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Performance characteristics and analysis of Jatropha oil in multi-cylinder turbocharge Compression Ignition Engine

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Abstract— *The rapidly depleting conventional petroleum resources have promoted research for alternative fuels for internal combustion engines. Among various possible options, fuels derived from triglycerides (vegetable oils/animal fats) present promising ''greener'' substitutes for fossil fuels. Vegetable oils, due to their agricultural origin, are able to reduce net CO2 emissions to the atmosphere along with import substitution of petroleum products. A variety of edible and non-edible oils are considered for bio-diesel production. In the present work, Jatropha Biodiesel purchased from authorized agencies, and their important physical & chemical properties were tested & compared. It is found that these properties are approximately similar to diesel fuel and suitable to use in diesel engine. Also petro-diesel is purchased from local authorized agency and used before and after the biodiesels for verifying the engine condition due to biodiesels. The biodiesel from jatropha oil is used in a M&M Turbo Charged make four stroke, four cylinders, and water cooled diesel engine in pure and blended form without any modification in engine design or fuel system. The performance characteristics of an engine are studied with different proportions of biodiesel and petro-diesel .The power, torque, and brake thermal efficiency using biodiesel are found higher at various load conditions than the petro-diesel; however specific fuel consumption is found slightly more. The biodiesel blend JBD20 have shown better performance than the diesel and other blends.*

Keywords—*Jatropha, transesterification, Bio-diesel blend, JbD20, JBD30, JBD60*

I. INTRODUCTION

Diesel engines are the most efficient prime movers. From the point of view of protecting global environment and concerns for long-term energy security, it becomes necessary to develop alternative fuels with properties comparable to petroleum based fuels. Unlike rest of the world, India's demand for diesel fuels is roughly six times that of gasoline hence seeking alternative to mineral diesel is a natural choice [1]. Biodiesel production is undergoing rapid technological reforms in industries and academia. This has become more obvious and relevant since the recent increase in the petroleum prices and the growing awareness relating to the environmental consequences of the fuel over dependency [2].

Why Bio fuels?

In recent years several researches have been made to use vegetable oil, animal fats as a source of renewable energy known as bio diesel that can be used as fuel in CI engines. Vegetable oils are the most promising alternative fuels for CI engines as they are renewable, biodegradable, non toxic, environmental friendly, a lower emission profile compared to diesel fuel and most of the situation where conventional petroleum diesel is used. Even though "diesel" is part of its name there is no petroleum or other fossil fuels in bio diesel. It is 100% vegetable oil based, that can be blended at any level with petroleum diesel to create a bio diesel blend or can be used in its pure form. Non edible vegetable oils are the most significant to use as a fuel compared to edible vegetable oils as it has a tremendous demand for using as a food and also the high expense for production. Therefore many researchers are experimenting on non edible vegetable oils. In India the feasibility of producing bio diesel as diesel substitute can be significantly thought as there is a large junk of degraded forest land, unutilized public land, and fallow lands of farmers, even rural areas that will be beneficial for overall economic growth.

There are many tree species that bear seeds rich in non edible vegetable oils. Some of the promising tree species are Pongamia pinnata (karanja), Jatropha curcas (Ratanjyot) etc. But most surprisingly as per their potential only a maximum of 6% is used. Biodiesel is a low-emissions diesel substitute fuel made from renewable resources and waste lipid. The most common way to produce biodiesel is through transesterification, especially alkali-catalyzed transesterification [3]. For the land use impact, Jatropha improved the structural ecosystem quality when planted on wasteland, but reduced the functional ecosystem quality. Fertilizer application (mainly N) is an important contributor to most negative impact categories. Optimizing fertilization, agronomic practices and genetics are the major system improvement options [4].

There are four primary ways to make biodiesel, direct use and blending, microemulsions, thermal cracking (pyrolysis) and transesterification. The most commonly used method is transesterification of vegetable oils and animal fats. The transesterification reaction is affected by molar ratio of glycerides to alcohol, catalysts, reaction temperature, reaction time and free fatty acids and water content of oils or fats [5]. Asia could potentially become a major market for, and exporter of biofuels. Several Asian countries are developing rapidly and the demand for vehicles is expected to rise exponentially. Concomitantly, the demand for road transportation fuels is expected to soar [6].

The diesel engine has been applied to many fields such as diesel generator; power plant for cars, buses, ships, boats and Lorries. One of the main reasons for its wide applications is because diesel engine has its particular advantages of higher efficiency, lower fuel consumption; higher reliability and durability, compared with other types of engines such as petrol engine, gas turbine. Another reason for diesel engine widely being used is due to the fuel that it uses - diesel. Diesel is a kind of widely available and relatively cheap fossil fuel extracted from petroleum [7]. Significant improvement in engine performance is observed compared to vegetable oil alone. The specific fuel consumption and the exhaust gas temperature are reduced due to decrease in viscosity of the vegetable oil [8].

