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Performance Evaluation of Diesel Engine Using Jatropha & Karanja Oil and Its Blends

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***Abstract*— Biomass derived vegetable oils are quite promising alternative fuels for agricultural diesel engines. Use of vegetable oils in diesel engines leads to slightly inferior performance and higher smoke emissions due to their high viscosity. The performance of vegetable oils can be improved by modifying them through the transesterification process. In the present work, the performance of single cylinder water-cooled diesel engine using methyl-ester of Jatropha and karanja oil as fuel was evaluated for its performance and exhaust emissions. The fuel properties of biodiesel such as kinematic viscosity, calorific value, flash point, carbon residue and specific gravity were found. Results indicated that B25 has closer performance to diesel and B100 has lower brake thermal efficiency, mainly due to its high viscosity compared to diesel. The brake thermal efficiency for biodiesel and its blends was found to be slightly higher than that of diesel fuel at tested load conditions and there was no difference between the biodiesel and its blended fuels efficiencies. For Jatropha and karanja biodiesel and its blended fuels, the exhaust gas temperature increased with increase in power and amount of biodiesel. But, diesel blends showed reasonable efficiency, lower smoke, CO2, CO and HC.**

Keywords—Bio-diesel,Blends,Transesterification. Introduction

I.INTRODUCTION

The constant increase in the rate of consumption of the fossil fuels, consequent upon the ever increasing population and the urbanization in the present day world, has made the depletion of these conventional fuel resources in the near future a quite inevitable fact. Also, the Greenhouse Gas emissions from these fossil fuels are constantly degrading the planet and causing global warming and other pollutant emission related problem. As such, the situation demands for an alternate source of energy that can be used to overcome the forecasted future energy crisis. In addition to this, if the energy source is clean and renewable, it will reduce the environmental issues as well. In this quest for an alternate and renewable energy resource, scientists have come up with a variety of options among which biodiesel-diesel blends as alternative fuels has become a popular option and is gaining the attention of many researchers. This is because scientists have seen that the properties of biodiesel prepared from vegetable oils are very close to commercial diesel and thus it has a promising future as an alternative fuel for diesel engine. Biodiesel being renewable, biodegradable and green fuel can reduce our dependence on conventional/ non-renewable fossil fuels as well as improve environmental quality in metro cities, urban and rural sectors by reducing obnoxious automotive/vehicular emissions. As such biodiesel has the potential to replace petroleum diesel in near future.

A.History of bio-diesel

Biodiesel has been around for a very long time from 1900. In 1893 Rudolf Diesel for the first time used the peanut oil for running the diesel engine. Later in 1937, Chavanne, a Belgian scientist found the concept of running the engine with vegetable oil called to be “Biodiesel”. However, it has not been widely used or widely manufactured till recent years. The reason that biodiesel cannot withstand long production run because Petroleum was cheaper and more widely available than biodiesel for many decades. However, the main problem of not using biodiesel commonly is the high NOx emission. According to OECD-FAO agriculture outlook report 2011-2020 [6] crude oil prices was assumed to increase in 2012 and continuous to show a rapid price rise by$107/barrel by 2020.The estimated biodiesel production is compared with the biodiesel trade around the world by 2020.

II.PROBLEM IDENTIFICATION

The purpose of the study is to describe the Jatropha and Karanja characteristics and production system in general, and to explore the performance of Jatropha and Karanja biodiesel production under prevailing energy and agricultural conditions in India. The focus is to identify motivational factors for continuation and termination of Jatropha cultivation and to assess environmental and socio-economic impacts of the Jatropha biodiesel production.

The objective of this study is to provide answers to the following research questions:

1. To what extent has Jatropha and karanja been able to meet the high expectations put on its performance as a biodiesel crop?
2. What motivational factors act as drivers and barriers to continued Jatropha and Karanja cultivation for farmers?
3. What are the environmental and socio-economic impacts of Jatropha and Karanja biodiesel production?

