Extraction of biodiesel from Jatropha oil and performance study of diesel engine with biodiesel fuels

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***Abstract*-** Biodiesel refers to a vegetable oil- or animal fat-based diesel fuel consisting of long chain alkyl (methyl, propyl or ethyl) esters. Biodiesel is typically made by chemically reacting lipids with an alcohol. Biodiesel is meant to be used in standard diesel engines and is thus distinct from the vegetable oils. Biodiesel can be used alone, or blended with diesel. 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 Jatropha oil by transesterification process represents one of the most promising options for the use of conventional fossil fuels.

In this project, the Jatropha oil is converted into jatropha oil methyl ester known as biodiesel, prepared in the presence of homogeneous acid catalyst with the help of Rotor Mantle which stirs the jatropha oil**.**

The physical properties such as density, flash point, viscosity, and load test were found out for Jatropha oil and Jatropha methyl ester. The blends of biodiesel (B10, B20, etc.) are tested on a diesel engine and Brake Horse Power (BHP), weight of fuel consumption (Wf) and specific fuel consumption (sfc) are determined.

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 Jatropha methyl ester is closely matched with the values of conventional diesel and can be used in the existing diesel engine without any modification.

***Index Terms*-** Biodiesel, Blends, Jatropha Transestrification, Performance

I. INTRODUCTION

Our earth contains various reservoirs of carbon that can be used in form of solid, gaseous or liquid fuels for meeting power requirements. However, we all completely rely upon fossil-based reserves due to which cost of these reserves have increased drastically to heights. In the coming generation there will be no fossil fuels left to meet our energy requirements. So, a renewable source of fuels is required for meeting the future energy needs of the world [1].

Here comes a need for Biodiesel. Biodiesel is biodegradable and non-toxic. Biodiesel fuel is a clean burning alternative fuel that is made from renewable source of materials. It does not contain pure petroleum crude (diesel), but is mixed with petroleum to produce various biodiesel blend. (e.g. - B20, B30). Thus it can be used in different engines. [2-3]

Blending of various types of vegetable oils with diesel fuel can help resolve problems and results in low CO, HC and smoke emissions. [4]

Biodiesel is different from vegetable oil or alternative fuels. It can be used perfectly in its unaltered form in diesel engines. Biodiesel is one of the easiest alternative fuel for future use. It can also be used on farms in farm equipment. [5]

The process of making of Biodiesel fuel is known as Transesterfication. Glycerol from the vegetable oil or fat is removed in this process. The absence of sulphur in 100% biodiesel extends the life of catalytic convertors. If combined with heating oil, Biodiesel fuel can be used to heat residential and industrial buildings. In a diesel powered combustion engine, biodiesel fuel eliminates use of any type of retrofits. [6]

In this research work, B10 and B20 blends of jatropha bio diesel with diesel were used as the biodiesel fuel and their performance was compared with diesel. Jatropha Bio diesel oil was prepared by transesterification using KOH as the catalyst and was tested in a 4- stroke direct natural aspirates diesel engine. [6]

The oil content is 25-30% in the seed. The oil contains 21% saturated fatty acids and 79% unsaturated fatty acids. Jatropha curcus oil cake is rich in Nitrogen, Phosphorous and Potassium and can be used as organic manure. Jatropha oil expelled from seeds and filtered through filter press can replace kerosene or oil lamp. [7-8]

II. METHOD

Biodiesel is typically produced through the process known as transesterification. In this method, reaction of a vegetable oil or animal fat with Ethanol in the presence of a catalyst yields glycerin and Ethyl esters. Methyl esters and glycerol are the by-products which are left behind in this process. Unlike traditional fuels, biodiesel fuel is free from substances such as sulphur and aromatics. It has passed all the health effects testing requirements, unlike other alternative fuel. In this present study, Jatropha Bio diesel was prepared by transesterification using KOH as the catalyst as it rapidly absorbs moisture from the atmosphere and was tested in a 4- stroke direct natural aspirates diesel engine.

The plant that is generally cultivated for the purpose of extracting jatropha oil is Jatropha curcas. The seeds are the primary source from which the oil is extracted. Owing to the toxicity of jatropha seeds, they are not used by humans. The major goal of jatropha cultivation, therefore, is performed for the sake of chemical compositions.

