PERFORMANCE AND ANALYSIS USING MAHUA SEED OIL

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Abstract

Biodiesel, a promising substitute as an alternative fuel has gained significant attention due to the predicted shortness of conventional fuels and environmental concern. The utilization of liquid fuels such as biodiesel produced from Mahua seed oil by transesterification process represents one of the most promising options for the use of conventional fossil fuels.The Mahua oil is converted into Mahua oil methyl ester known as biodiesel prepared in the presence of homogeneous acid catalyst. The physical properties such as density, flash point, Kinematic viscosity, Cloud point and Pour point were found out for Mahua oil and Mahua methyl ester. The same characteristics study was also carried out for the diesel fuel for obtaining the base line data for analysis. The values obtained from the Mahua methyl ester is closely matched with the values of conventional diesel and can be used in the existing diesel engine without any modification.Biodiesel, a promising substitute as an alternative fuel has gained significant attention due to the predicted shortness of conventional fuels and environmental concern. The utilization of liquid fuels such as biodiesel produced from Mahua seed oil by transesterification process represents one of the most promising options for the use of conventional fossil fuels. The Mahua oil is converted into Mahua oil methyl ester known as biodiesel prepared in the presence of homogeneous acid catalyst. The physical properties such as density, flash point, Kinematic viscosity, Cloud point and Pour point were found out for Mahua oil and Mahua methyl ester. The same characteristics study was also carried out for the diesel fuel for obtaining the base line data for analysis. The values obtained from the Mahua methyl ester is closely matched with the values of conventional diesel and can be used in the existing diesel engine without any modification.

Key Words: Mahua seed oil, transesterification, biodiesel

1.0 Introduction

The rising prices and dwindling reserves of conventional fuels have lead to intensive studies on the use of alternative fuels, especially renewable ones like vegetable oils and alcohols.

The need for energy is increasing continuously, because of increase in industrialization and population. The basic sources of this energy are petroleum, natural gas, coal, hydro and nuclear. Petroleum diesel continues to be a major fuel worldwide. Canada consumes ~23 million tonnes (~26 billion liters) of diesel annually and 46% of this is utilized in the transportation sector. The United States consumes 178 million tonnes of diesel fuel annually, and the global consumption is 934 million tonnes of diesel fuel per year. The major disadvantage of using petroleum-based fuels is that, day by day, the fossil fuel reserves are decreasing. Another disadvantage is atmospheric pollution created by the use of petroleum diesel. Petroleum diesel combustion is a major source of greenhouse gas (GHG). Apart from these emissions, petroleum diesel is also major source of other air contaminants including NO_x, SO_x, CO, particulate matter, and volatile organic compounds (VOCs). The decreasing fossil fuel reserves, and the atmospheric pollution created by petroleum-based fuels, have necessitated the need for an alternative source of energy.

Biomass is one of the better sources of energy. Fuels from renewable biomass have the potential to reduce the amount of CO_2, particulate matter, and GHG emissions. This is because the carbon contained in biomass-derived fuel is biogenic and renewable. Therefore, petroleum-based fuels can be complemented by fuels obtained from renewable sources. Many researchers have tried to develop vegetable-oil-based derivatives that approximate the properties and performance of petroleum-based diesel fuel. Biodiesel (monoalkyl esters) is one of such alternative fuel, which is obtained by the transesterification of triglyceride oil with monohydric alcohols. It has been well-reported that Biodiesel obtained from canola and soybean oil acts very well as a diesel fuel substitute. However, a major barrier in the commercialization of Biodiesel production from vegetable oil is its high manufacturing cost, which is due to the higher cost of virgin vegetable oil. Waste cooking oil, which is much less expensive than pure vegetable oil, is a promising alternative to vegetable oil for Biodiesel production.

1.1 Mahua Oil (Madhuca Indica):

Mahua plant is a large deciduous tree growing widely under dry tropical and sub tropical climatic condition. It is an important tree for the rural people especially for tribals, greatly valued for its flowers and its seeds. The flowers of this tree have got religious value and are distributed as prasadam at Lord Sri Rama Temple at Bhadrachalam,located in Khammam district, Andhra Pradesh. The tribal People prepare alcohol (called vippa or ippa sara in Telugu) from this flower by their own brewing techniques and consume in their social and cultural gatherings. Its botanical name is Madhuca Indica and common English name is Mahua or Butter tree. In Indian languages it is called Mahua /Mauwa in Hindi, Hippe in Kannada, and Vippa or Ippa in Telugu. These trees are widely found in India, are grown in Uttar Pradesh, Madhya Pradesh, Gujarat, Andhra Pradesh and Karnataka and monsoon forest of Western Ghats. The trees in Andhra Pradesh are tall and reach a height of 20-25 feet. Flowering of mahua occurs in February-April. The fruits ripen in June-July and fall off soon after ripening. They start giving flowers and fruits between 10th and 15th year after plantations. An average sized tree yields about 50 -100 kg flower in a season that lasts around a month. One mahua tree has an annual average yield of 62.5 kg of flower and 59 kg of gully. The major fatty acid contents are oleic (37.21)Stearic(25.96), Palmitic(19.93) and Linoleic (14.740)

