EXPERIMENTAL INVESTIGATION ON THE USE OF MAHUA OIL IN A FOUR STROKE C.I. ENGINE

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Abstract. Developing countries are meeting their energy requirements through the bulk use of fossil fuels. Major amount of these countries exchequer is being spent on fossil fuels. Large-scale use of petrol & diesel is posing serious problem of depletion of petroleum fuels. Every research, which ensures development of viable alternative for diesel, is good for any country’s economy. So vegetable oil properties being very close to diesel fuel are the suitable alternatives for petrol & diesel. The engine is self-governed type. The viscosity of Mahua oil is approximately 10-15 times higher than diesel fuel. The performance characteristics are compared by running the engine with pure diesel, blends (Mahua +Diesel) with heating. Acceptable thermal efficiencies are obtained with the use of 50% Mahua oil and 50% diesel blend injection pressure at 200 atm., when the engine is run with the blend fuel.

1.Introduction:
The present source of fuels used in I.C engines viz. gasoline and diesel will deplete with in other 25 years if consumed at an increasing rate, which is estimated to be the order of 3% per annum. According to the survey carried out in the year 1994-95, in India the oil production is about 27 million tones and the oil consumption is about 64 million tones. As a result of it, oil is imported. During this year, India spent about Rs. 12,000 crores to import crude oil. From this data, it is clear that oil consumption in India is rising at an alarming rate where as the oil production is decreasing. Hence, there is an urgent need to develop alternate fuels for I.C. Engines. The use of vegetable oil as an alternative to diesel fuel is not a new concept. In fact early engines were demonstranated with vegetable oils. In a developing country such as India where mass transportation plays a key role, the suitability of alternate fuels for a diesel engine like cetane number and calorific value similar to diesel. They have
heat contents approximately 80-90% of diesel fuel. Vegetable oils have better ignition qualities for diesel engine than light alcohol’s, their cetane number being over 30. There are many vegetable oils which can be used in diesel engines like peanut oil, linseed oil, grape seed oil, palm oil, silkworm pupae oil, simarouba oil, Mahua oil etc. Thus at this situation, a great importance has given to find alternate fuels for diesel and petrol [1]. The use of vegetable oils in normal diesel engine leads to problems because of their high viscosity, high carbon residue and the gum formation tendency. Out of various vegetable non-edible oils like Mahua oil has good scope, as fuel in diesel engine.

1. The viscosity of vegetable oils is much higher than that of diesel it can cause problems in fuel handling, pumping, atomization and fuel jet penetration [2]. This would require modification in the engine fuel system.

2. Vegetable oils are slower burning it can give rise to exhaust smoke fuel impinging on cylinder walls and lubricating oil contamination to overcome. This combustion system must be modified to speed up air fuel mixing. The indirect engines are more suitable than direct injection engines for vegetable oils because of a single relatively large size nozzle hole

We have been tried out to increase the performance by the following modifications.

1. Heating decreases the viscosity of vegetable oil. So that it can be atomized easily. In order to accomplish this, the oil is heated in between 650 to 900 c.

2. The normal injection pressure is increased from 150 kgf/cm² to 180 kgf/cm².

2. LITERATURE REVIEW

In tests conducted in Japan using a precombustion chamber type diesel engine fuelled by crude carcass oil and diesel blends and it is reported that thermal efficiency and emission were comparable to engine tests of using diesel oil [4]. Problems encountered including filtered blockage and carbon deposits at the injection nozzle and pre-combustion chamber. Engine failure due to fuel filter blockage occurred after two hours and 20 hours using 100% curcas oil and an equal blend of curcas to diesel oil respectively. Comparatively testing was carried out on farm diesel engines using 100% transesterised curcas, curcas diesel blends (25%-75%, 50%-50%, 100% diesel oil). Since the early 80’s numerous studies determined the effect of different plant oil base fuels on Co, Co₂, No, He and poly cyclic aromatic hydro carbons emission (PAH) tests have been done on 25%-diesel fuel, 50% of diesel fuels. The test with same proportion by using karanj and palm oil each at once have also been done. The research in I.C.engines and control of atmospheric pollution. Furthermore, the main fuel, petroleum is in danger of being used-up within next few decades [3]. Hence it has become imperatives for engineering graduates to evolve efficient and clean burning engines and also to develop alternative fuels and their combustion aspects.