II. PROBLEMS WITH BIODIESEL

Major problems encountered with vegetable oil as bio diesel used in CI engine are its low volatility and high viscosity due to long chain structure. The common problems faced are excessive pumping power, improper combustion and poor atomization of fuel particles. The conversion of the vegetable oil as a CI engine fuel can be done any of the four methods; pyrolysis, micro emulsification, dilution/blending and transesterification.

Preparation of laboratory samples of esterified jatropha oil (bio diesel) [9]:

The oil yielding plant Jatropha curcas L. is a multipurpose and drought resistant large shrub, which is widely cultivated in the tropics as a live fence. The Jatropha plant can reach a height up to 5 m and its seed yield ranges from 7.5 to 12 tonnes per hectare per year, after five years of growth. The oil content of whole Jatropha seed is 30-35 % by weight basis.

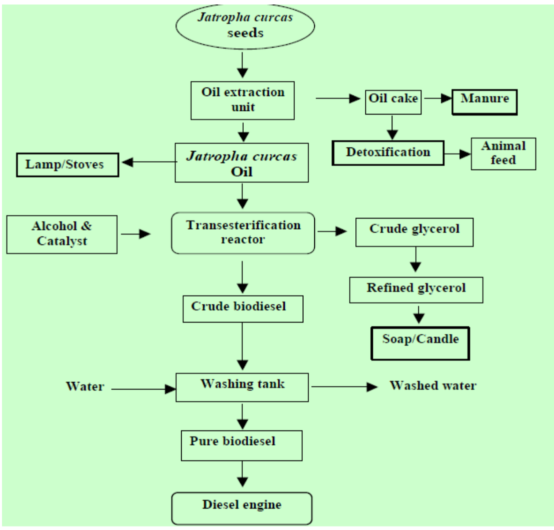

Fig. 1 Process flowchart for biodiesel production from jatropha seeds and by products

Jatropha oil is blended with alcohol and catalyst mixture in transesterification reactor. The reactor is kept at reaction temperature for specific duration with vigorous agitation. After reaction, the biodiesel and glycerol mixture is sent to the glycerol settling tank. The crude biodiesel is collected and washed to get pure biodiesel. Depending upon the need, the size of the unit can be scaled up to get higher production capacity. The fuel properties of jatropha biodiesel produced in the pilot plant are given in the table 4.

Catalyst
→ Jatropha oil + Alcohol Jatropha biodiesel + Glycerol

Fig. 2 Jatropha Plant

Fig. 3 Jatropha Seed

Objectives of Project:

Keeping in mind the benefits of biodiesel and so the consequential importance renewable in the near future, the work was undertaken with following specific objectives:

1. To conduct short term field test on C.I. engine.
2. To study performance of C.I. engine with biodiesel produced from Jatropha oil

In the present work, karanja biodiesel purchased from Mint-bio fuels ltd., Pirangut Pune. And their physio-chemical combustion properties were provided by same company. And then used for performance analysis in "4-stroke 4-cylinder water cooled diesel engine."

III. EXPERIMENTAL SETUP

Introduction

Study of Engine Performance has been an important process since the evolution of the engines. In the very early stages, only the external performance was studied with help of loading with a Dynamometer and measuring the parameters like Torque, Output power, Specific Fuel Consumption etc as the world progressed further, the necessity of refinement of engine design leaded to study the combustion events occurring inside the cylinder head. For this, in the earlier research, Mechanical Spring and piston type recorders were used. But, these had certain disadvantages like effects of spring stiffness etc. Further, with the advent of Piezo electric crystals, the Piezo Sensors have started been used with the amplification systems. Earlier the data was displayed on a Cathode Ray Oscilloscope, further recorded on Strip chart recorders and then analyzed separately. Now with help of Data Acquisition devices and using a PC, we can get this work done quite accurately. ATE has developed the Computerized IC engine Test Rigs with an intent not only to give the students how the testing is done and data is acquired, but to give them a more clear idea about the real time combustion by developing the combustion analysis system with Updates of the Pressure-Crank angle and Pressure Volume Curves every cycle. Along with that, one can get all other data like Heat Balance Sheet, Thermal efficiencies, BSFC, ISFC, Mech. Efficiency, Air-fuel ratio etc. Further the test rig is designed such that, if regular testing is to be carried out without using the Data Acquisition, it is possible to do that.

Components of the Computerized Test Rig

A Computerized Engine Test Rig consists of the following systems.

