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Experimental Investigation of Suitability of Jatropha Bio-Diesel as a Engine Fuel in 4-Stroke Diesel Engine

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***Abstract*— Today's scenario of finding alternate fuel options for reducing demands of conventional fuels and also to reduce environmental hazards issues, this analysis may give such an effective measure for suitability of biofuel to be used in an engine as an ecofriendly and potential alternate. The bio-diesel used in an engine with different blending of diesel and biodiesel (95:05, 90:10, 85:15, 80:20 respectively by volume). The result showing similar effects in mechanical efficiency, specific fuel consumption, break thermal efficiency etc. of this blending over pure diesel fuel used in engine. Also a cost effective comparison is done for using biodiesel blending in different proportions.**

***Keywords*— Bio-diesel, blending, jatropha, alternate fuel**

I. Introduction

Due to Increased utilization of traditional resources, this is obvious that our conventional resources are at a state of depletion. Also the toxic smoke coming out from the burning of this fossil fuels are dramatically hazarding human life. That gives rise to find some other replacement for fulfillment of the uses of that resource in daily life in a prominent way.

TABLE-1 PRODUCTION AND IMPORT OF CRUDE OIL IN INDIA (MT)

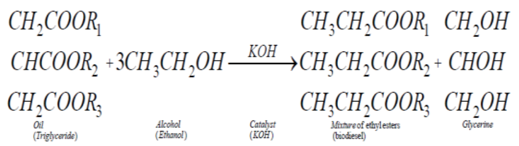
	Capita	Prim. Energy	Production	Import
	Million	*TWh*	*TWh*	*TWh*
2004	1,080	6,662	5,430	1,230
2007	1,123	6,919	5,244	1,745
2008	1,140	7, 222	5,446	1,836
2009	1,155	7,860	5,844	2,116
2010	1,171	8,056	6,032	2,110
2012	1,241	8,716	6,291	2,483
Change in 2004-10	8.4%	20.9%	11.1%	72%
MT = 11.63 TWh				

Source: IEA Key October, crude oil p.11, coal p. 13 gas p. 15

Biodiesel is the promising option as alternative fuels for diesel engine (edible or non-edible). Biodiesel is defined as the esters of mono-alkyl with long chain of fatty acids derived from different sources of non-edible seeds oils, algae, waste cooking oil and fats. Biodiesels are renewable, eco-friendly, emission less, easily available and also less costly. Biodiesel have some advantages as compared to conventional diesel fuel. The most important advantages of using biodiesel are biodegradability, derived from natural resources, higher cetane number and reduced exhaust emissions. Also, biodiesels are free from sulfur or aromatic compounds and reduces air pollution like carbon monoxides, hydrocarbons and particulate matter. Therefore, this makes biodiesel as an ideal fuel for future and it is gaining a worldwide attention [8]. Many researchers have concluded that vegetable oils and their derivatives are good alternate option to replace diesel fuel requirements. The first use of vegetable oil in a compression ignition engine was first demonstrated through Rudolph Diesel who used peanut oil in his diesel engine. Biodiesel has become more important recently because of its environmental benefits and the fact that it is made from renewable resources [1]. The uses of oils from coconut, soyabean, sunflower, safflower, linseed and palm and different vegetable oils amongst others have been attempted. The long term use of vegetable oils led to injector choking and the thickening of crankcase oil which resulted in piston ring sticking also some other issues occurs in performance of engine and the cost efficiency is much less than using diesel oil. So, vegetable oils are regretted used in diesel engines because of endurance issues [2]. To overcome this problem, various modifications of vegetable oils have been employed such as transesterification [3]

A. *Transesterification of vegetable oils*

Biodiesel is a methyl ester produced from a process called transesterification of triglyceride in vegetable oils or animal fat and waste etc. This technique uses a strong acid such as sulfuric acid or Sodium hydroxide or carbonates or enzymes to catalyze the esterification of the FFAs, and process is done by reacting lower alcohols such as methanol or ethanol with triglyceride [2, 4].



B. *Properties of different biodiesels*

ASTM characterization of the fuel was done to en-sure that the test fuel used in the study conforms to the ASTM D6751-08 standard (ASTM, 2008). Such procedures were: cloud and pour point (ASTM D2500), flash point (ASTM D93), kinematic viscosity (ASTM D445), acid number (ASTM D664) and gross heating value (ASTM D4809) [7].