Fig: 1.1 Mahua plant with flower

Fig: 1.2 Mahua dried flower (Right) & cotyledons (Left)

2.0 Methodology

2.1 Preparation of Esters:

2.1.1HEATING

Before esterification fatty acids contains some moisturizing and dust particles in it. Due to low temperature those will be accumulated in the oil. In order to remove them the oil should be allowed to heat up to its boiling point , so that all the dust particles present in it will be formed as a layer and the moisturizing particles will be evaporated. This process is done for 30 minutes around. Now the oil is very clean to undergo the process..

2.1. 2 COOLING

Before tending to esterification the heated oil should be cooled. Because if we add alcohol to the heat oil the added alcohol will be decomposed as its boiling point is very low (i.e. 65 C).

2.1.3 ADDING KOH & METHANOL

After cooling, the oil is ready for the esterification. Cooled oil should be collected in a round bottomed flask and placed on magnetic stirrer by setting its temperature below 65 C as shown in fig. Now we have to add methanol of required quantity to the stirring oil. After methanol getting dissolved in it KOH as catalyst is added to the stirring oil. So that the esters are formed in the oil as a precipitation. This process is done for around 45 minutes.

2.1.4 PRECIPITATION

Now the oil should be collected in a separating funnel and kept a side for a day to form layers of precipitates. Arrangement is done as per the following figure. After forming the precipitate the separated oil should be sent for distillation and the collected precipitate has many uses.

2.1.5 *SEPERATION DISTILLATION:*

This is the process in which the methanol present in the oil is removed. Here if the oil is heated above the boiling point of methanol it starts evaporating. That is collected by distillation process. Here the evaporated methanol is cooled by the water flowing through the evaporation pipe. That evaporated methanol is cooled and converted to liquid and collected in a conical flask. This process is done for long time till an hard layer is formed on the oil.

Ulf Schuchardta et all discussed the transesterification process with methanol as well as the main uses of the fatty acid methyl esters. The general aspects of this process and the applicability of different types of catalysts (acids, alkaline metal hydroxides, alkoxides and carbonates, enzymes and non-ionic bases, such as amines, amidines, guanidines and triamino(imino)phosphoranes) are presented. Several applications of fatty acid esters, obtained by transesterification of vegetable oils, are described. Sanjib Kumar Karmee et prepared biodiesel from crude pun gam oil by using KOH as catalyst and methanol. The conversion was 92% at 60^0C with 1:10 molar ratio (oil: methanol) for KOH (1% by wt) catalyzed transesterification. The fuel properties compared well with accepted biodiesel standards i.e. ASTM and German biodiesel standards. Barnwal et al made an attempt to review the biodiesel production technologies, its utilization in existing diesel engines and environmental aspects. Fangrui Ma et al discussed the different methods for producing biodiesel from natural oils and fats. The main factors affecting transesterification are reported to be molar ratio of glycerides to alcohol, catalysts, reaction temperature and time and the contents of free fatty acids and water in oils and fats. The commonly accepted molar ratio of alcohol to glycerides is 6:1. Base catalysts are more effective than acid catalysts and enzymes. The recommended amount of base catalyst is between 0.1 and 1% w/w of oils and fats. Higher reaction temperatures speed up the reaction and shorten the reaction time. The reaction is slow at the beginning for a short time and than proceeds quickly and than slows down again. Base catalyzed transesterification's are basically completed within one hour.

2.2 *Transesterification of Mahua oil*

Biodiesel refers to a diesel equivalent, processed fuel which is derived from biological sources .It is defined by the World Customs Organizations (WCO) as "a mixture of mono-alcohol esters of long chain (C16-18) fatty acids derived from vegetable oil or animal fat, which is a domestic renewable fuel for diesel engines ".despite being energetically favorable, direct use of straight vegetable oils in fuel engines is problematic. Due to high viscosity (about 11 to 17 times higher than diesel fuel) and low volatility, they do not burn completely and form deposits in the fuel injector of diesel engines. The high molecular weight and the chemical structure of vegetable oils contribute to their high viscosity. The high viscosity of vegetable oils creates operational problems like difficulty in engine starting, unreliable ignition and deterioration in thermal efficiency. In long term use, durability problems like nozzle coking, carbon deposition in different parts of the engine and lubricating oil dilution are encountered. Further more, acrolein (a highly toxic substance) is formed through thermal decomposition of glycerol. Several production methodologies have been reported. This includes