1) Dynamometer – Eddy Current type with computerized torque measuring
2) Engine fitted with a Piezo sensor for Pressure measurement
3) Connection between Dynamometer and Engine
4) Computerized Air Flow measurement system
5) Computerized Fuel Flow measurement system
6) Computerized Water Flow measurement system
7) Exhaust Gas Calorimeter with Computerized Temperature measurement system

Engine Specification

Table 1 Engine specifications [10]

Sr. No.	Particulars	Specification
1	Model	MDI 3200 TCA
2	Make	M&M
3	Power (kW)	27.6 KW
4	Speed (rpm)	5000 RPM
5	Cylinder Bore (mm)	88.9
6	Stroke Length (mm)	101.6
7	Connecting Rod Length (mm)	177.8
8	Cubic Capacity	2523 C.C.
9	Compression Ratio	18.1 : 1
10	No. of Strokes	4
11	No of Cylinders	4
12	Cooling	Water cooled
13	Fuel	Diesel

Fig.4 Photograph of multi-cylinder C.I. engine test Rig

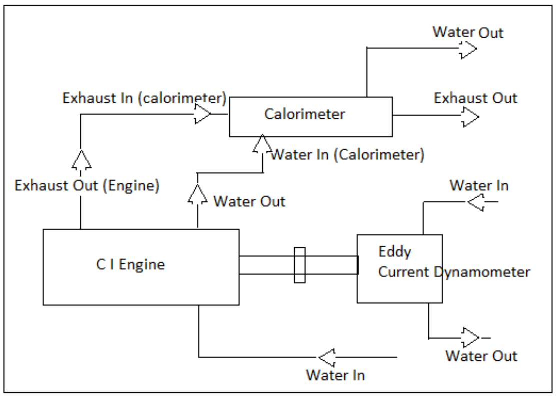

Fig. 5 Schematic diagram of engine setup

IV. PERFORMANCE ANALYSIS OF JATROPHA BIODIESEL

Performance tests were conducted on stationary cylinders, diesel engine, by using Jatropha Biodiesel and its various blends with diesel from no load to full load condition. The tests were also conducted with conventional diesel fuel for comparison; Biodiesel is blended with diesel in proportion like 20%, 30%, and 40%. These blends are termed as JBD20 (20% Jatropha Biodiesel + 80% diesel), JBD40 (30% Jatropha Biodiesel + 70% diesel), JBD60 (40%Karanja Biodiesel + 60% diesel). Petro diesel is used before and after the Jatropha Biodiesel and their blends for verifying the engine performances because biodiesel and blends. The diesel used before the Jatropha is denoted as Diesel2 and after the Jatropha denoted as Diesel3 for convenience. All the performance tests were conducted in the I.C. Engine laboratory.

Engine Performance Analysis

The performance of an internal combustion engine is mainly studied with the help of combustion and operating characteristics. These characteristics obtained by using diesel and Jatropha biodiesel in 4 cylinders, 4 strokes, M&M make, turbo charge diesel engine. Performance tests were conducted from no load to full load conditions at 2000rpm for diesel, JBD20, JBD40 and JBD60.

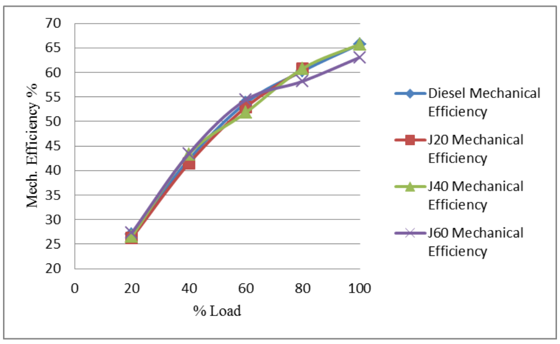

Fig. 6 % Load Vs Mechanical efficiency

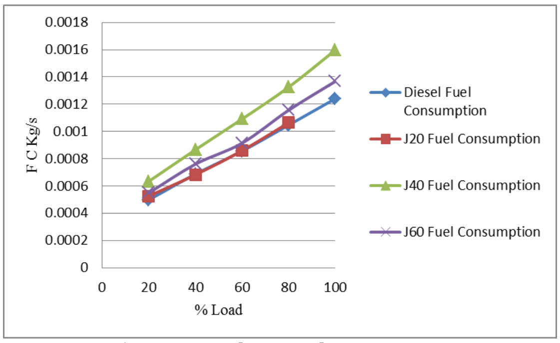

Fig. 7 % Load Vs Fuel consumption

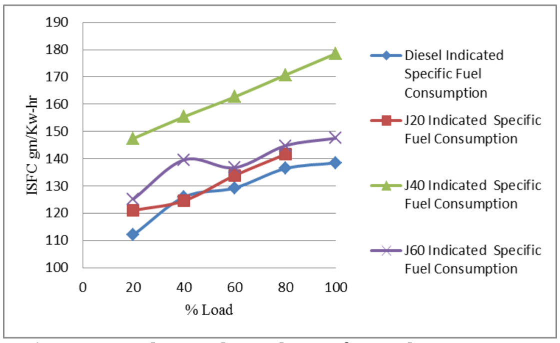

Fig. 8 % Load Vs Indicated specific Fuel consumption

According to the test, it was observed that at low load, mechanical efficience of diesel and all consider blends of biodiesel were same but the load incresed, the mechanical efficiency was varised. At full load, JBD40 showes same efficiency as diesel.