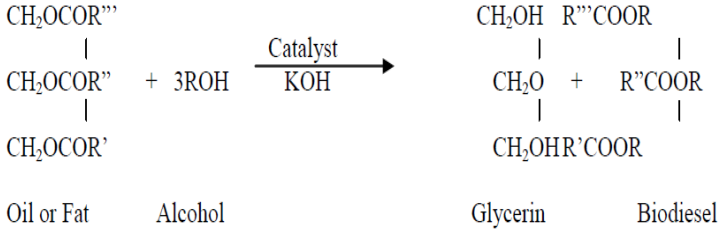
III.THEORY

A.Biodiesel

1.Production process of biodiesel

1.1.Transesterification reaction:

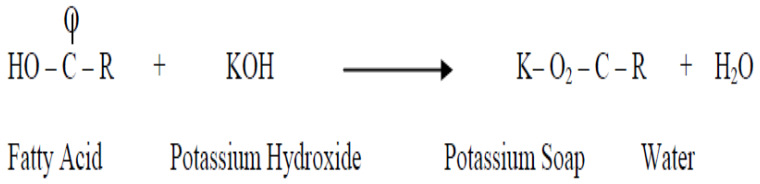
The major components of vegetable oils and animal fats are Triglycerides. To obtain biodiesel, the vegetable oil or animal fat is subjected to a chemical reaction termed transesterification.



a. Filtering: Filter the vegetable oil to remove solid particles from it. You may have to warm it up a bit first to get it to run freely; 35°C should be enough. A Cartridge filter is used for the same.

b. Removing the Water: Heat the oil first to remove the water content. Vegetable oil will probably contain water, which can slow down the reaction and causes saponification (soap formation). Raise the temperature to 100°C, hold it there and allow water contents to boil off. Run the agitator to avoid steam pockets forming below the oil and exploding, splashing hot oil. Or drain water puddles out from the bottom as they form, you can save oil that comes out with the water later. When boiling slows, raise the temperature to 130°C for 10 minutes and allow cool to it.

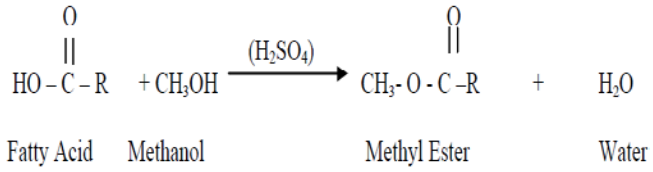
c. Catalytic Reaction:



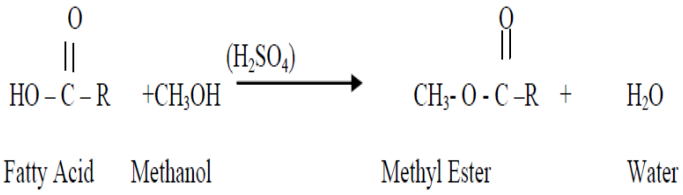
IV.ACID CATALYST REACTION

A.Acid Esterification.

Oil feedstock containing more than 4 % Free Fatty Acids go through an acid Esterification process to increase the yield of biodiesel. This feedstock's are filtered and preprocessed to remove water and contaminants, and then fed to the acid Esterification process. The catalyst, sulfuric acid, is dissolved in methanol and then mixed with the pretreated oil. The mixture is heated and stirred, and the Free Fatty Acids are converted to biodiesel. Once the reaction is complete, it is dewatered and then fed to the transesterification process. Some feedstock must be pretreated before they can go through the transesterification process. Feedstock with less than 5 % Free Fatty Acid, do not require pretreatment. When an alkali catalyst is added to the feedstock's (With FFA > 5 %), the Free Fatty Acid react with the catalyst to form soap and water as shown in the reaction below:



Up to about 5% FFAs, the reaction can still be catalyzed with an alkali catalyst but additional catalyst must be added to compensate for that lost to soap. The soap created during the reaction is either removed with the glycerol or is washed out during the water wash. When FFA level is above 5 %, the soap inhibits separation of the glycerol from the methyl esters and contributes to emulsion formation during the water wash. For these cases, an acid catalyst such as sulfuric acid can be used to esterify the FFAs to methyl esters as shown in the following reaction:



B.Acid Transesterification Reaction

In this process, the feedstock is reacted with an alcohol (like methanol) in the presence of a strong acid catalyst (Sulfuric Acid), converting the Free Fatty Acids into biodiesel. The remaining triglycerides are converted to biodiesel in the transesterification reaction

Fig.1 Transesterification set up

V.BASE CATALYZED REACTION:

Oil feedstock's containing less than 4 % Free Fatty Acids are filtered and preprocessed to remove water and contaminants and then fed directly to the transesterification process along with any products of the acid Esterification process. The catalyst, potassium hydroxide, is dissolved in methanol and then mixed with and the pretreated oil. If an acid Esterification process is used, then extra base catalyst must be added to neutralize the acid added in that step. Once the reaction is complete, the major co-products, biodiesel and glycerin, are separated into two layers.The base catalyzed production of biodiesel generally occurs using the following steps:

A) Mixing of alcohol and catalyst:

The catalyst is typically sodium hydroxide (caustic soda) or potassium hydroxide (potash). It is dissolved in the alcohol using a standard agitator or mixer. The alcohol/catalyst mix is then charged into a closed reaction vessel and the oil or fat is added.The system from here on is totally closed to the atmosphere to prevent the loss of alcohol. The reaction mix is kept just above the boiling point of the alcohol (around 160 °F) to speed up the reaction and the reaction takes place. Recommended reaction time varies from 1 to 8 hours, and some systems recommend the reaction take place at room temperature. Excess alcohol is normally used to ensure total conversion of the fat or oil to its esters. Care must be taken to monitor the amount of water and free fatty acids in the incoming oil or fat. If the free fatty acid level or water level is too high it may cause problems with soap formation and the separation of the glycerin by-product downstream.

B) Separation.

Once the reaction is complete, two major products exist: glycerin and biodiesel. Each has a substantial amount of the excess methanol that was used in the reaction. The reacted mixture is sometimes neutralized at this step if needed. 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.

C) Alcohol Removal.

Once the glycerin and biodiesel phases have been separated, the excess alcohol in each phase is removed with a flash evaporation process or by distillation. In others systems, the alcohol is removed and the mixture neutralized before the glycerin and esters have been separated. In either case, the alcohol is recovered using distillation equipment and is re-used. Care must be taken to ensure no water accumulates in the recovered alcohol stream.

D) Glycerin Neutralization.

The glycerin by-product contains unused catalyst and soaps that are neutralized with an acid and sent to storage as crude glycerin. In some cases the salt formed during this phase is recovered for use as fertilizer. In most cases the salt is left in the glycerin. Water and alcohol are removed to produce 80-88% pure glycerin that is ready to be sold as crude glycerin. In more sophisticated operations, the glycerin is distilled to 99% or higher purity and sold into the cosmetic and pharmaceutical markets

E) Methyl Ester Wash.

Once separated from the glycerin, the biodiesel is sometimes purified by washing gently with warm water to remove residual catalyst or soaps, dried, and sent to storage. In some processes this step is unnecessary. This is normally

the end of the production process resulting in a clear amber-yellow liquid with a viscosity similar to petro diesel. In some systems the biodiesel is distilled in an additional step to remove small amounts of color bodies to produce a colorless biodiesel. Additional assurances and confidence that biodiesel purchased form a Certified Biodiesel Marketer will meet ASTM specifications.

F.Drying: Removal of water from Methyl ester by heating at 100°C temperature. Finally get pure biodiesel (B100).

Fig. 2 Pure biodiesel Preparation of Blends of Biodiesel

At present the amount of biodiesel available is less than that of diesel. The biodiesel blended with diesel by volume as B10 (10% karanja biodiesel & 90% diesel fuel), B 20 (20% karanja biodiesel & 80% diesel fuel), B 30 (30% karanja biodiesel & 70% diesel fuel), B 40 (40% karanja biodiesel & 60% diesel fuel), B 50 (50% karanja biodiesel & 50% diesel fuel), B 100 (100% karanja biodiesel & 00% diesel fuel).then the samples were proceed for their property testing .