1. Blending of oil
2. Micro emulsion,
3. Cracking or Pyrolysis
4. Pre-heating &
5. Transesterification.

Among these the transesterification is the commonly used commercial process to produce clean and environmental friendly fuel. Methyl / ethyl esters of sunflower oil rice bran oil, palm oil or edible oil and also, are expensive. Hence they are not suitable for use as feed stock for Biodiesel production in economical way. The non-edible oils such as jatropha oil and karanja oil, even though attractive due to their low cost, requires considerable amount of land and time for cultivation. Mahua oils provide a viable alternative to diesel, as they are easily available. This contains some degradation products of vegetable oils and foreign material. These impurities can be removed by heating and filtration. It has been reported that a cetane number of Mahua oil methyl ester is around 42 and it demonstrates its potential to replace diesel.

Transesterification is the general term used to describe an important class of organic reactions where ester is transformed into another by interchange of the alkoxymoisty. Transesterification involves stripping the glycerin from the fatty acids with a catalyst such as sodium or potassium hydroxide and replacing it with an anhydrous alcohol, that is usually methanol. The resulting raw product is than centrifuged and washed with water to clean it of impurities. This is methyl or ethyl ester as well as a smaller amount of glycerol, a valuable by –product used in making soaps, cosmetics and numerous other products. The three basic methods of ester production from oil /fat or the base-catalyzed transesterification, the acid –catalyzed esterification and enzymatic catalysis. The most commonly used method among this is the base catalyzed transesterification technique as it is the most economical process.

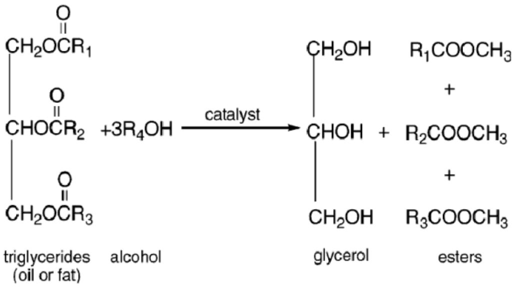


Table 2.1 PROPERTIES OF MEMS

Property	Unit	mahua seed oil	MEMS
Density	kg/m^3	820	885
Kinematic viscosity	c St	36.7	4.73
Flash point	$^{\circ}$C	290	142
Calorific value	kJ/kg	37750	38650
Acid value	Mg KOH/g	3.05	0.08

3.0 EXPERIMENTAL SETUP

The experimental set up consists of engine, an alternator, top load system, fuel tank along with immersion heater, exhaust gas measuring digital device and manometer.

3.1 Engine

The engine is from VNR-VJIET. The engine is single cylinder vertical type four stroke, water cooled, compression ignition engine. The engine is self governed type whose specifications are given in Appendix 1 is used in the present work.

3.2 Reasons for selecting the engine

The above engine is one of the extensively used engines in agricultural and industrial sector in India. This engine can withstand the peak pressures encountered because of its original high compression ratio. Further, the necessary modifications on the cylinder head and piston crown can be easily carried out in this type of engine. Hence this engine is selected for the present project work.

3.3 Dynamometer

The engine is coupled to a generated type electrical dynamometer which is provided for loading the engine. Fuel injection pump is driven by consuming some part of the power produced by the engine. It will provide the required pressure to the injector. The pump is BOSCH fuel injection pump.

3.4 Fuel injector(BOSCH)

A cross sectional view of a typical BOSCH fuel injector is shown in Appendix 1.

The injector assembly consists of

1. A needle valve 2. A compression spring 3. A nozzle & 4. An injector body

3.5 U-tube manometer

The one end of the U-tube manometer is connected to the orifice of the air tank and the other end is exposed to the atmosphere, the manometer liquid used is water.

3.6 Digital thermometer

It consists of a temperature sensing element connected to the electronic digital display which is operated by battery.

3.7 Various parts of experimental set up

1. Fuel injector with immersed heater
2. Manual stirrer
3. Graduated burette
4. Water inlet pipe
5. Engine
6. Water outlet pipe
7. Air filter
8. Exhaust pipe
9. Air suction tank
10. Manometer
11. Digital thermometer
12. Series of lamps
13. Ammeter
14. Voltmeter
15. Energymeter
16. Connections to the loading system
17. Alternator

4.0 EXPERIMENTAL PROCEDURE

Before starting the engine, the fuel injector is separated from the fuel system. It is clamped on the fuel injection pressure tester and operate the tester pump. Observe the pressure reading from the dial at which the injector starts spraying. In order to achieve the required pressure by adjusting the screw provided at the top of the injector.

