Effect of Soapnut Bio-Diesel Blends With Petro-Diesel as Engine Fuels on Performance Parameters of a Single Cylinder Four Stroke CI Engine

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Abstract— In order to meet increasing global demand for energy and to compensate for the depletion of fossil fuel supplies in coming years, some alternative clean energy sources is a need. Bio-diesels are one of the alternative fuels which can minimize the consumption of fossil fuels and can also meet the environmental concerns. In our work, the feasibility of Soapnut (Sapindus Mukorossi) bio-diesel is being investigated experimentally on engine performance. Soapnut bio-diesel blends with petro-diesel were tested on four stroke cylinder CI engine and the engine performance parameters were studied for low, medium and high loads on blends B5, B10 and B20 without any modification in engine design.

Key words: Bio-Diesel, Alternative Fuels, Soapnut Bio-Diesel, Engine Performance Parameters

I. Introduction

Modern lifestyles demand a steady, reliable supply of energy. It lies at the heart of our mobility, our prosperity and our daily comfort. A high rise in the energy demand is observed globally and it thus is partially result of the need of economic growth and development in order to reduce the difference between the countries. Non renewable energy sources are being depleted at rapid rate these days. If this continues, the earth will be completely exhausted of all its natural energy reserves within few years. Another negative effect is that the ozone layer is getting thinner which also leads to warming up the earth. Bio-diesel is made through a chemical process which is called as “Transesterification” whereby glycerine is separated from the fat or vegetable oil. The process leaves behind two products-methyl esters and glycerine. The National Bio-diesel Board (USA) also has a technical definition of "bio-diesel" as a mono-alkyl ester. Due to the concern on the availability of recoverable fossil fuel reserves and the environmental problems caused by the use those fossil fuels, considerable attention has been given to bio-diesel production as an alternative to petro-diesel. However, as the bio-diesel is produced from vegetable oils and animal fats, there are concerns that bio-diesel feedstock may compete with food supply in the long-term. Hence, the recent focus is to find oil bearing plants that produce non-edible oils as the feedstock for bio-diesel production. Blends of bio-diesel and conventional hydrocarbon-based diesel are products most commonly distributed for use in the retail diesel fuel marketplace. Much of the world uses a system known as the "B" factor to state the amount of bio-diesel in any fuel mix.

- 100% bio-diesel is referred to as B100.
- 20% bio-diesel, 80% petro diesel is labelled as B20.
- 5% bio-diesel, 95% petro diesel is labelled as B5.
- 2% bio-diesel, 98% petro diesel is labelled as B2.

In this experiment B5, B10, B20 blends and petro diesel was used as fuel to check performance of CI engine. Below are advantages and disadvantages of bio-diesel.

A. *Advantages*

1) Bio-diesel is made from renewable resources and has lower toxicity.
2) Bio-diesel feed stocks are readily and easily available.
3) Bio-diesel is biologically degradable and thus reduces the danger of soil contamination.
4) Bio-diesel refineries are comparatively simpler and more environmental friendly.
5) Effect of using Blends of Soapnut Bio-Diesel with Petro-Diesel as Engine Fuels on Performance Parameters of a Single Cylinder Four Stroke Diesel Engine.
6) Bio-diesel performs just as well as petro-diesel and can be blended up to 40% with petro-diesel without engine modification.
7) Bio-diesel causes less environmental pollution and toxic hazards.
8) Bio-diesel has a higher cetane number and lubricity rating.
9) Bio-diesel is relatively less inflammable, easy to handle and store.

B. *Disadvantages*

1) At present, Bio-diesel fuel is about one and a half times more expensive than petroleum diesel fuel.
2) It requires more energy to produce bio-diesel fuel from crops, plus there is the energy of sowing, fertilizing and harvesting.

II. System development

A. *Parameter Selection*

To study the performance characteristics of an engine, parameter is to be considered, the change in this parameter results in the change in performance characteristics. The parameter selected throughout the experimentation is:-

1) *Variable engine load.*

Engine performance characteristics plotted against the above parameter *i.e.* engine load are:-

- Engine speed.
- Brake power.
- Torque
- Brake specific fuel consumption (BSFC).

These are the most important parameters for deciding the usefulness of the fuel.

B. Preparation of Biodiesel

To prepare biodiesel from soapnut following procedure must be adopted:

- Taking out soapnut seeds from the soapnut fruit.
- Extracting oil from the soapnut seeds.
- Executing trans-esterification reaction on the soapnut oil.
- Separating out the by-products and biodiesel produced after reaction.

Soapnut fruit consists of seed as the inner part and kernel as the outer part. For the preparation of the biodiesel only the inner part i.e. seeds are useful. Removing out the kernel is a must and it can be done by simply hammering the fruit by some weight. A small oil extracting machine is used for extracting oil. It's an electrically driven machine with belt and gear drive for the transfer of power. The seeds are put in the hopper where the blade is continuously rotating with the help of gear derive mechanism which puts a proportionate amount of seeds into the main extracting machine part from one side. The main machine part consists of a cylindrical rod horizontally placed which applies compressive force on the seeds and extracts oil from it. The residual is thrown out from the other side of the rod. The process continues till the hopper is emptied. The oil obtained is filtered and collected in the container.