TABLE-II PROPERTIES OF VEGETABLE OILS

Vegetable Oil	***Cetane Number***	***Heating Value (MJ/kg)***	***Cloud Point (°C)***	***Pour Point (°C)***	***Flash Point (°C)***	***Density (kg/ltr)***
Corn	37.6	39.5	-1.1	-40	277	0.909
Cotton Seed	41.8	39.5	1.7	-15	234	0.914
Crambe	44.6	40.5	10.0	-12.2	274	0.904
Linseed	34.6	39.3	1.7	-15.0	241	0.923
Peanut	41.8	39.8	12.8	-6.7	271	0.902
Rapeseed	37.6	39.7	-3.9	-31.7	246	0.911
Safflower	41.3	39.5	18.3	-6.7	260	0.911
Sesame	40.2	39.3	-3.9	-9.4	260	0.913
Soya bean	37.9	39.6	-3.9	-12.2	254	0.913
Sunflower	37.1	39.6	7.2	-15.0	274	0.916
Jatropha	45	40	16	2	240	0.912
Pongamia	51	46	23	-	160	0.882
Diesel	50	43.8	-5	-16	76	0.855

Source: reference no. [5, 6]

II. MATERIALS AND METHODS

A. *Materials*

Jatropha biodiesel was prepared from previously extracted and refined oils at Chhattisgarh biofuel development authority

[CBDA] plant at Raipur Chhattisgarh and also purchased from here. And then the experimental setup of 4-stroke single cylinder diesel engine was prepared at MPCCET College Bhilai. The following fuel and fuel blends are used for experimental work as follows:

100% pure Diesel- D100
5% Jatropha Biodiesel-95% Diesel-B5
10% Jatropha Biodiesel-90% Diesel-B10
15% Jatropha Biodiesel-85% Diesel-B15
20% Jatropha Biodiesel-80% Diesel-B20

B. *Experimental setup*

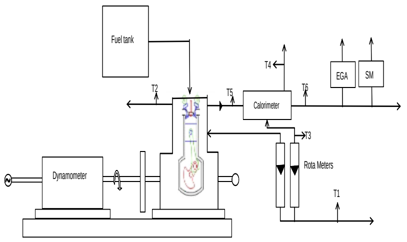


Fig.1- Single Cylinder Four Stroke Diesel engine test rig

Engine Specification

01. Make of Engine : Kirloskar
02. Type of Engine : 4 Strokes / Vertical
03. No of Cylinder : One
04. Type of Cooling : Water Cooled
05. Rated Power : 5 HP
06. Rated Speed : 1500 RPM
07. Bore/stroke : 80/110 mm
08. Loading Arrangements : Rope brake

III. RESULT AND DISCUSSIONS

In order to study the performance of IC engine using biodiesel and its blends with diesel, an experimental performance has been done. The efficiency, Power and brake specific fuel consumption (BSFC) of the engine was measured and calculated under variable load conditions for different blends.

A. *Mechanical efficiency of jatropha biodiesel blends*

Engine load taken in kg. B5 blend of biodiesel more prominent value then diesel at each load condition like at 9 kg load, 53.5% and 54.7% are the mechanical efficiencies of D100 and B5 respectively. The mechanical efficiency is approximately same as D100 at B20.

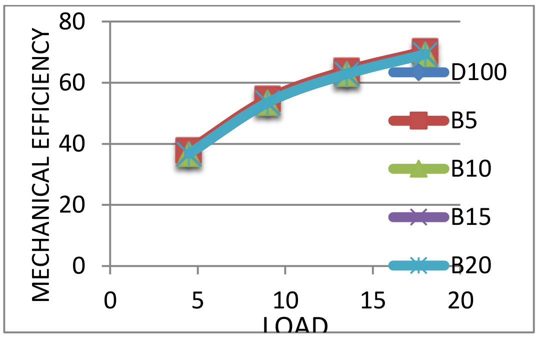


Fig.2- Mechanical efficiency in varing load

B. *Brake thermal efficiency Vs Brake horse power*

Comparing Brake Thermal Efficiency at 13.5 kg load, for the diesel fuel it was 12.4 % and for the jatropha biodiesel (B05) it was found 12.42 %. So, we can say that Brake Thermal Efficiency in case of jatropha biodiesel is increases as compare to pure diesel fuel and for the biodiesel fuel (B20) it will increases by 5%. In other words, the Brake Thermal Efficiency for jatropha biodiesel and its blends was found to be slightly higher than that of diesel fuel at tested load conditions. The reason being that, the jatropha biodiesel contains approximately 10% higher oxygen than diesel fuel which may results in better combustion.