Initially, the diesel alone is allowed to run the engine for about 20 minutes so that it gets warmed up and steady state running conditions are attained. Before starting the engine, the lubricating oil level in the engine is checked and it is also ensured that all moving and rotating parts are lubricated. The cooling water flow rate is properly adjusted.

After the steady state conditions are attained, the following observations are noted at each load.

i. Load on dynamometer
ii. Time taken for 10cc fuel consumption

iii. Manometer reading of air flow meter to complete air consumption
iv. The reading of digital electronic device for exhaust gas temperature
v. The inlet and outlet water temperatures using thermometer
vi. Time taken for 2 liters of cooling water for calculation of water flow rate.
vii. Reading from voltmeter and ammeter.
The above experiment is repeated for various loads on the engine.

The experimental procedure is similar as foresaid. While starting the engine, the fuel tank is filled in required fuel proportions up to its capacity. The engine is allowed to run for 20 minutes, for steady state conditions before load is applied.
The test is carried on the engine for the following fuel blends.
1.100% MEMS
2. 90% MEMS+10% Diesel- B10
3.80% MEMS+20% Diesel- B20
4.100% Diesel

4.1 MEASUREMENTS

4.1.1 Measurement of brake power

The power developed by the engine is measured by using electrical dynamometer. The pump is run by using the power developed by the engine. The total power is obtained by adding pump power to the product of voltage and current.

4.1.2 Measurement of fuel

The fuel flow is measured by volume through a burette tube which is fixed between fuel tank and fuel pump. A T-joint prepared and one side of it is connected to the fuel measuring tube. The remaining two sides of the joints are connected to the fuel tank and fuel pump respectively. Fuel flow is measured by noting the time taken for 10cc of fuel consumption by stop watch.

4.1.3 Measurement of air flow

Air flow is measured by using a viscous flow air meter. A paper element filter is an integral part of the meter. The meter consists of an orifice, the pressure drop across the orifice is measured by manometer, is ensured that there are no leakages in the connecting tubing.

4.1.4 Measurement of heat balance quantities

The rate of water flow and its inlet & outlet temperature are necessary to measure the heat carried away by the cooling water. The rate of water circulated in the cylinder jacket is measured by collecting the outflow water in 2 L jar. Heat carried away by cooling water per minute vise equal to the weight of water flow per minute multiplied by rise in temperature.

The heat carried away by exhaust gases is determined by knowing exhaust gas temperature, room temperature and weight of exhaust gases and the value of specific heat of exhaust gases. The total heat input, heat equivalent of BP and heat equivalent of FP are also calculated to find the unaccounted heat.

4.1.5 Measurement of exhaust gas temperature:

The temperature of exhaust gas is measured by using digital electronic devices. It gives the exhaust gas temperature directly.

5.0 Calculations & Graphs

The parameters that are determined at different loads are as follows:

- Brake Power (kW) = Voltage x Current / 1000 = B.P = VI / 1000
- Total Fuel Consumption (kg/hr)
  T.F.C = (Fuel consumption in ml x Sp. gr x 3600) / (1000 x Time of Fuel Consumption)
- Density of air (ρ_a) = Pressure / (Universal Gas Const x Room Temp in K)
  = P/RT = (1.01325 x 10^5) / (287 x (29 +273))
- Air Consumption (m^3/hr) = Area of the suction pipe (m^2) x Anemometer Reading (m/hr)
- Specific Fuel Consumption (kg/ kW-hr) = S.F.C = T.F.C/ B.P
- Swept Volume (m^3/hr) = π/4 x d^2x l x n x N/2 x 60
- Volumetric efficiency (%) = A.C in m^3/hr/ Swept Volume in m^3/hr
- Mass Flow rate of Cooling water (M.F.R) = 3600 / (t/2) kg/hr
- Heat input of Fuel (H.F) = (T.F.C x C.V)/60 kJ/min
- Heat carried away by cooling water (H.C) = (M.F.R x T x 4.18)/60 kJ/min
- % of Heat input = (H.C or H.E or H.B or h_f)/H.F x 100 kJ/min
- Mass Flow rate of Exhaust Gases = A.C + T.F.C kg/hr
- Heat carried away by Exhaust gases (H.E) = M.E x C_p x d_t /60 kJ/min
- Heat Equivalent to B.P (H.B) = B.P x 60 kJ/min
- Heat Equivalent to F.P = h_f = F.P x 60 kJ/min

