "Experimental study on Thermal barrier coated (TBC) Diesel Engine Performance with blends of diesel and palm biodiesel" SAE International,01-1519-[2010]
7]. Saurabh Srivastava,A.Rehman,Savita Dixit,Atul Lanjewar and S. P.Chincholkar, "Biodiesel as a alternative fuel for pollution control in diesel engine",Asian J.Exp. Sci.,vol 19,pp 13-22,[2005]
8]. Modi A.J. and Gosai D.C., "Experimental analysis of performance of Bio-fuels (Jatropha & Palm Bio-diesel) on Thermal Barrier Coated (TBC) Diesel Engine", Presented at The 3rd International conference of Advances in Mechanical Engineering (ICAME - 2010), January 4-6,[2010].