Fig.3 Blends of Biodiesel

VI.EXPERIMENTAL TEST RIG AND TEST PROCESS

Fig.4 Rig and test process

TABLE I ENGINE SPECIFICATIONS

Sr no.	Particular	Specification
1	Engine maker	Kirloskar
2	Orifice diameter(m)	0.02
3	Dynamo. Arm length(m)	0.185
4	Coefficient of discharge (Cd)	0.6
5	Cylinder diameter D(m)	0.088
6	Stroke L(m)	0.11
7	No. of cylinder	1
8	Engine type	4 stroke
9	Type of cooling	water cooled

Experiments were carried out on stationary water cooled, naturally aspirated, 4-stroke, single cylinder, indict injection compression ignition engine (IDI) engine with specification shown in above table.. The arrangement of testing shown in photo (1,2). The engine test process was carried out in two phases as described below.

VII.RESULTS AND CONCLUSION

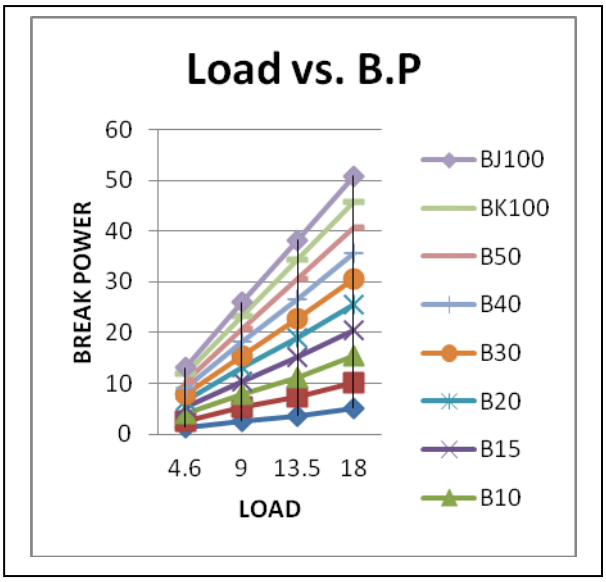


Fig.5 Load vs Break power

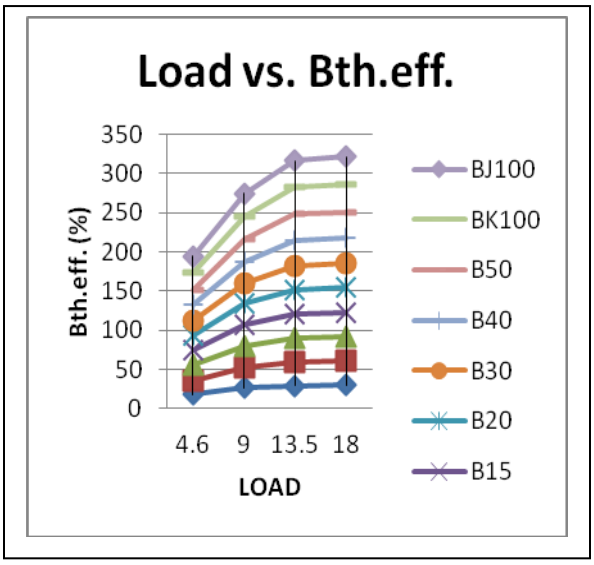


Fig.8 Load vs Break thermal efficiency

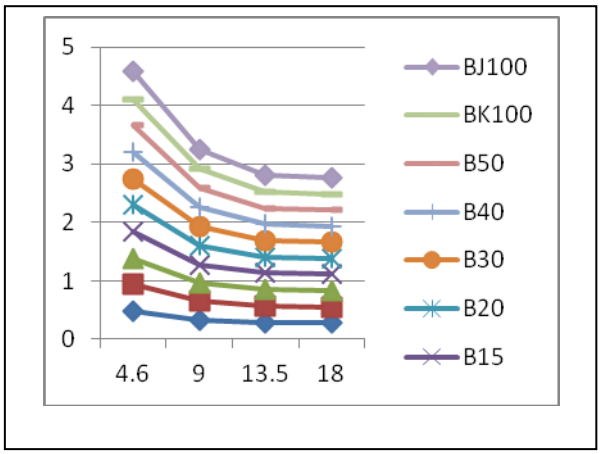


Fig.6 Load vs BSFC

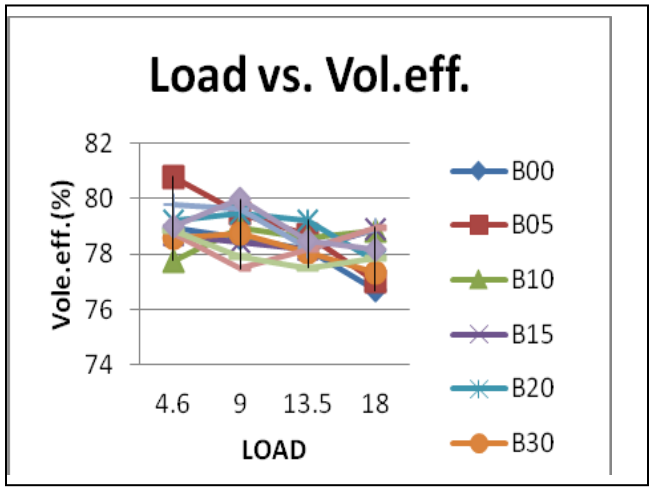