- Heat Unaccounted (H.U) = H.F – (H.C + H.E + H.B + h_f) kJ/min
- I.P = B.P + F.P kW
- $\eta_{th(B)}$ % = B.P / H.F x 100
- $\eta_{th(I)}$ % = I.P / H.F x 100
- η_{mech} % = B.P / IP x 100

5.1.1 Sample Calculations For 100% Diesel:

B.P = VI / 1000
= 225 x 3.55 / 1000
= 0.80 kW
T.F.C = (Fuel consumption x Sp. gr x 3600) / 1000 x Time of Fuel Consumption in sec
= (10 x 0.885 x 3600) / 1000 x 56.85
= 0.56 kg/hr
Density of air (ρ_a) = P/RT = (1.01325 x 10^5) / 287 x (29 +273)
= 1.173 kg/m^3
A.C (m^3/hr) = Area of the suction pipe (m^2) x Anemometer Reading (m/hr)
= π/4 x (5.08 x 10^{-2})^{2}x 7.1
= 14.38 m^3/hr
S.F.C = T.F.C/ B.P
= 0.56 / 0.80
= 0.7 kg / kW-hr
Swept Volume = π/4 x d^2x l x n x N/2 x 60
= π/4 x (80 x 10^{-3})^{2}x 110 x 10^{-3}x 1 x 1500/2 x 60
= 24.885 m^3/hr
Volumetric efficiency (%) = A.C in m^3/hr/ Swept Volume in m^3/hr
= 14.38 / 24.885
= 57.80 %
Time for 2L water collection (t) = 4.93 sec

Mass Flow rate of Cooling water (M.F.R) = 3600 / (t/2) = 1460.44 kg/hr

Heat input of Fuel (H.F) = (T.F.C x C.V)/60
= (0.56 x 42,650)/60 = 404.6 KJ/min

Heat carried away by cooling water (H.C) = (M.F.R x T x 4.18)/60
= 101.74 KJ/min
As % of Heat input = H.C/H.F x 100
= 101.74/404.6 x 100
= 25.15 %

Mass Flow rate of Exhaust Gases = A.C + T.F.C
= 16.87 + 0.56
= 17.43 kg/hr

Rise in Exhaust gas Temperature = 1.0 °C

Heat carried away by Exhaust gases (H.E) = M.E x C_p x d_t /60
= 17.43 x 1.005 x 1/6 = 47.00 KJ/min
As % of heat input = H.E/H.F x 100
= 47/404.6 x 100
= 11.62 %
Heat Equivalent to B.P (H.B) = B.P x 60
= 0.8 x 60
= 48 kJ/min
As % of Heat input = H.B/H.F x 100
= 48/404.6 x 100
= 11.86 %
Heat Equivalent to F.P = h_f = F.P x 60
= 1.6 x 60
= 96 kJ/min
As % of Heat input = h_f / H.F x 100
= 96/404.6 x 100
= 23.73 %
Heat Unaccounted (H.U) = H.F – (H.C + H.E + H.B + h_f)
= 404.6 – (101.74 +47 + 48 + 96)
= 111.86 kJ/min
As % of Heat input = H.U / H.F x 100
= 111.86 / 404.6 x 100 = 27.65 %
I.P = B.P + F.P
= 0.80 + 1.6
= 2.4 kW
$\eta_{th(B)}$ % = B.P / H.F x 100
= 48 / 404.6 x 100
= 11.86 %
$\eta_{th(I)}$ % = I.P / H.F x 100
= 144 / 404.6 x 100
= 35.59 %
η_{mech}% = B.P / IP x 100
= 48 / 144 x 100
= 33.32 %

5.1.2 Engine Soft Test Report

Engine Details :

ICEngine set up under test is Research Diesel having power 3.50 kW @ 1500 rpm which is 1 Cylinder, Four stroke , Constant Speed, Water Cooled, Diesel Engine, with Cylinder Bore 87.50(mm), Stroke Length 110.00(mm), Connecting Rod length 234.00(mm), Compression Ratio 18.00, Swept volume 661.45 (cc)

Combustion Parameters :

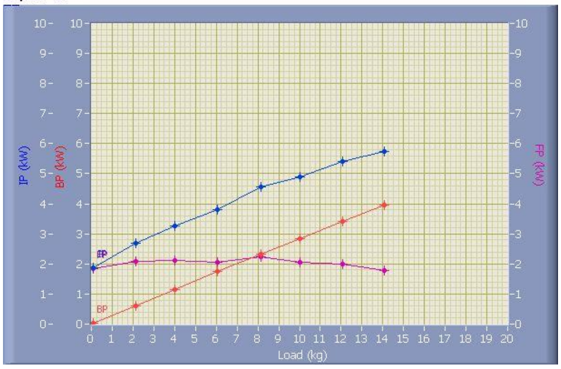
Specific Gas Const (kJ/kgK) : 1.00, Air Density (kg/m^3) : 1.15, Adiabatic Index : 1.41, Polytrophic Index : 1.28, Number Of Cycles : 10, Cylinder Pressure Referance : 4, Smoothing 2, TDC Reference : 0

Performance Parameters :

Orifice Diameter (mm) : 20.00, Orifice Coeff. Of Discharge : 0.60, Dynamometer Arm Legnth (mm) : 185, Fuel Pipe dia (mm) : 12.40, Ambient Temp.