3. EXPERIMENTAL SETUP

The experimental came upon consists of engine, associate generator, prime load system, fuel tank beside heating element, exhaust gas activity digital device and pressure gage.

Engine:

The engine which is supplied by M/s ANIL & Company. 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.

Reasons for selecting the engine
The engine is one amongst the extensively used engines in agricultural and industrial sector in Bharat. This engine will withstand the height pressures encountered as a result of its original high compression quantitative relation. Further, the required modifications on the plate and piston crown are often simply dispensed during this kind of engine. Hence this engine is chosen for the current project work.

4. ENGINE SPECIFICATIONS

Make of the engine : ANIL, RAJKOT
General details : Four stroke, compression ignition, constant speed, vertical, water cooled
Number of cylinders : One
Bore : 80mm
Stroke : 110mm
Swept volume : 553cc
Compression ratio : 16.5
Rated output : 3.7Kw at 1500rpm
Injection nozzle : MICO-BOSCH 3hole nozzle
Fuel injection pressure : 210atm
Injection timing : 27o C TDC (static for diesel)
Combustion chamber : Hemispherical, open combustion chamber

Figure 1: Experimental Setup

Dynamometer

The engine is coupled to a generated type electrical dynamometer which is provided for loading the engine.

Fuel injection pump
The 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.

**U-tube manometer**

The one of 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.

**Digital thermometer**

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

5. **Procedure:**

Before starting the engine, the fuel injector is separated from the fuel system. it is clamped on the fuel injection pressure tested and operates the tester pump. Observe the pressure reading from the dial. At which the injector starts spraying. Inorder to achieve the required pressure by adjusting the screw provided at the top of the injector. This procedure is repeated for obtaining the various required pressures.

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

i. Load on dynamometer
ii. Time taken for 10 cc 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 two liters of cooling water for calculation of water flow rate.
vii. Reading from voltmeter and ammeter
viii. Time taken for 10 revolutions of rotating disc in energy meter.

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 min, for steady state conditions, before load is performed.

We have not been observed any separation in the blend of 50% Mahua oil & 50% diesel. We have heated the blend about 70°C in order to reduce the viscosity for easy flowing in the tubes, better injection and atomization in the cylinder the viscosity is nearly equal to the viscosity of diesel. Finally, the engine is run by blend (200atm) at various injection pressures the corresponding observations are noted.

The test is carried on the Anil Engine for the following fuel blends:

1. 100% Diesel
2. 25% Diesel + 75% Mahua Oil
3. 50% Diesel + 50% Mahua Oil
4. 75% Diesel + 25% Mahua Oil
5. 100% Mahua Oil

6. Calculations:

For 100% Diesel:

\[ B.P = \frac{VI}{1000} = \frac{(220 \times 2.5)}{1000} = 0.55 \text{ KW} \]

\[ T.F.C = \frac{(\text{Fuel consumption} \times \text{Sp.gr.} \times 3600)}{1000 \times \text{Time of fuel consumption in sec}} \]

\[ = \frac{(10 \times 0.85 \times 3600)}{1000 \times 46} = 0.665 \]

Density of air (\( \rho_a \)) = \( \frac{P}{RT} = \frac{1.01325 \times 10^5}{287 \times (29 + 273)} = 1.169 \)

A.C = \( 140 \times \frac{Cd \sqrt{\rho_a h X 3600}}{4} \)

\[ = 140 \times 0.62 \times \frac{3.14}{4} \times (5.08) \times \sqrt{(4.5 \times 10^{-3} \times 360)} \times 3600 \]

\[ = 45.99 \]

