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Performance analysis of CI engines using blends of Bio-diesel as fuel

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Abstract: ***Diesel engine is a popular prime mover in rural areas, particularly in the places where electrical power is not available. The rapid depletion of fossil fuel with increased environmental concern has stimulated worldwide efforts to produce alternative to diesel. The fuel of bio-origin may be the biodiesel obtained from edible or non-edible vegetable oil through transesterification process. Most of the properties of biodiesel compare favorably with the characteristics required for CI fuel. This fuel in the form of blend with diesel performs almost as neat diesel fuel with no engine modification. Honge oil is non-edible vegetable oil and coconut is edible oil. In the present investigation the blends of proportion B20 is made for Honge (Pongamia) Oil Methyl Ester (POME) and coconut Oil Methyl Ester (COME) with diesel were used to run a single cylinder CI engine and significant improvements in engine performance was noticed for combined blends of POME and COME. This project presents the performance analysis of CI engines using pongamia, coconut oil and their combined blends with diesel.***

Keywords: about four key words separated by commas**.**

1. Introduction

The world is based on transportation of goods & resources from one place to another place. This involves lot of media like airways, waterways, Roadways, Railways etc. depending upon the distances, the particular media is employed. There are about millions of vehicles all around the world for transportation of goods, passengers etc. The vehicle size varies depending upon the quantity of goods and resources. These operate with fuels like gasoline, Diesel, Gas etc. The more attention is given for Diesel fuels since it is used widely compare to other fuels. There will be depletion of these resources, since they are non-renewable alternate fuel are employed.

The vegetable oils are most widely used alternate fuel in place of diesel and vegetable oils have been evaluated as a partial or complete substitute to diesel fuel They have better ignition qualities for diesel engines; their cetane number is over 40. Moreover the vegetable oils cannot be used directly as a fuel because the viscosity of vegetable oil is much higher than that of diesel. It can cause problems in fuel handling, pumping, atomizing etc. Also vegetable oils are slower burning. Hence conversion is required. There are thousands of vegetable oils among that Honge oil and coconut oil are taken based on lubricity and higher calorific value.

2. Transesterification Process

The Transesterification is the process used for preparation of Bio-Diesel using vegetable oils. Bio-Diesel is a mono-alkyl esters of long chain fatty acids derived from vegetable oils. It is chemically called Free Fatty Acid Alkyl Ester. Even though "diesel" is part of its name, there is no petroleum or other fossil fuels in biodiesel. Biodiesel refers to the pure fuel before blending with diesel fuel. The Reaction is as shown below

CH_2OCOR'''			CH_2OH		R'''COOR
|			|		
CH_2OCOR'''	+	3ROH ⟶	CH_2OH	+	R'''COOR
|			|		
CH_2OCOR'''			CH_2OH		R'''COOR
Oil or Fat		Alcohol (3)	Glycerin		Bio-Diesel (3)

Biodiesel is a substitute fuel for compression-ignition internal combustion engines. It is produced by the transesterification of waste or vegetable oils and animal oils, or fats with lower alcohols. Biodiesel is a clean burning fuel made from vegetable oils. Biodiesel is made up of almost 10% oxygen, making it a naturally "oxygenated" fuel. It is obtained by reaction of vegetable oil with alcohol in presence of catalyst.

The NBB has also formed the National Biodiesel Accreditation Commission that has put into place an accreditation program for companies selling biodiesel and biodiesel blends. It has approval for biodiesel marketers, and provides the consuming public with additional assurances and confidence that biodiesel purchased form a Certified Biodiesel Marketer will meet ASTM specifications. Once the program has been fully implemented, NBB recommends that all biodiesel marketers become certified, and that all biodiesel consumers specify the purchase of biodiesel from NBAC Certified Marketers. [8]

3. Methodology

The Transesterification process experimental Setup Consists of the followings Water bath with Temperature Control, Air – Cooled Condenser, Round Bottom flask, Separating funnel, Weight Measuring Device.

Preparation of Catalyst with alcohol:
Approximately 4-6g of NaOH pallets is weighed and dissolved in a 250ml methyl alcohol and stir it well for about 5 to 8 minutes. Then the solute particles will dissolves into solvent and forms a solution having base catalyst.

