Performance Analysis of CI Engine using Biodiesel Blends of Coconut Oil and Honge Oil

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Abstract— The accessibility of energy resources plays a key role in the development of a country. Over the last few decades, there is an augment in the utilization of energy worldwide resulting in the exhaustion of fossil fuels. This necessitates craving on other countries for energy resources. Therefore, a renewable eco-friendly alternate fuel has to be replaced in place of fossil fuel which can be vegetable oils as an alternate fuel for diesel. Since, oils are more viscous it cannot be used directly in CI engines without any engine modification thus; an alteration of vegetable oils to biodiesel is done by a Tran's esterification process. The present paper is restricted to Bio fuel substitute for the production of diesel which can be achieved from a number of edible and non-edible oil resources. The oil obtained from these seeds of different categories was Trans esterified by suitable method depending on their FFA content to achieve the optimum level of biodiesel. The obtained biodiesel was used to run the CI-Engine and analysis was done with all the standard parameters. Finally, the blends of Cocos Nucifera and Pongamia Pinnata Bio-Diesel were used to evaluate the efficiency of CI-Engine system by employing variable reaction mixtures to determine the performance of the CI-Engine using Trans esterified methyl ester blends with diesel.
Key words: CI Engine, Biodiesel Blends, Coconut Oil and Honge Oil

I. INTRODUCTION

Energy is the primary mover of profitable growth and plays an essential role in sustaining the modern economy and society. The energy crisis and environmental pollution are of alarming concern worldwide. The international energy markets have relied heavily on fossil fuels like coal, crude oils and natural gas which provides most of the world's supply of primary energy needs. The extensive worldwide use of fossil fuels not only threatened to energy security but also resulted in serious environmental problems particularly, climatic detrimental changes. One of the key challenges facing the world is how to meet the growing energy needs and sustain economic growth without contributing any pollutants which alters the climate harmfully. The cleaner renewable sources of energy with cost-effectiveness are the vital solution to combat the issues of global energy crisis. The ethanol and bio-diesel are the two liquid bio fuels that can substitute gasoline, diesel respectively.

Thus the study helps to determine the best alternate fuel for diesel powered CI engines.

II. CHEMICAL CONVERSION PROCESS

Vegetable oils are in general called as Tri-Glycerides. These Glycerides are long chain fatty acids. The composition of fatty acids must be ensured before conversion. The amount of fatty acids affects the quality of oil, longer the chain of fatty acids oil will be more viscous in nature. The FFA (Free Fatty Acid test) test determines the composition by titrating the oil with base with known normality.

Initially FFA test is carried out by taking 10g of oil, 50ml of isopropyl alcohol and 2 to 3 drops of 0.1N NaOH which is a base catalyst is added to a conical flask which is then heated upto 60°C, shake the mixture and allow it to cool upto room temperature. Later add 2 to 3 drops of phenolphthalein indicator to the mixture.

Titrate the mixture against 0.1N NaOH through burette until pale pink colour appears. Note down volume of NaOH consumed from burette and calculate the FFA using the formula

$$FFA\ (\%) = 0.282V$$

If amount of FFA is less than 4% single stage Transesterification Process is Preferred and If amount of FFA is greater than 4% Double stage is preferred. Bio-diesel is an alternate fuel for Compression-Ignition engines. It is produced by the transesterification vegetable oils and fats with lower alcohols. Bio-diesel is a clean burning fuel made from vegetable oils. Bio-diesel 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.

III. MATERIALS & METHODOLOGY

The survey was conducted in the regions of Mysuru district to obtain firsthand information from lead farmers followed by merchants respectively. The samples were procured from seed and oil merchants for further study.

A. Oil Extraction from the Seed Samples

The selected seed samples were subjected for oil extraction using suitable blenders and unit. The oils were statistically evaluated for its quality and quantity using standard procedure.

B. Transesterification Process

The transesterification experimental setup consists of automated Water bath with Temperature Control, Air-cooled Condenser, Round Bottom flask (1000ml), Separating funnel (1000ml), Electronic weighing machine, Conical flask, Test tube, Burette and Stirrer.