S.F.C = \( \frac{T.F.C}{B.P} = \frac{0.665}{0.55} = 1.209 \text{ kg/kwhr} \)

Swept Volume = \( 3.14/4(80 \times 10^{-4})^2 \times 110 \times 10^{-3} \)

\[ = 0.559 \text{ m}^3 \]

A.C. Stroke = \( A.C \times 2 \times 1500 \times 60 \)

\[ = 45.99 \times 2 \times (0.832 \times 1500 \times 60) = 1.228 \text{ 10-3 Volumetric Efficiency} = (A.C \times \text{Stroke}) \]

\[ \times 100 / \text{ VS} = 0.0241 \text{ Time for 2Lt water Collection (t) = 4} \]

Mass Flow Rate of Cooling Water (W.F.R) = 3600/t X 2 W.F.R = 1800Kg/hr

Heat input of fuel (H.F) = \( T.F.C \times C.V / 60 \)

\[ = 465.5 \text{ KJ/min} \]

Heat Carried Away by Cooling Water (H.C) = \( W.F.R \times T \times 4018 \)

\[ = 1800 / 60 \times 1 \times 4.18 \]

\[ = 120.54 \text{ KJ/Min} \]

As % of Heat input = \( H.C / H.F \times 100 \)

\[ = 120.54 / 465.5 \times 100 \]
= 25.89

Mass Flow Rate of Exhaust Gases = A.C+T.F.C=M.E M.E = .665+A.C=45.665 kg/hr

Rise in Exhaust Gas Temperature = 150-29 = 121

Heat Carried Away By Exhaust Gases (H.E) = M.EXCpXdt/60

= M.EX1.005X121/60=1.3502

As % of Heat input = H.E/H.F X 100

=1.35 /465.5 X 100=0.29%

Heat Equivalent to B.P (H.B) = B.P X 60

=0.55X60

=33Kj/min

As % of Heat input = H.B/H.F X 100 =33/465.5 X 100
As % of Heat input = 7.089

Heat Equivalent TO F.P = hf = F.P X 60

=1.5 X60 =90 kw

As % of Heat input = hf/H.F X 100

=90 /465.5X100=19.33%

Heat Unaccounted (H.U) = H.F-(H.C+H.E+H.B+ hf)

= 465.5- (125.4+94.4+33+90)

= 122.7 kw

As % of Heat input = H.U/H.F X 100

= 122.7/465.5

= 26.35 %

I.P. = B.P. + F.P.

= 33 + 90 = 123 kw

th (B) % = B.P. / H.F. X 100

= 33 /465.5 X 100

= 07.08 %
th (I)% = \frac{IP}{HF} \times 100

= 123 / 465.5 \times 100

= 26.42 \%

mech % = \frac{BP}{IP} \times 100

= 33 / 123 \times 100

= 26.82 \%

7. TABULAR COLUMNS:

| Table 1: Values for Pure Diesel |
|-------------------------------|
| Elec trical reading( w)       | 0   | 500 | 1000 | 1500 | 2000 | 2500 |
| Speed (rpm)                   | 1500| 1500| 1500 | 1500 | 1500 | 1500 |
| Brake Power(kw)               | 0.55| 0.8 | 0.95 | 1.110| 1.387| 2.00 |
| Time For 10cc fuel consumpt ion se c | 46 | 41.70 | 37.32 | 34.34 | 32.40 | 28 |
| T.F.C(kg/hr)                  | 0.665| 0.734| 0.82 | 0.891| 0.994| 1.093 |
| S.F.C                         | 1.20 | 0.917| 0.863| 0.802| 0.680| 0.546 |
| Incl ine d manometer reading( mm) | 4.5 | 4.5 | 4.3 | 4.3 | 4.3 | 4.3 |
| A.C                           | 45.93| 45.93| 44.90| 44.90| 44.90| 44.90 |
| A/F Ratio                     | 69.06| 62.57| 54.75| 50.39| 47.56| 41.08 |
| IP                            | 123 | 138 | 147 | 156.6 | 173.2 | 210 |
| \eta_{\text{th (d)}}         | 7.08 | 9.34 | 9.9 | 10.67 | 12.59 | 15.68 |
| \eta_{\text{th (l)}}         | 26.42| 26.85| 25.60| 25.10| 26.21| 27.44 |
### Table 2: Values for 50% MahuaOil and 50% Diesel