Biodiesel is produced from edible or non-edible oil through a trans-esterification reaction. This chemical reaction converts oil into a mixture of esters of the fatty acids that makes up the oil (or fat). Thus the reaction leads to the formation of methyl or ethyl esters.

The formation of methyl or ethyl esters by trans-esterification requires raw oil (Soapnut oil), methanol or ethanol and KOH as catalyst. For preparation of one batch of biodiesel, 500 ml oil is taken in a flask and heated with the help of burner to obtain the temperature of 55^0C-60^0C. In another flask 100-150 ml of ethanol is taken and 3.5 gm of KOH is added to it. This solution mixture is stirred till the whole KOH is dissolved in the ethanol. Meanwhile the temperature of oil is checked frequently with the help of thermometer. The oil requires two to three hours to attain the required temperature. After the oil is heated, the heated oil is mixed in the solution of ethanol and KOH, and the whole solution is put in an air tight container. This air tight container is shaken for 10-15 minutes and then allowed to settle under gravity for 24 hours. After 24 hours two layers are obtained in the container, upper layer is of the biodiesel and the lower layer is of the by-product i.e. glycerol.

The products obtained after the trans-esterification reaction i.e. biodiesel and glycerol are put in a separating funnel and allowed to settle under gravity for some time. Then these products are separated out and thus we obtain biodiesel.

Fig. 1: Bio-diesel obtained after trans-esterification

C. Experimental Setup

The experiment was done on single cylinder four stroke diesel engine. The schematic representation of an engine and the test rig is shown in figure 2 and figure 3. Engine is coupled with eddy current dynamometer. Dynamometer mounted with speed censor, this sensor feeds output to the control panel. Fuel meter is connected to the engine fuel intake line. Airflow meter measures inlet air flow at suction line of engine air inlet. Cylinder pressure is measured by probe inserted in cylinder, which feeds its output to control panel.

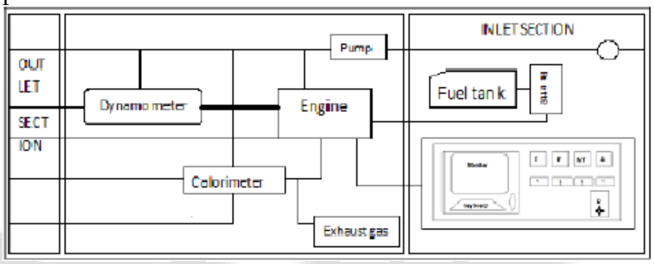

Fig. 2: The schematic representation of the setup.

Fig. 3: Actual experimentation test rig.

Equipment	Specifications
Engine	Engine model: Single cylinder four stroke diesel engine. Engine make: Comet Maximum output: 5 Bhp/3.7 Kw at 1500 rpm Bore: 80 mm Stroke: 110 mm Compression ratio: 16:1 Cooling: Air cooled
Eddy current	Water cooled eddy current

dynamometer	dynamometer Maximum BHP: 10 at 1500 rpm
Air flow rate transmitter	Anemometer: Hot wire type Output: 4-20 ma
Load cell transmitter	S type, range: 0-25 Kg Output: 4-20 ma
Fuel sensor transmitter	Range: 1.5 gm Output: 4-20 ma
Pressure sensor	Measuring range: 0-250 Bar

Table 1: Technical specifications of CI engine.

D. Test Procedure

Experimentation is performed on computerized single cylinder four stroke diesel engine with eddy current dynamometer. The total experimentation data is obtained on computer with the help of software. The Software is called Data Acquisition System. The procedure is as follows:-

1) The engine was started without any load.
2) After running the engine for 25 minutes, readings were taken by varying the load.
3) After completion of this test, engine fuel tank was completely drained in order to prevent mixing with blends.
4) The same procedure was followed to obtain readings from B5, B10, B20 blends.
5) Finally readings of various performance parameters obtained for blends from the Data Acquisition System were compared with petro diesel.

III. Results and Discussion

Soapnut Bio-diesel fuel properties were calculated as per ASTM D6751 and compared with petro diesel properties. The total experimentation data is obtained on computer with the help of data acquisition system provided by "Apex Engineering Solutions". There is communication link between experimental setup and IC engine software operated on computer.

A. Soapnut Bio-Diesel Properties

Sr. No	Property	Test Method	Soapnut Bio-diesel
1	Cetane Number	ASTM D613	58
2	Density (kg/m^3) (At Room Temp.)	ASTM D1298	874
3	Kinematic Viscosity (mm^2/s) (At 40^{0}C)	ASTM D445	4.88
4	Flash Point (^{0}C)	ASTM D93	42
5	Higher Heating Value (Mj/Kg)	ASTM D4868	41.70

Table 2: Properties of Bio-diesel

B. Results

The values of performance parameters of blends showed nearby results with petro-diesel properties and thus blends of soapnut bio-diesel can be used to run a diesel engine. Further, the results obtained from petro-diesel and blends of soapnut bio-diesel were compared and represented in graphs with respect to varying loads.