The Chemicals used in the transesterification process were of Methanol (CH3OH), Sodium Hydroxide (NaOH) pallets, Iso-propyl alcohol (C3H7OH) and Phenolphthalein indicator. The steps involved in this process are described below.

Approximately 3.5-6g of NaOH pellets is weighed and dissolved in a 300ml methanol and after stirring well for about 10 minutes. Then the solute particles will dissolves into solvent and forms a solution having base catalyst which is a methoxide mixture.

The Reaction is as follows.

1 mol Triglyceride + 1 mol Alcohol $\longrightarrow$ 1

mol Triglyceride + 1 mol RCOOR1
1 mol Triglyceride + 1 mol Alcohol ⟶ 1
mol Monoglyceride + 1 mol Alcohol
1 mol Monoglyceride + 1 mol RCOOR2 ⟶ 1
mol Glycerol + 1 mol RCOOR3

The 1litre of vegetable oil is taken into round bottom flask and heated upto 65^{0}C with continuous stirring. At 65^{0}C add 300ml methoxide mixture continue heating for half an hour, the color changes from turbid orange to chilly red. Drain a sample into test tube and allow it to settle (2 Distinct layers are observed due to density difference) Run the process for another 1½ hour

Fig. 1:

C. *Separation*

Transfer the mixture to separating funnel and allow glycerin to settle for 2 hours. Then there will be a precipitation of oil on bottom of the separating funnel and the bio-diesel will stays at the top which is as shown in finally the bio-diesel is separated and it contains glycerin and catalyst. Drain the glycerin layer and store it. Transfer the biodiesel to plastic washing apparatus.

D. *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 4.3. Acid wash is done if it contains more impurities. So that impurities are neutralized.

E. *Fuel Preparation*

The Trans-esterified biodiesel is chemically added with conventional diesel. It is evident that dilution or blending of vegetable oil with other fuels like diesel fuel would bring the viscosity close to a specification range. Therefore,

Jatropha oil was blended with diesel oil in varying pro-portions with the intention of reducing its viscosity [4, 5]. Using this fuel, the engine test is performed in our laboratory for various proportions and the following results have been obtained which is as shown in tables.

IV. PROPERTY TEST

The following are some of the properties test conducted.

1) Flash and Fire Point
2) Specific gravity and Density
3) Viscosity
4) Calorific Value

A. *Flash & 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 oil is exposed to high temperature in service. Ignition delay and combustion pattern have their dependency on flash and fire point of the fuel which as shown in figure 4

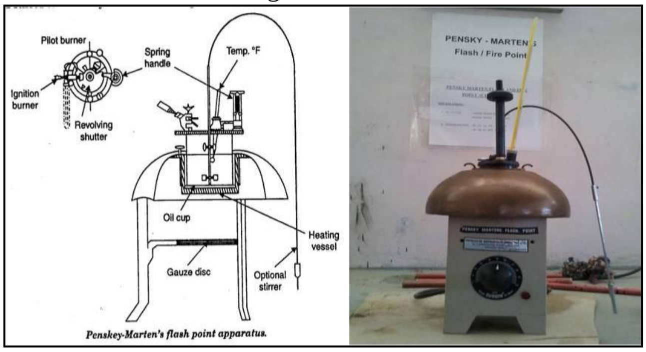

Fig. 2:

B. *Specific Gravity & Density*

Specific gravity is also called as relative density which is defined as the weight of liquid sample to weight of standard liquid. Generally distilled water is chosen as standard liquid. The specific gravity for bio-diesel is given by

Density of the liquid is defined as the ratio of weight per unit volume for liquids. The density can be calculated by using specific gravity. Density = 1000 x Specific Gravity.

$$SG = \frac{\text{Weight of the liquid sample}}{\text{weight of standard liquid}}$$

C. *Viscosity*

Viscosity is that property of the liquid that 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 by say bolt viscometer which as shown in figure 5.