Main constituents in jatropha are:

- Moisture: 6.20%
- Protein: 18.00%
- Fat: 38.00%
- Carbohydrates: 17.00%
- Fiber: 15.50%
- Ash: 5.30

III. EXPERIMENTATION

The apparatus used for experimentation was a single cylinder, four-stroke, direct injection (DI), water-cooled, diesel engine with mechanical rope brake loading was used for this study which is developing a power output of 5.2 KW @ 1500 rpm. The engine specifications are given in Table 1.

Table I: ENGINE SPECIFICATIONS

RATED POWER	5.2 KW@ 1500rpm
SPEED	1500 RPM
No. OF CYLINDERS	ONE
COMPRESSION RATIO	17.5:1
BORE	87.5mm
STROKE	110mm
ORIFICE DIAMETER	20mm
TYPE OF IGNITION	COMPRESSION IGNITION
METHOD OF LOADING	ROPE BRAKE
METHOD OF STARTING	CRANK START

The engine was tested with Diesel, and blend ratios of 10%, 20%, and 30% at variable speeds. The engine has run smoothly through the whole study and no major problem was reported. Performance parameters such as brake horse power, brake specific fuel consumption, weight of fuel consumption were evaluated.

Also a viscosity test was conducted on a redwood viscometer to compare the viscosity of biodiesel with diesel. Also Flash and Fire point test was conducted on a testing apparatus known as Pensky-Martens Flash and fire point testing apparatus to compare the properties of biodiesel with traditional fuel. Also density test was also conducted for both the fuels

IV. TESTING PARAMETERS AND TESTING

A) **VISCOSITY TEST: -** This test was conducted on both fluids, i.e. on diesel and biodiesel. The test is conducted on a redwood viscometer. Resistance offered by any fluid against flow is known as viscosity. It is generally expressed in centistokes (Cst). It decreases with increase in temperature. This test was done to check and compare the viscosity of biodiesel with conventional fuel, which led to the conclusion that biodiesel can be used instead of conventional fuel.

The testing parameters that were recorded after the test can be seen as under:-

Table II: Viscosity Table
(Room Temperature 32^{o} C)

FUEL	Temperature (^{o}C)	Quantity (ml)	Viscosity (cst)
BIODIESEL	40	50	5.2
DIESEL	40	50	4.5

B-) FLASH AND FIRE POINT TEST: - The lowest temperature at which a liquid can vaporize to form an ignitable mixture in air is known as flash point of a volatile liquid. The vapor may cease to burn when the source of ignition is removed at the flash point. The fire point is slightly a higher temperature, which is defined as the temperature at which the vapor continues to burn after being ignited. There are various international standards for defining them, but the most common is that, the liquids having a flash point less than 43^{o}C are flammable, while those having a flash point above this temperature are combustible.

This test was done on both conventional diesel available and biodiesel in order to check the flash and fire point temperature which should match or nearby values. This test is conducted on a Flash and fire point testing apparatus known as Pensky-Martens Flash and fire point testing apparatus, where the vapors above the liquid are not in equilibrium with the liquid temperature.

This test when conducted lead to the conclusion that Biodiesel can be used instead of conventional diesel fuel.

The testing parameters that were recorded after the test can be seen as under:-

Table III: Flash Point and Fire Point

S. No.	Oil	Flash point temperature (^{o}C)	Fire point temperature (^{o}C)
1	DIESEL	50	65
2	BIO-DIESEL	175	184

C-) **DENSITY TEST:-**This test is also conducted on both conventional fuel and biodiesel. The ratio of mass to volume is termed as Density. This test was done in order to check the density of both the fuels which should match or nearby values,

which only lead to conclusion that Bio-Diesel can be used instead of conventional fuel.
The testing parameters that were recorded after the test can be seen as under:-