These graphs give the clear visualization of the effects on engine performance when the bio-diesel is introduced in different proportions without any modification in engine design.

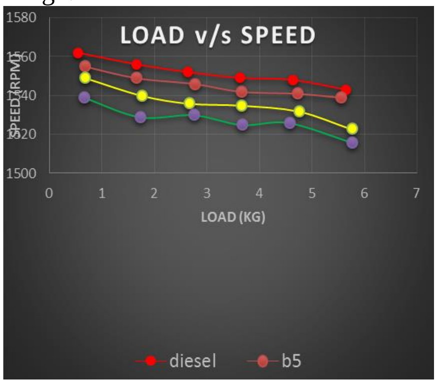

Fig. 4: Load v/s Speed

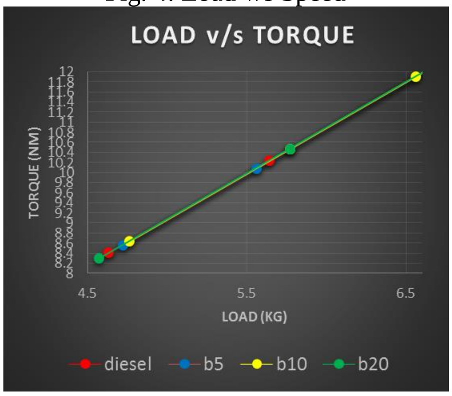

Fig. 5: Load v/s Torque

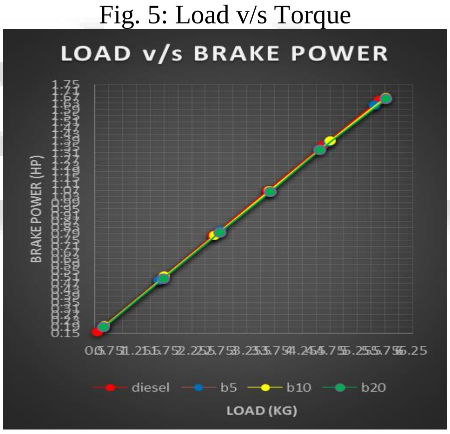

Fig. 6: Load v/s Brake Power

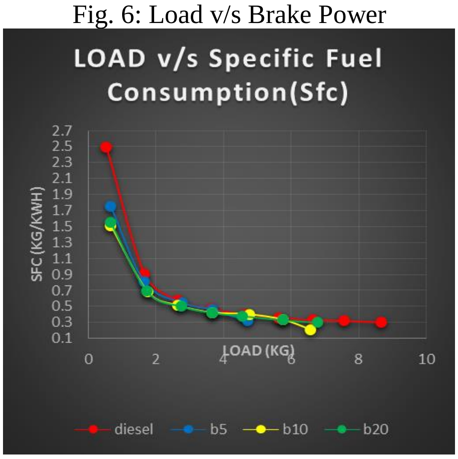

Fig. 7: Load v/s SFC

C. Discussion

In fig no.4 load v/s speed graph is plotted for petro diesel and blends. In the beginning B5 showed highest speed among all the blends and B20 showed the least speed but here performance of petro diesel was observed to be superior prior to all fuels. Only B5 blend's readings were observed to form nearly a linear graph similar to petro diesel. At medium load sharp reduction in speed was observed for B20 blend among all fuels. Main reason behind low performance of B20 is that, though it has highest oxygen content, its calorific value is low due to higher percentage of bio-diesel. Soapnut bio-diesel shows less calorific value compared to petro diesel, therefore amount of heat released is low as compared to petro diesel and other blends.

In fig no.5 load v/s torque graph is plotted for petro diesel and blends. All fuels showed nearly same value of torque but among all fuels petro diesel showed highest values for all loads. Among all blends B20 showed highest value.

In fig no.6 load v/s brake power graph is plotted for petro diesel and blends. Brake power of B10 blend was observed to be greater at low load among all fuels. For medium load and higher load, petro-diesel showed highest brake power while among blends B10's brake power was highest.

In fig 7 load v/s specific fuel consumption graph is plotted for petro diesel and blends. Except low load, B20 showed least specific fuel consumption among all fuels. Petro-diesel has highest specific fuel consumption among all fuels but for medium load B10 showed same specific fuel consumption as petro diesel.

IV. Conclusion

The experiment leaded to following conclusions

1) For hilly areas where torque plays an important role,B20 is best choice as it provides highest torque among blends and has least specific fuel consumption among all fuels used in this experiment.
2) For medium performance purpose, B10 is best choice as its properties were intermediate to petro diesel and B20.
3) For low load and medium speed again B10 is good choice because its brake power was observed to be greater among all fuels used in this experiment.
4) Finally we can conclude that depending upon applications, we can use different blends of bio-diesel and soapnut bio-diesel can be used as an alternative fuel for petro diesel successfully when blended up to 20 percent i.e up to B20.

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