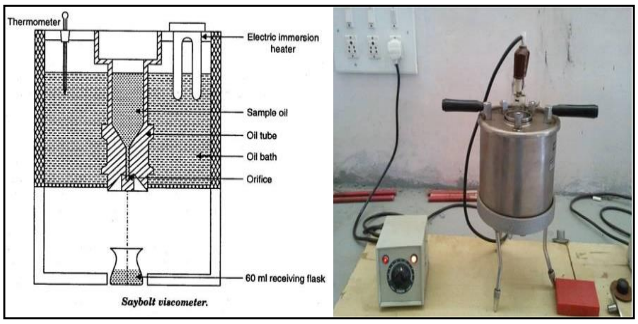

Fig. 3:

Type/Properties	Diesel	Honge	Coconut
Flash Point(°C)	65	137	113
Fire Point (°C)	82	149	128
Density (g/cm3)	814	820	834
Kinematic Viscosity	15.38	14.02	14.86
Specific Gravity	0.814	0.834	0.821

Calorific Value kj/kg	42000	35462	34838

Table 1: Properties Test Results of Diesel, Coconut Oil & Honge Oil

D. Formulae used for Calculations

1) Total Fuel Consumption

- Mf = (Xcc*SG)/(1000*t) Kg/sec
- Specific Fuel Consumption
- BSFC = (Mf*3600)/BP Kg/KW-hr
- Brake Power
- BP = (2*∏*N*T)/60 KW
- Brake Mean Effective Pressure
- BMEP = (BP*60000)/(LANK) KPa
- Heat in fuel supplied to Engine
- Hf= Mf*CV KW
- Brake Thermal Efficiency
- η_{bth} = BP/Hf

E. Experimental Rig

The study was carried out in the laboratory comprising of a single cylinder, water cooled, and four stroke Diesel engine connected to mechanical type loading. The setup is provided with constant speed of 1500rpm and variable mechanical loading. The specifications of the engine are as follows

Make	: Kirloskar
Model	: TV1
Fuel	: Diesel
No of cylinder	: 1
Cooling type	: Water
Compression ratio	: 17.5:1
Rated power	: 7hp @ 1500rpm
Bore and stroke	: 80mm and 110mm
Torque	: 1500rpm
Fuel injection pressure	: 175bar

V. PERFORMANCE TEST

Engine performance is an indication of the degree of success of the engine performs its assigned task, i.e. the conversion of the chemical energy contained in the fuel into the useful mechanical work. The performance of an engine is evaluated on the basis of the following

A. Brake Power (B.P)

The power developed at the output shaft of the engine is termed as Brake Power; it is the power available at the crankshaft of the engine.

B. Specific Fuel Consumption (SFC)

It is defined as the ration of fuel consumed per unit time to power output.

C. Brake Thermal Efficiency (BTE)

It is the ratio of output shaft power (Brake power) to the Heat input supplied to the engine.

D. Brake Mean Effective Pressure (BMEP)

Mean effective Pressure is defined as a hypothetical pressure which is thought to be acting on the piston throughout the power stroke. If the mean effective pressure is based on Brake power then it is called as Brake Mean Effective Pressure (BMEP).

Fig. 4: CI Engine

VI. RESULTS & DISCUSSION

A. Coconut Biodiesel Blends

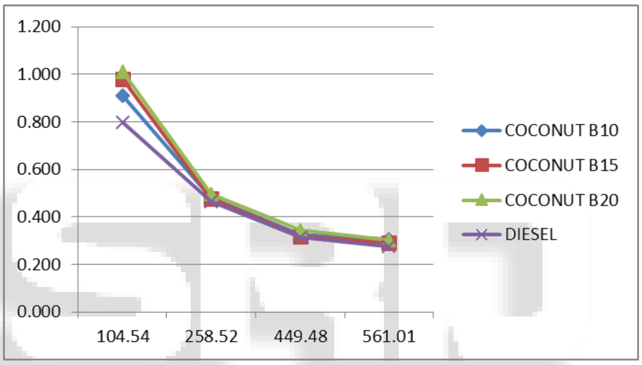

Fig. 5: BMEP (Kpa) vs BSFC (Kg/KW-hr)

The graph shows the variation of BMEP with respect to BSFC that for coconut biodiesel blends. From the graph it is clear that BSFC decreases with increase BMEP this variation occurs for the increment loads. The conventional diesel has less BSFC.