It is shown in figure 6. Fuel consumption for JBD40 at full load showes higher than diesel. JBD20 shows less fuel consumption than other blends. Break specific fuel consumption is more for JBD40 and less for JBD20. At low load brake power is same for diesel and JBD20, JBD40 and JBD60. Brake specific fuel consumption decresed with increasing load, JBD20 shows less brake specific fuel consumption .

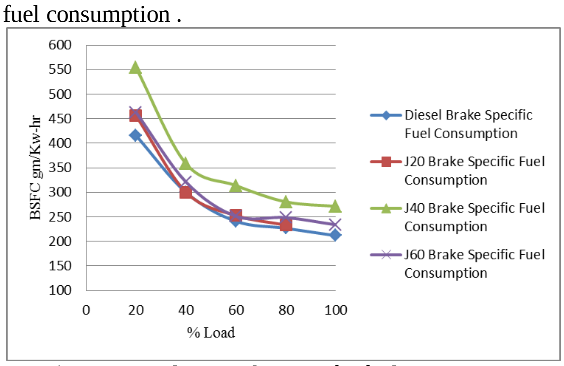

Fig. 9 % Load Vs Brake specific fuel consumption

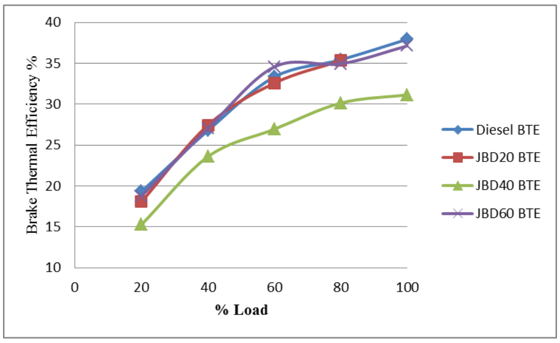

Fig. 10 % Load Vs Brake thermal efficiency

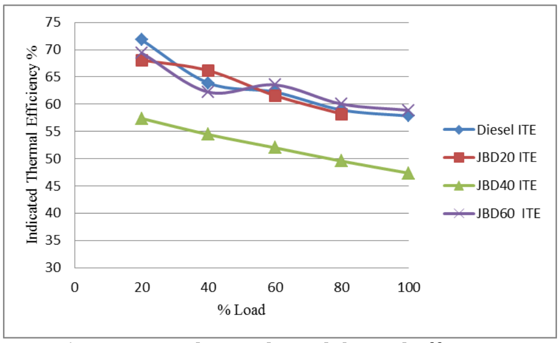

Fig. 11 % Load Vs Indicated thermal efficiency

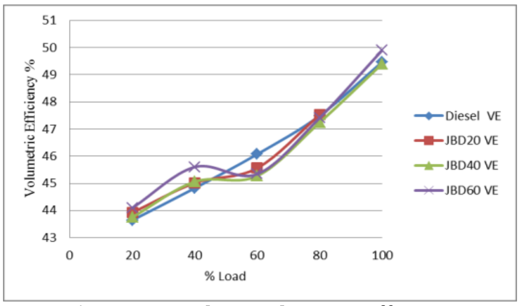

Fig. 12 % Load Vs Volumetric efficiency

JBD40 shows less brake thermal efficiency and more indicated thermal efficiency than diesel and other blends. Air-fuel ratio decreses with increasing load. At full load condition, JBD60 shows higher volumetric efficience.

V. CONCLUSION

The main objective of the present investigation was to evaluate the performance characteristic of engine with the jatropha biodiesel. Biodiesel production is mordern and technological area for researchers due to constant increse in prices of petrolium diesel and environmental advantages. Biodiesel from jatropha oil was produced by alkali catalysed transesterification process.

According to the present investigation, it was observed that JBD40 shows less indicated and brake thermal efficiency and more specific fuel consumption than diesel and other blends viz JBD20, JBD60. Performance of JBD20 at full load condion shows same to diesel. JBD20 is more sutaible blend of jatropha oil. It shows high BTE, ITE and less specific fuel consumption.

The performance tests were conducted with diesel and various blend of Jatropha biodiesel at different loads and constant speed (2000rpm). From the experimental results obtained, Jatropha biodiesel is found to be a promising alternative fuel for economic running of compression ignition engines.

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