Reaction:
The vegetable oil is mixed with methanol dissolved in NAOH for about 1:2-2.5 ratio, Suppose if the vegetable oil taken is 200ml then 400ml of methanol with NaOH is added and then treated in a round bottom flask. Then the round bottom flask and its mixture are kept in water bath. The water bath has a temperature Control and the temperature is set for about 60-80^{0}C to maintain uniform temperature distribution as shown in figure 3.1. The flask mixture kept in a water bath for heating to about 5 to 6 hrs. After some time there will be layers created due to density difference.

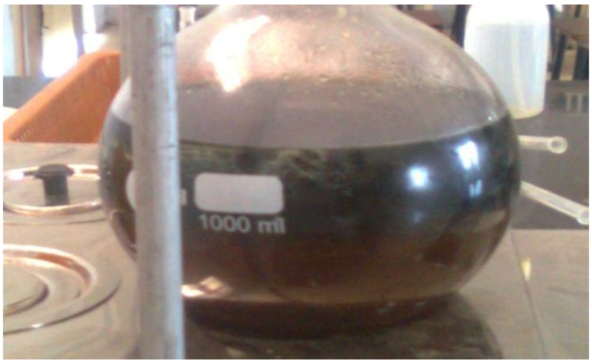

Fig 3.1 Reaction of Vegetable oil and Methano

Separation:
The Mixture is separated using a separating funnel and it is kept around 2hrs as shown in figure 3.2. Then there will be a precipitation of oils on bottom of the separating funnel and the bio-diesel will be at above layer. Finally the bio-diesel is separated and it contains impurities and catalyst.

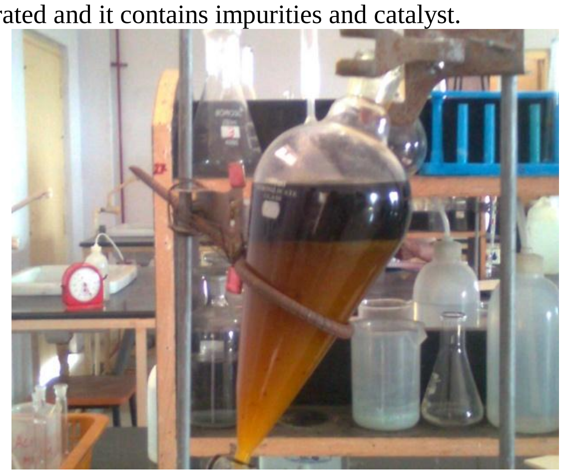

Fig 3.2 Separation of Bio-diesel and impurities of Honge oil

Removal of glycerin:
The glycerin phase is much denser than biodiesel phase and the two can be gravity separated with glycerin simply drawn off the bottom of the settling vessel. In some cases, a centrifuge is used to separate the two materials faster as shown in figure 3.3. Acid wash is done if it contains more impurities. So that impurities are neutralized.

Fig 3.3: Removal of Impurities

Removal of catalyst:
The biodiesel is mixed with acid as well as hot water and treated in a separating funnel for about 3-4hrs as shown in figure 3.4. Then acid and water absorbs the Base NaOH by neutralization reaction and forms salt. This salt is separated and finally pure bio-diesel is obtained.

Fig 3.4 Removal of Catalyst

B. PROPERTIES TEST

As CI engines are designed to run with diesel as fuel, alternative fuels need to have properties closer to that of diesel, large variation in properties may lead to erratic running of engine and may cause damage, poor performance. The following are the some of the properties test

1. Flash and Fire Point
2. Density and Viscosity
3. Calorific Value

Flash and Fire Point:
The flash point of oil is the minimum temperature at which vapor is given off at a sufficient rate to form an inflammable mixture but not supporting continuous combustion. The Fire Point of oil is the minimum temperature at which, rate of evaporation is sufficient to provide for continuous combustion. Knowledge of these two points is used to safeguard against the risk of fire when the lubrication oil is exposed to high temperature in service. Ignition delay and combustion pattern have their dependency on flash and fire point of the fuel as shown in figure 3.5.