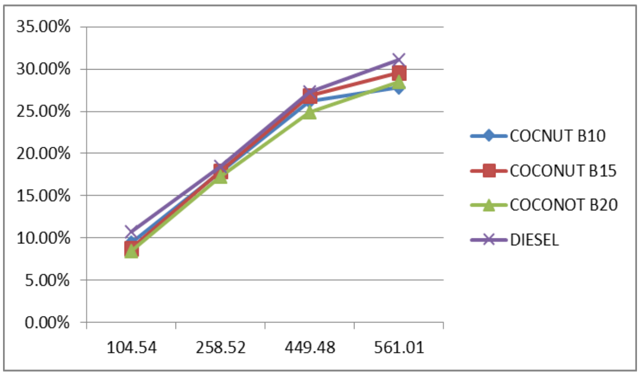

Fig. 6: BMEP (Kpa) vs BTE

The figure shows the variation of BMEP with respect to BTE graph for coconut biodiesel blends. From the graph it is clear that brake thermal efficiency increases with increase brake mean effective pressure but BTE is having little maximum value for conventional diesel fuel.

B. Honge Biodiesel Blends

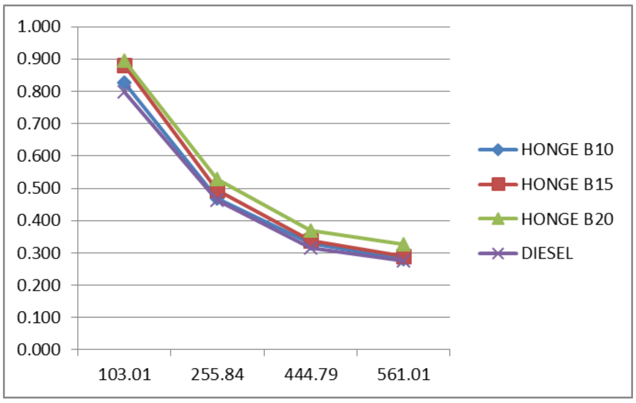

Fig. 7: BMEP (Kpa) vs BSFC (Kg/KW-hr)

The graph shows the variation of BMEP with respect to BSFC that for Honge biodiesel blends. From the graph it is clear that BSFC decreases with increase BMEP this variation occurs for the increment loads. The conventional diesel has less BSFC

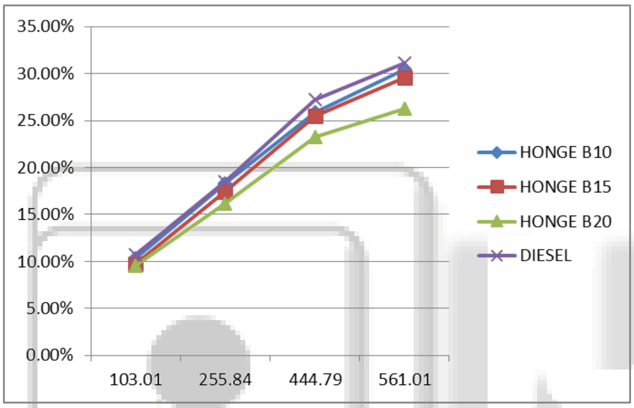

Fig. 8: BMEP (Kpa) vs BTE

The figure shows the variation of BMEP with respect to BTE graph for Honge biodiesel blends. From the graph it is clear that brake thermal efficiency increases with increase brake mean effective pressure but BTE is having little maximum value for conventional diesel fuel.

VII. CONCLUSION

The conclusions deriving from present study is to evaluate the tests which are conducted on 4-stroke, single cylinder, water cooled and direct injection diesel engine by using Coconut oil Methyl Ester biodiesel blends of B10, B15 and B20, Honge oil Methyl Ester biodiesel blends of B10, B15 and B20 with pure diesel at constant speed of 2000 rpm. From the better efficiency point of view it can be conclude that the blend B20 has better performance in the sense of Brake Thermal Efficiency, Specific Fuel Consumption. No engine seizing, injector blocking was found during the entire operation while the engine running with different blends of Biodiesel. The B20 sample is giving best performance than other blends. Also B20 has greater thermal efficiency and lesser specific fuel consumption compared to Diesel and B10, B15 blends.

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