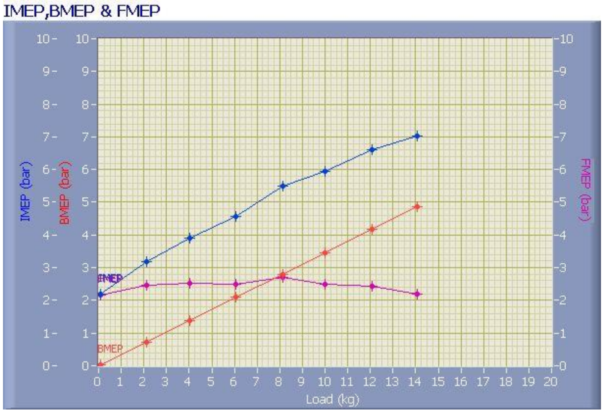
(Deg C) : 32, Pulses Per revolution : 360, Fuel Type : Diesel, Fuel Density (Kg/m^3) : 850, Calorific Value Of Fuel (kj/kg) : 50076

IP, BP &



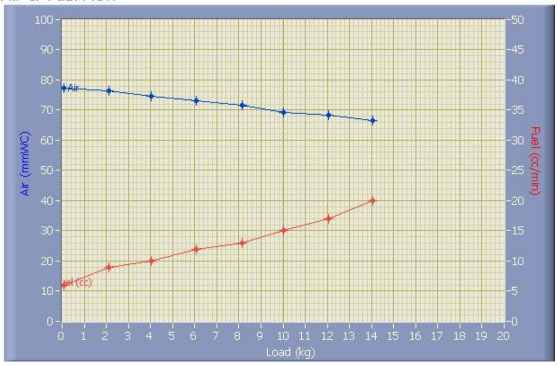
Speed (rpm)	Load (kg)	IP (kW)	BP (kW)	FP (kW)
1538.00	0.09	1.86	0.03	1.83
1527.00	2.12	2.69	0.62	2.07
1516.00	4.01	3.26	1.16	2.10
1513.00	6.07	3.81	1.75	2.07
1506.00	8.13	4.56	2.33	2.23
1494.00	10.00	4.89	2.84	2.05
1488.00	12.06	5.41	3.41	2.00
1482.00	14.07	5.75	3.96	1.78

IMEP,BMEP & FMEP



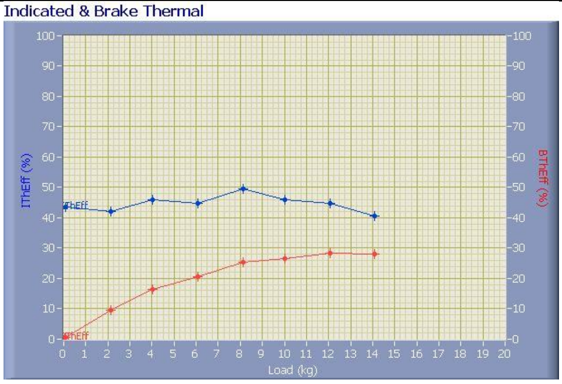
Speed (rpm)	Load (kg)	IMEP (bar)	BMEP (bar)	FMEP (bar)
1538.00	0.09	2.19	0.03	2.16
1527.00	2.12	3.19	0.73	2.46
1516.00	4.01	3.90	1.38	2.52
1513.00	6.07	4.57	2.09	2.48
1506.00	8.13	5.49	2.80	2.69
1494.00	10.00	5.93	3.45	2.49
1488.00	12.06	6.60	4.16	2.44
1482.00	14.07	7.03	4.85	2.18

Air & Fuel Flow



Speed (rpm)	Load (kg)	Air (mmWC)	Fuel (cc/min)
1538.00	0.09	77.24	6.00
1527.00	2.12	76.36	9.00
1516.00	4.01	74.55	10.00
1513.00	6.07	72.99	12.00
1506.00	8.13	71.52	13.00
1494.00	10.00	69.29	15.00
1488.00	12.06	68.39	17.00
1482.00	14.07	66.43	20.00