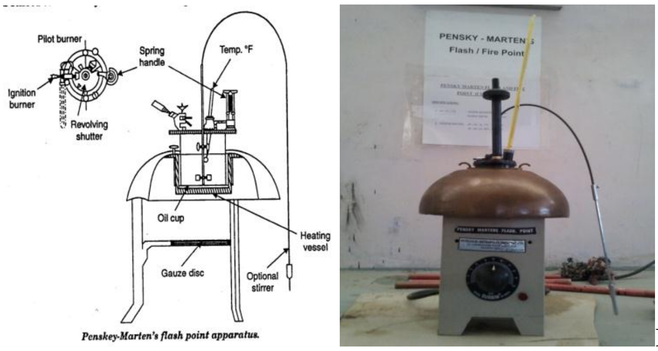

Fig 3.5 Flash Point and Fire point Experimental Apparatus

The below table shows the flash and fire point of various oils and diesel obtained in experimentation

FUELS	FLASH POINT (in ^{o}C)	FIRE POINT (in ^{o}C)
Diesel	45	54
Pongamia Methyl Ester	46	57
Coconut Methyl Ester	47	57

Table 3.1 Flash point & Fire point of various fuels

Density and Viscosity:

Viscosity is that properly where by the liquid resists a change in its shape, it is also refer to as internal friction. Viscosity decreases with an increase in temperature. The viscosity is determined in saybolt viscometer as shown in figure 3.6

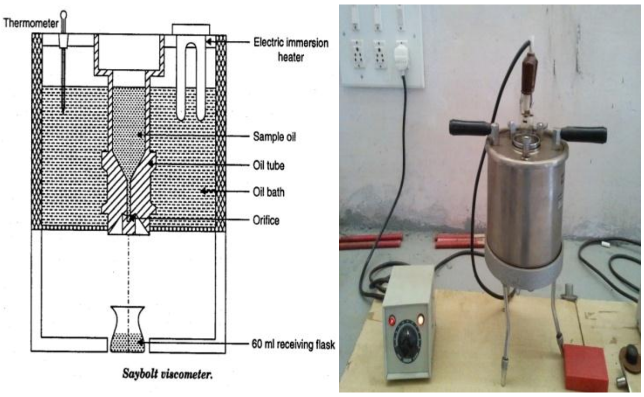

Fig 3.2 Density and viscosity Apparatus (Saybolt Viscometer)

The below table shows the Density and specific Gravity of various fuels

FUELS	SPECIFIC GRAVITY	DENSITY (Kg/m^3)
Diesel	0.833	833.33
Pongamia Methyl Ester	0.9	900
Coconut Methyl Ester	0.85	850

Table 3.3 Specific Gravity and Density of various fuels

The below table shows the Viscosity of various fuels

FUELS	TEMPERATURE (in ^{o}C)	VISCOSITY (Poise)
Diesel	41	1.503
Pongamia Methyl Ester	46	2.36
Coconut Methyl Ester	46	1.53

Table 3.4 Viscosity of various fuels

Calorific Value:

Calorific value decides heat energy released in combustion. The combustion process generates water vapor and certain techniques may be used to recover the quantity of heat contained in this water vapor by condensing it.

The Table 3.5 gives the calorific value of various fuels

FUELS	CALORIFIC VALUE (MJ/Kg)
Diesel	42
Pongamia Methyl Ester	36.21
Coconut Methyl Ester	42

Table 3.5 Calorific Value of various fuels

4. Experimental Test RIG

The test rig consisted of a four-stroke greaves make Diesel engine, coupled Mechanical dynamometer. The engine is water-cooled type and therefore both load test as well as Heat balance sheet can be conducted. It runs at a Maximum speed of 1500 rpm. The test rig is complete with base, air measurement system, and fuel measurement system and temperature measurement arrangement using thermocouples to measure temperature digitally. The specifications of engine is as shown in figure 4.1 which has

Cylinder Bore	D = 80 mm
Cylinder Stroke	L = 110 mm
Brake Horse Power	B H P = 10HP
Rated Speed	N = 1500 rpm
Make	Kirloskar
Type	Naturally aspirated
Loading Type	Mechanical