Table IV: Density Table

S. No.	Oil	Density(g/cm^3)
1	DIESEL	0.841
2	BIO_DIESEL	0.838

D-) LOAD TEST AND PERFORMANCE TEST:-

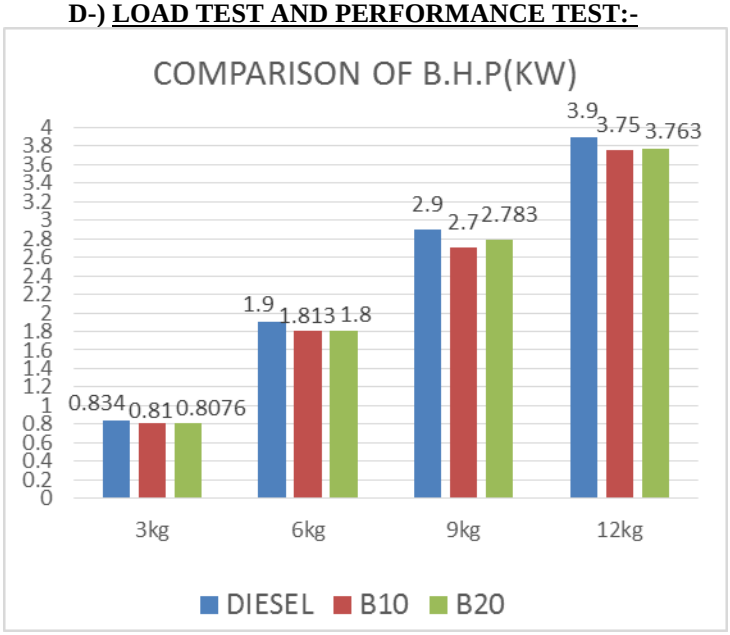

Figure 1: BRAKE HORSE POWER

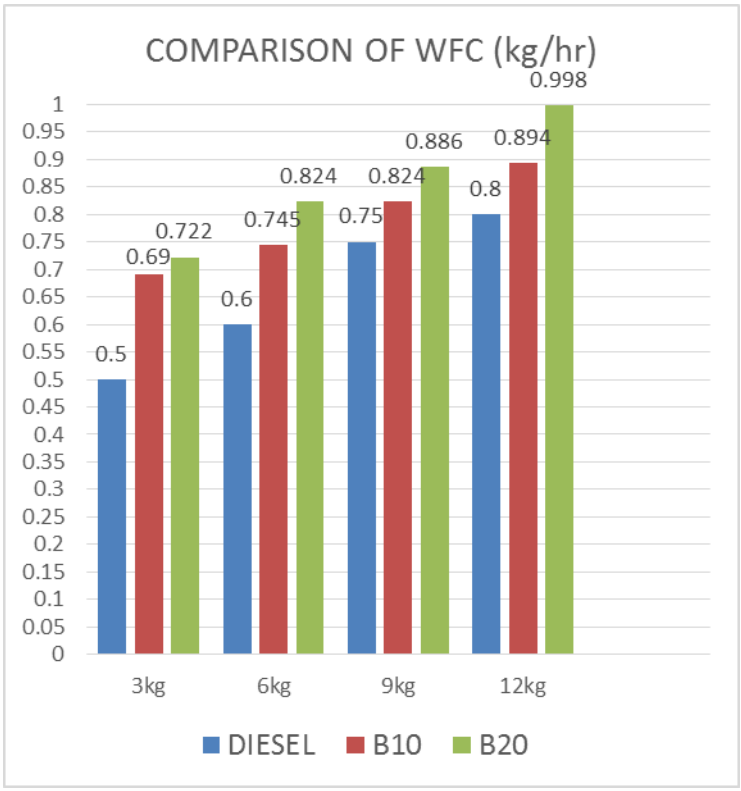

Figure 2: WEIGHT OF FUEL CONSUMPTION

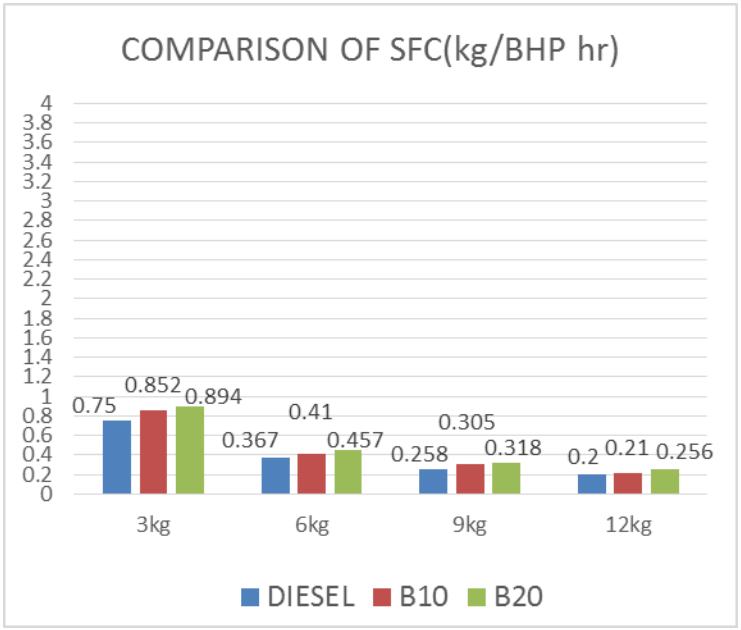

Figure 3: SPECIFIC FUEL CONSUMPTION

1.) FOR B 10 (10% BIODIESEL & 90% DIESEL):-
From the charts above, we get to see that:-

a.) As load increases, brake horse power increases.
b.) As load increases, weight of fuel consumption also increases.
c.) As load increases, specific fuel consumption decreases.

2.) <u>FOR B 20 (20% BIODIESEL & 80% DIESEL):-</u>
From the charts above, we get to see that :-

a.) As load increases, brake horse power increases.
b.) As load increases, weight of fuel consumption also increases.
c.) As load increases, specific fuel consumption decreases.

V. RESULTS AND DISCUSSIONS

The combustion and emission characteristics of single cylinder compression ignition engine fuelled with Jatropha Oil biodiesel and its blends have been analyzed and compared to the standard diesel fuel. Based on the experimental results, the following conclusions are obtained:-

1.) The Biodiesel from Jatropha Oil has been extracted successfully. The catalyst used was NaOH.
2.) The flash and Fire point of biodiesel are approximately four time more than diesel which shows that indeed Jatropha Oil Bio diesel can be used as an alternative to conventional fuel.
3.) Density and viscosity of Biodiesel is near about to Diesel.
4.) Weight of fuel consumption and Specific fuel consumption increases as quantity of biodiesel increases in blending condition and as the load increases Weight of fuel consumption increases and Specific fuel consumption decreases for each of the three blends.
5.) Brake horse power reduces as quantity of biodiesel increases in blending conditions and with increase in load Brake horse power increases for each of the three blend.

VI. CONCLUSONS