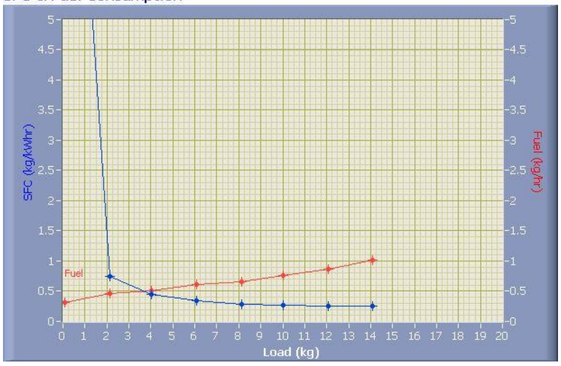
Indicated & Brake Thermal



Speed (rpm)	Load (kg)	IThEff (%)	BThEff (%)

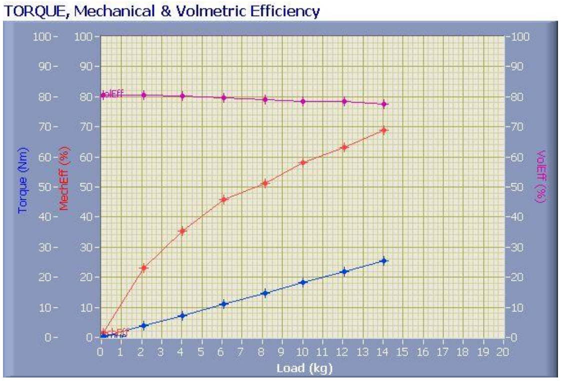
1538.00	0.09	43.67	0.61
1527.00	2.12	42.09	9.64
1516.00	4.01	45.97	16.30
1513.00	6.07	44.78	20.50
1506.00	8.13	49.43	25.23
1494.00	10.00	45.93	26.69
1488.00	12.06	44.86	28.29
1482.00	14.07	40.50	27.92

SFC & Fuel Consumption



Speed (rpm)	Load (kg)	SFC (kg/kWh)	Fuel (kg/h)
1538.00	0.09	11.76	0.31
1527.00	2.12	0.75	0.46
1516.00	4.01	0.44	0.51
1513.00	6.07	0.35	0.61
1506.00	8.13	0.28	0.66
1494.00	10.00	0.27	0.77
1488.00	12.06	0.25	0.87
1482.00	14.07	0.26	1.02

TORQUE, Mechanical & Volmetric Efficiency



Speed (rpm)	Load (Kg)	Torque (Nm)	Mech Eff. (%)	Vol Eff. (%)
1538.00	0.09	0.16	1.40	80.55
1527.00	2.12	3.85	22.91	80.67
1516.00	4.01	7.28	35.46	80.29
1513.00	6.07	11.02	45.79	79.60
1506.00	8.13	14.76	51.05	79.16
1494.00	10.00	18.15	58.11	78.54
1488.00	12.06	21.89	63.06	78.34
1482.00	14.07	25.53	68.95	77.52

Result data

Air Flow (kg/h)	Fuel Flow (kg/h)	SFC (kg/kWh)	Vol Eff. (%)	A/F Ratio	HBP (%)	HJW (%)	HGas (%)	HRad (%)
28.39	0.31	11.76	80.55	92.76	0.61	40.81	13.91	44.67
28.22	0.46	0.75	80.67	61.49	9.64	30.01	13.74	46.61
27.89	0.51	0.44	80.29	54.68	16.30	29.52	15.58	38.60
27.59	0.61	0.35	79.60	45.09	20.50	28.48	15.92	35.10
27.31	0.66	0.28	79.16	41.20	25.23	30.51	18.80	25.46
26.89	0.77	0.27	78.54	35.14	26.69	29.59	19.47	24.26
26.71	0.87	0.25	78.34	30.81	28.29	27.72	19.84	24.15
26.32	1.02	0.26	77.52	25.81	27.92	25.42	19.35	27.30

6. RESULTS AND DISCUSSIONS

Experiments have been conducted and performance curves are obtained for the following methyl esters of Mahua seed oil and its blends with diesel.

1. 90% Methyl esters of Mahua seed oil + 10%diesel
2. 80% Methyl esters of Mahua seed oil +20% diesel
3. 100% diesel

The curves of B.P, brake thermal efficiency, mechanical efficiency have been plotted for these samples, for varying load conditions. The individual performance curves for 100% methyl esters of Mahua seed oil sample are shown in figures.

6.1Engine Efficiencies

Mechanical Efficiency

It is observed that Mechanical efficiency increases with load and also increases with percentage of MEMS in the test fuel for all the loads and hence observed that Mechanical Efficiency of MEMS is 5.83% higher than that of pure Diesel.