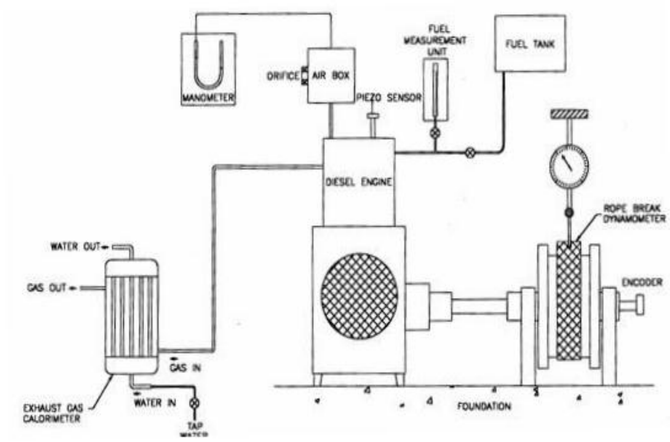

Fig 4.1 Diesel engine Specifications

The experimental procedure of performance analysis of CI engine in this test is first Check the lubrication system of the engine and fuel tank level and Allow the water to Circulate through the cylinder block and Calorimeter. Then Start the engine using the push button. After that Load the engine in steps of 3 kgs (3,6,9) and Note down the readings of Engine speed, Time taken for 10 cc of Fuel consumed and Net brake load. Repeat procedure for different loads. Finally stop the engine by first removing the load on the engine and then cutting of the fuel supply and Continue experimentation for about 20 trials and take the final reading of all average of 20trials obtained.

B. FORMULAE USED FOR CALCULATIONS

(1) Quantity of fuel used, $M_f = \dfrac{Xcc \times SG}{1000 \times t}$ (in Kg/ Sec)

Where Xcc = Volume of fuel Consumed (10cc)
SG = Specific Gravity of the fuel
t = Time taken for fuel consumed (10cc)

(2) Heat in fuel supplied to the Engine:

$Q_f = m_f \times CV$ (in KW)

Where, CV = Calorific Value Of fuel in (KJ/Kg)

(3) Brake Power Output, B.P = $\dfrac{2 * \pi * N * T}{60{,}000}$ (in KW)

Where, T = Torque in (KN-m) = P*r*9.81
P = Net Load in Kg
r = Radius of rope (0.15m)
N = Rated rpm of the Engine (1500rpm)

(4) Specific Fuel Consumption

S.F.C = $\dfrac{m_f \times 3600}{BP}$ (in Kg/KW-Hr)

(5) Brake Thermal Efficiency (BTE), $\eta_{BTE} = \dfrac{BP}{Q_f}$

(6) Brake Mean Effective Pressure (BMEP)

BMEP = $\dfrac{60 * BP}{100 * L * A * N * k * n * 100}$ (in bars)

Where, L = Stroke Length (0.11m)
D = Bore diameter (0.08m)
A = Area of Cylinder ($A = \pi D^2 / 4$)($A = 5.02E\text{-}03 m^2$)
k = Stroke type (4 Stroke K=0.5)
n = Number of Cylinders (n=1)

5. Results And Discussions

1 Diesel and B20 POME

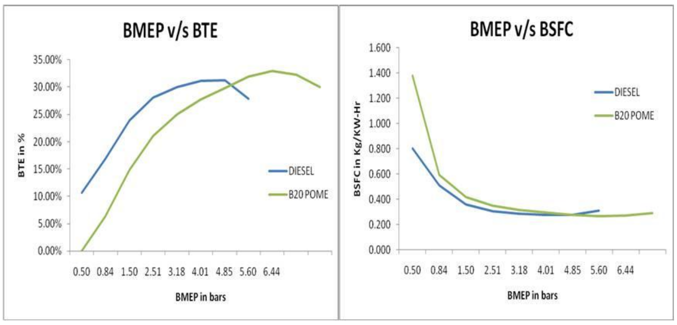

Fig 5.1 Performace graphs of Diesel and B20 POME

By the above comparision shown in fifure 5.1 the B20 POME has a better perfoemance as Diesel Engines and gives very good performance than diesel. The engine runs very smoother due to self lubricity of POME. So it can be used as alternate fuel for CI engines.

2 Diesel and B20 COME

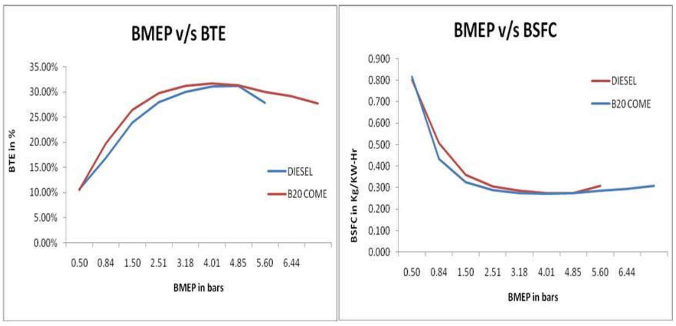

Fig 5.2 Performace graphs of Diesel and B20 COME

By the above comparision shown in Fig 5.2 the B20 COME has matched performance with diesel but the performance can be improved by mixing COME with other oil blends.