- In the current investigation, it has confirmed that Jatropha Oil may be used as a resource to obtain biodiesel. .The cost of production is low on small scale production, but the cost is high if mass production and accuracy is the goal. The physical and chemical properties of biodiesel extracted were discussed above and on comparing them with conventional diesel oil we can conclude that the various properties discussed above are of nearby values of the diesel oil.
- Glycerin which is the by-product of the chemical reaction can be sold to the pharmaceutical companies, since it is used to produce valuables such as creams and toothpaste.
- Engine performance tests and other tests shows that Jatropha Oil as a fuel does not differ greatly from that of diesel. A slight power loss, combined with an increase in fuel consumption, was experienced with Jatropha Bio diesel. This may be due to the lower heating value of the ester.

From the above testing results and experimentation and study it can be clearly observed that the biodiesel made from Jatropha Oil can be used as an alternative fuel to conventional fuel as it showed better results than diesel in terms of engine performance and emission.

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REFERENCES

[1] Iranica Journal of Energy & Environment 4 (2): 136-141, 2013 ISSN 2079-2115 IJEE an Official Peer Reviewed Journal of Babol Noshirvani University of Technology DOI: 10.5829/idosi.ijee.2013.04.02.10.
[2] www.iea.org/about/copyright.asp.
[3] Author, (2001). Rudolf Diesel. Internal-CombustionEngine. www.invent.org/book/book-text/31.html. 7/19/2001.
[4] Blending of various types of vegetable oils with diesel fuel can help resolve problems and results in low CO, HC and smoke emissions.
[5] http://journeytoforever.org/biofuel_library/VegetableOilsKnothe.pdf.
[6] Special Issue of International Journal of Sustainable Development and Green Economics (IJSDGE), ISSN No.: 2315-4721, V-2, I-1, 2, 2013.
[7] http://umexpert.um.edu.my/file/publication/00003241_94737.pdf.
[8] "New Biodiesel Blend Specifications Published by ASTM International".
[9] Nbb.grassroots.com.http://nbb.grassroots.com/09Releases/ASTMBlend/.
[10] www.iphe.org.uk/publications/tech_literature.html.

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