6.1.2 Indicated Thermal Efficiency

It is observed that Indicated thermal efficiency increases with load and decreases with percentage of MEMS in the test fuel for all the loads. It is observed that the indicated thermal efficiency of MEMS is 8.27% higher than that of 100% Diesel.

6.1.3 Brake Thermal Efficiency

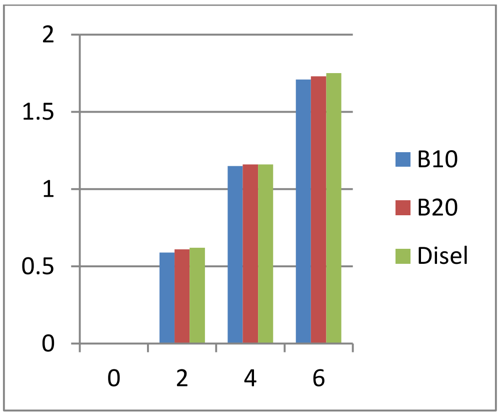
It is also observed that Brake thermal efficiency increases with load and decreases with percentage of MEMS in the test fuel for all the loads. Maximum thermal efficiency of 32.60% was attained using a blend of 90% D and 10% MEMS.

6.1.4 Exhaust Gas Temperature

It is observed that the Exhaust gas temperatures were higher for MEMS than Diesel also observed that it increases with load because more fuel is burnt at higher loads to meet the power requirement and it increases with percentage of MEMS in the test fuel for all the loads. The exhaust gas temperature is maximum for 100% MEMS and it is 63% higher than that of 100% Diesel.

6.1.5 Specific Fuel Consumption

It is observed that the minimum Specific Fuel Consumption using 100% MEMS was 39.64% higher than that of diesel. The differences in SFC may be a reflection of higher density and lower calorific value of MEMS compared to those of Diesel. The main reason for the improvement in SFC may be the reduction in Viscosity and better spray atomization.



Graph 6.1: comparison between diesel , B10&B20 Blend BP(KW)

Based on the result, 0.1% of high BP for Diesel than bio Diesel.

7. CONCLUSION

An existing 4 – stroke CI engine running with diesel is selected and tested with different blends of methyl esters of Mahua seed oiland diesel and their blends for obtaining different engine performance characteristic curves.

So methyl esters of Mahua seed oiland its blends with diesel replace diesel with in the range of experiment. The performance is expected to be as good as 100% diesel. Transest erified Mahua seed oilwill have viscosity which is comparable to that of diesel. So there is no need of pre-heating of oil.

Methyl esters of Mahua seed oilblends permits acceptable engine performance. The most important property of Mahua seed oilthat affect the engine durability is viscosity. The viscosity of the Mahua seed oilwas brought into acceptable limits by transesterification. The esters form stable blends with biodiesel oil.

The following conclusions are drawn.

1. The Mechanical Efficiency of 100% Diesel is observed as 63.06 and that of a blend of 10% MEMS and 90% Diesel is 65.53. The Mechanical Efficiency of the blend of 10% MEMS and 90% Diesel is 3.91% higher than that of 100% Diesel.
2. The Brake Thermal Efficiency of a blend of 10% MEMS and 90% Diesel is 13.87%. higher than that Diesel.
3. The Indicated thermal efficiency of a blend of 10% MEMS and 90% Diesel is 8.271% higher than that of the Diesel.
4. The Specific Fuel Consumption for a blend of 10% MEMS and 90% Diesel is 38.43% higher than that of the Diesel.
5. The Volumetric efficiency for blend of 10% MEMS and 90% Diesel is is 0.06% less than that of the Diesel.
6. Based on the result ,the 17.08% of SMOKE in Diesel higher than B10.
7. Based on the result ,the **14.58% of NO_x** in Diesel higher than B10.
8. Based on the result ,the 18.66% of CO_2 in Diesel higher than B10.
9. Based on the result ,the 3.48% of O_2 in B10 higher than Diesel.
10. Based on the result ,the 18.66% of CO_2 in Diesel higher than B10.
11. Based on the result ,the 7.5% of HC in Diesel higher than B10.
12. Based on the result ,the 38.33% of CO in Diesel higher than B10.
13. Flash and fire points are comparatively higher for esters, thus reducing fire hazards.
14. Engine shows better performance with MEMS blends with diesel rather than pure diesel.
15. Mahua seed oilis an economic choice for biodiesel production because of its availability and low cost.

Hence, the use of the ester blends can be effective in existing diesel engines with out an engine modification. The use of these esters as partial diesel substitutes can boost the economy.

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