Fig.9 Load vs volumetric efficiency

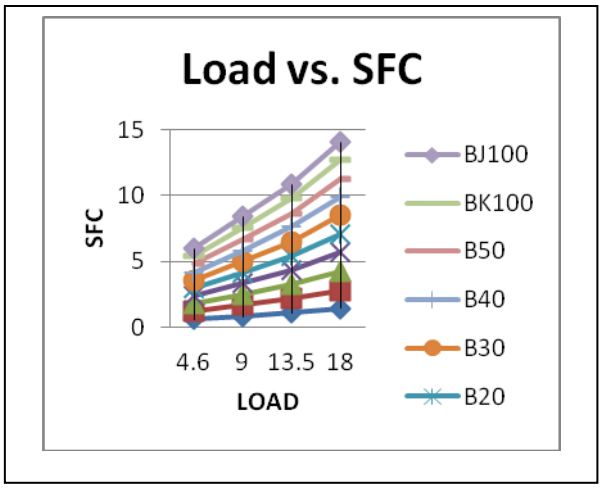


Fig.7 Load vs SFC

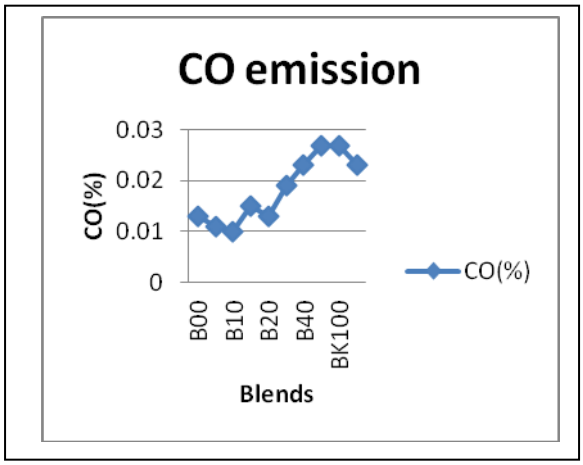


Fig.10 CO emission

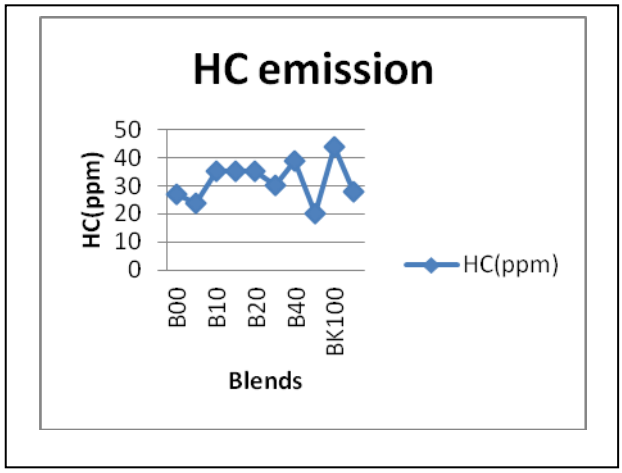


Fig.11 HC emission

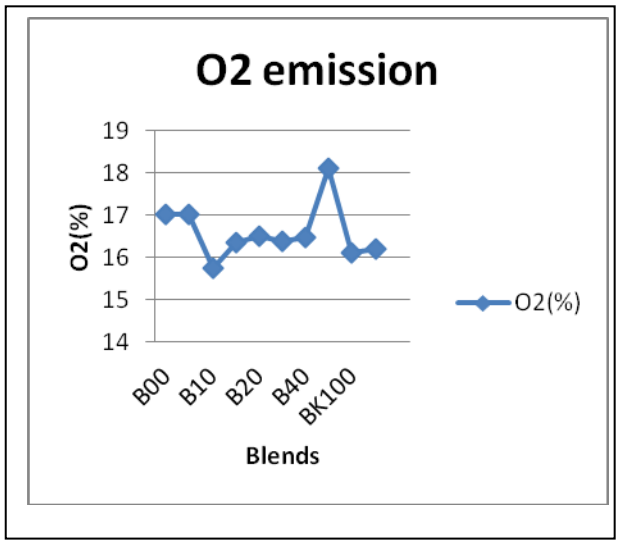


Fig.12 O2 emission

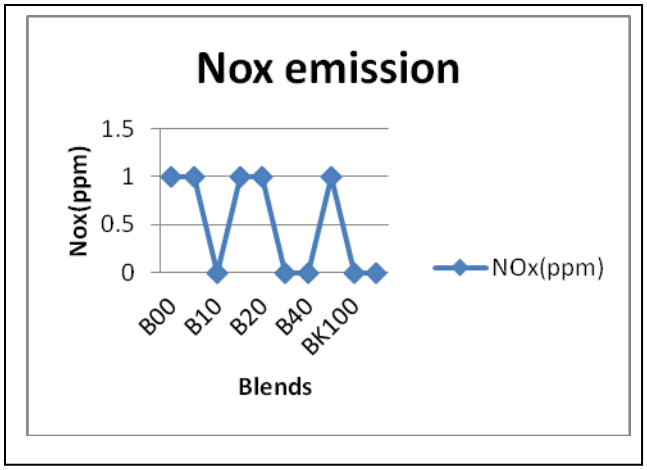


Fig.13 NOx emission

The Experimental work carried out in this study was analyzed and the results were discussed as above and the major findings are listed.

Viscosity of the blends is found close to that of the diesel. in this. The main objective of the experiment is to analyse the performance and emissions characteristics of Jatropha and Karanja oil in the Diesel engine.

The Jatropha and Karanja oil has viscosity higher than that of the diesel so viscosity is reduced by blending these both biodiesel with the diesel.

a. The results shows that engine performance when fuelled with the biodiesel are comparable to that when fuelled with petroleum diesel.
b. The fuel consumption when fuelled with the biodiesel are near about same when that fuelled with pure diesel, since a little more biodiesel must be supplied to the engine to produce an equivalent amount of work, as evidence by the lower calorific value stated earlier.
c. All blends having Jatropha biodiesel shows break specific fuel consumption close to diesel.
d. The higher concentration of the blends found to improve brake thermal efficiency. Jatropha+Karnja biodiesel blends gives a good improvement in brake thermal efficiency due to the additional lubricity and oxygen contentis the possible reason for it.
e. Brake power is comparable for the all the fuel tested. The variation in the power is very less for all the tested fuels.
f. For various blends of biodiesel volumetric efficiency is found very close to pure Diesel.
g. CO, CO2, HC,NOx emission for the biodiesel blends up to 5% is lower than that of the diesel fuel.

Other blend also gives better emission results as compared to the pure diesel fuel.

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