3 Diesel and B20 COMBINED OIL

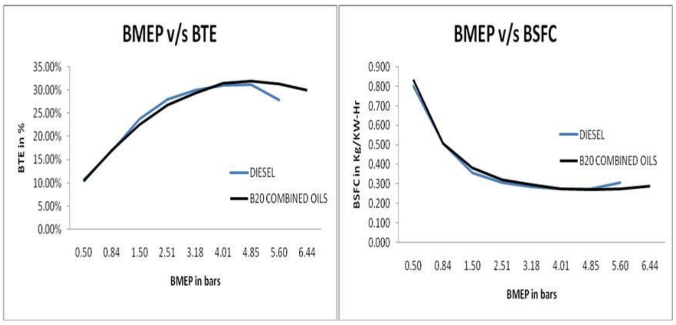

Fig 5.3 Performace graphs of Diesel and B20 COMBINED OIL (50% POME 50% COME)

By the above comparision the B20 Combined has a nice perfoemance as Diesel Engines. The engine runs very smoother due to self lubricity of POME and higher calorific value due to COME. By mixing the oils one can achive 2 to 3 properties at a time. So it can be used as alternate fuel for CI engines.

4 Various blends and diesel

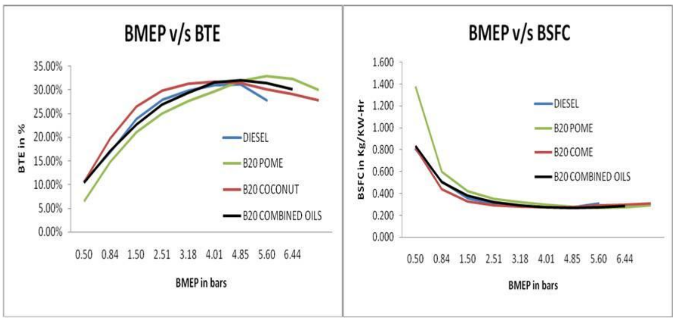

Fig 5.4 Performace graphs of Diesel and Various Blends

The graph shows that variation of Brake Thermal efficiency with various types of biodiesel blends. At the net load 17 kg, the BTE value of diesel is around 30%. The COME has an BTE of 32.3% and the BTE of POME is around 31% and for Combined oil is 30.5%. The diesel has a less BTE compared to all others blends at higher loads meaning that any vegetable oil blends will have high BTE than diesel at higher loads. Among all the blends the B20 COME has high BTE than B20 POME and B20 combined oil.

The graph shows that variation of Brake Specific Fuel Consumption with various types of biodiesel blends. At the net load 17 kg, the BSFC value of diesel is around 0.28 Kg/Kw-Hr. The combines oil has an BSFC of 0.274Kg/KW-Hr and the BSFC of POME is around 0.275Kg/KW-Hr and for COME is 0.270Kg/KW-Hr. The diesel has a more BSFC compared to all others blends meaning that any vegetable oil blends will have less BSFC than diesel. Among all the blends the B20

Combined Oil has lowest BSFC than B20 POME and B20 COME.

6. Conclusions

- In this work it is observed that B20 used as a fuel in CI engines makes the power delivery smoother and performance considerably closer to that of diesel as fuel as shown by many of the researchers.

- Blend B20 with POME showed slightly lower brake thermal efficiency and slightly higher but closer BSFC when compared to that of pure diesel all over the range of loading. Even though Calorific value of POME is lower than that of diesel probably self lubricity is the reason for showing closer performance when compared to pure diesel.

- Blend B20 with COME showed higher brake thermal efficiency and lower BSFC when compared to that of pure diesel all over the range of loading. This is because of higher calorific value of COME.

- Combined B20 with 50% POME and 50% COME showed almost the same trend of performance as that of diesel and this can be analyzed as higher calorific value of COME and self lubricity of POME improves the performance of other methyl esters when it is blended.

- As all desired properties and qualities cannot be expected. In a methyl ester of any oil, combined biodiesels made up by blending suitably selected methyl esters of different oils pose as strong contenders to pure diesel as fuels in CI engines.

- The only drawback is that there is no blend which satisfies all the properties at a same time. This can be improved with some engine modifications. Hence there is a wide scope for further research

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