|                      | 0      | 500    | 1000   | 1500   | 2000   | 2500   |
|----------------------|--------|--------|--------|--------|--------|--------|
| Electrical reading(w)|        |        |        |        |        |        |
|                      |        |        |        |        |        |        |
| Speed (rpm)          | 1500   | 1500   | 1500   | 1500   | 1500   | 1500   |
| Brake Power (kw)     | .66    | .8     | 1.11   | 1.35   | 1.66   |        |
| Time For 10cc fuel   | 54.8   | 41     | 42.3   | 36.9   | 33.2   | 30.5   |
| consumption (sec)    |        |        |        |        |        |        |
| T.F.C (kg/hr)        | 0.55   | .72    | .74    | .82    | .92    | 1.003  |
| S.F.C                | .83    | .9     | .74    | .72    | .68    | .6     |
| Inclined name thread | 4.5    | 4.4    | 4      | 4      | 4      | 4      |
| Inclined name thread |        |        |        |        |        |        |
| Time For 10cc fuel   | 54.8   | 41     | 42.3   | 36.9   | 33.2   | 30.5   |
| consumption (sec)    |        |        |        |        |        |        |
| T.F.C (kg/hr)        | 0.55   | .72    | .74    | .82    | .92    | 1.003  |
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| S.F.C                | .83    | .9     | .74    | .72    | .68    | .6     |
| Inclined name thread | 4.5    | 4.4    | 4      | 4      | 4      | 4      |
| Inclined name thread |        |        |        |        |        |        |
| Time For 10cc fuel   | 54.8   | 41     | 42.3   | 36.9   | 33.2   | 30.5   |
| consumption (sec)    |        |        |        |        |        |        |
| T.F.C (kg/hr)        | 0.55   | .72    | .74    | .82    | .92    | 1.003  |
| S.F.C                | .83    | .9     | .74    | .72    | .68    | .6     |
| Inclined name thread | 4.5    | 4.4    | 4      | 4      | 4      | 4      |
| Inclined name thread |        |        |        |        |        |        |
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| S.F.C                | .83    | .9     | .74    | .72    | .68    | .6     |
| Inclined name thread | 4.5    | 4.4    | 4      | 4      | 4      | 4      |
| Inclined name thread |        |        |        |        |        |        |
| Time For 10cc fuel   | 54.8   | 41     | 42.3   | 36.9   | 33.2   | 30.5   |
| consumption (sec)    |        |        |        |        |        |        |
| T.F.C (kg/hr)        | 0.55   | .72    | .74    | .82    | .92    | 1.003  |
| S.F.C                | .83    | .9     | .74    | .72    | .68    | .6     |
| Inclined name thread | 4.5    | 4.4    | 4      | 4      | 4      | 4      |
| Inclined name thread |        |        |        |        |        |        |
| Time For 10cc fuel   | 54.8   | 41     | 42.3   | 36.9   | 33.2   | 30.5   |
| consumption (sec)    |        |        |        |        |        |        |
1.4 Brake Power Vs Total Fuel Consumption

50% Mahua Oil & 50% Diesel

1.2

1.0

0.8

0.6

0.4

0.2

0.0

-0.2 -0.4 -0.6 -0.8 -1.0 -1.2 -1.4 -1.6 -1.8 -2.0

BRAKE POWER

Figure 2: Brake power vs TFC

1.2 Brake Power Vs Specific Fuel Consumption

50% Mahua Oil & 50% Diesel

1.0

0.8

0.6

0.4

0.2

0.0

-0.2 -0.4 -0.6 -0.8 -1.0 -1.2 -1.4 -1.6 -1.8 -2.0

BRAKE POWER

Figure 3: Brake vs TFC for Mahua oil

0.6 Brake Power Vs Specific Fuel Consumption

Pure Diesel

0.5

0.4

0.3

0.2

0.1

0.0

-0.1 -0.2 -0.3 -0.4 -0.5 -0.6 -0.7 -0.8 -0.9 -1.0

BRAKE POWER

Figure 4 Brake Power vs SFC for Mahua oil

450 Brake Power Vs Exhaust Gas Temperature

50% Mahua Oil & 50% Diesel

400

350

300

250

200

150

100

50

0

0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0

BRAKE POWER

Figure 6 Brake Power vs EGT for Mahua oil

450 Brake Power Vs Exhaust Gas Temperature

Pure Diesel

400

350

300

250

200

150

100

50

0

0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0

BRAKE POWER

Figure 7 Brake Power vs EGT for Mahua oil
10

Figure 8 Brake Power vs BTE for Mahua oil

Figure 9 Brake Power vs BTE for Diesel

Figure 10 Brake Power vs ITE for Pure diesel

Figure 11 Brake Power vs ITE for Mahua oil

Figure 12 and 13 Bp vs ME for mahua
HB = Heat equivalent to Brake Power
HC = Heat carried away by Cooling water
HE = Heat carried away by Exhaust Gases
HF = Heat input of Fuel
HU = Heat Unaccounted
8. RESULTS AND DISCUSSIONS

Results pertaining to MAHUA oil:

We have done experiments on the ANIL engine with pure diesel and blends of Mahua oil and diesel. In order to compare the performance of the engine with pure diesel and blend, we are discussing the following various results on the basis of brake power (BP)

Engine Efficiencies

Apart from expressing engine performance in terms of power, it is essential to express in terms of efficiencies.

THERMAL EFFICIENCY

a. Indicated and Brake Thermal Efficiency

These efficiencies give an idea of the output generated by the engine with respect to heat supplied in the form of fuel. From fig. show the indicated thermal efficiency for blend is more than the pure diesel. Fig. shows the brake thermal efficiency for blend is more than pure diesel. Due to high content of oxygen in vegetable oils, the combustion takes place within short time, the m.e.p. increases then B.P. increases.

b. Mechanical Efficiency

Mechanical efficiency indicates how good an engine is, in converting the indicated power to useful power. Fig. shows the mechanical efficiency for blend is less than the pure diesel. Because higher fuel-injection pressures increases the degree of atomization. The fitness of atomization reduces ignition lag.

c. Specific fuel consumption

The fuel consumption characteristics of an engine are generally expressed in terms of specific fuel consumption. Fig depicted that the fuel consumption for the blend is less than the pure diesel at all injection pressures. The B.P. developed by the engine for the blend is greater than the B.P. developed for diesel.

d. Exhaust Gas Temperature

From fig. it signifies that the exhaust gas temperature for the blend is less than the pure diesel. During dissociation the heat is observed and the value is decremented.
9. Conclusion

Experimental work is conducted on various fuel blends of Mahua oil and diesel to ascertain the suitability of Mahua blends for an ANIL diesel engine.

From the results and discussions the following conclusions are drawn.

- As the energy content of Bio-Diesel blends is less, specific fuel consumption values are higher than that of pure diesel.
- The mechanical efficiency of the fuel blends is seen to be nearer to that of pure diesel.
- The indicated thermal efficiency of 100% diesel is higher than the Bio-Diesel fuel because fuel consumption using the various blends is more.
- The brake thermal efficiency is less for fuel blends as compared to pure diesel and can be improved by modifying the fuel injector pump.
- Of all these blends 50% oil & 50% diesel gives closer values to that of pure diesel and is recommended for use in Single cylinder, four stroke, ANIL engine.

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