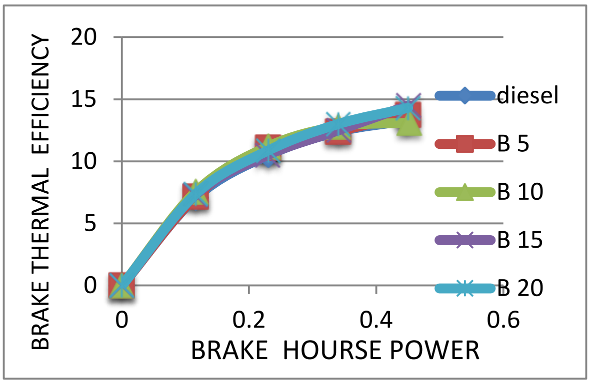


Fig.3- Brake thermal efficiency Vs Brake horse power

C. Mechanical efficiency and Brake horse power

Comparing Mechanical efficiency with brake horse power at various loads, like at 18kg for the diesel fuel it was 69.4% and for the jatropha biodiesel(B20) it was found approximately same 69.38%, for jatropha biodiesel (B5) it was having slight less value. This was because of the indicated horse power is proportional to the brake horse power which ratio is equal to the mechanical efficiency. The figure 4 shows the relation between brake horse powers of engine and the mechanical efficiency.

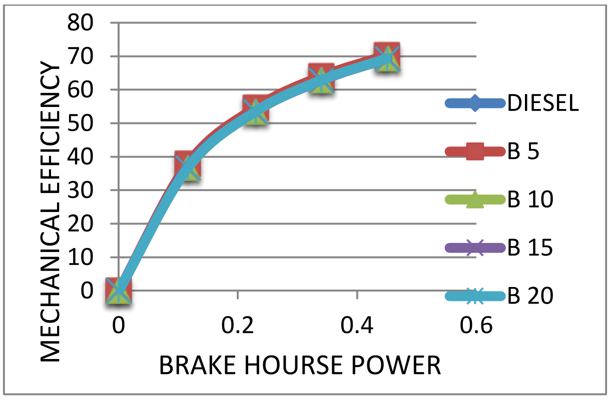


Fig.4- mechanical efficiency Vs Brake horse power

*D. Brake power Vs specific fu*el consumption

Looking at the Specific Fuel Consumption at 18 kg load condition, it was 2.464 kg/BHP hr for diesel fuel and 2.4 kg/BHP hr for jatropha biodiesel (B05) and for B20 it was 2.35. The meaning is Specific Fuel Consumption reduces by 4.7% for jatropha biodiesel (B20) compare to diesel fuel. From the result table we can also conclude that for other blending Specific Fuel Consumption is almost nearer to diesel fuel.

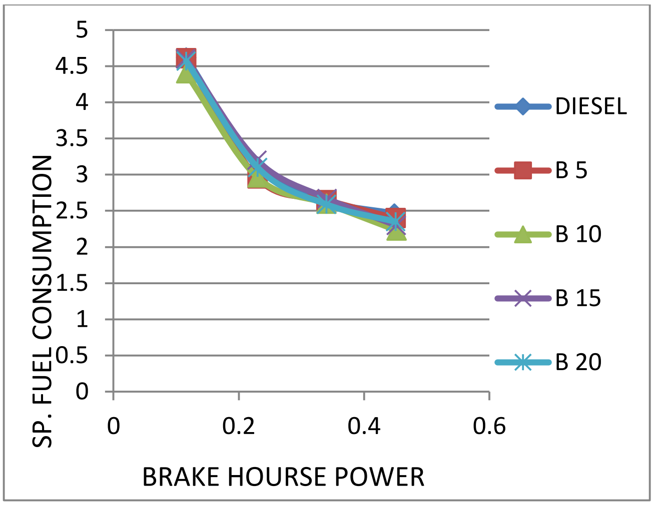


Fig. 5- specific fuel consumption consumed for brake horse power at different conditions

E. Cost analysis of Diesel oil, Non-Edible Biodiesel and Edible Biodiesel Oil

As per the CBDA the cost of a biodiesel of non-edible (jatropha) oil is varies between 45-50 INR per liter. And the average prize of diesel oil in Chhattisgarh is about 70 IN per liter. Also the costing of a biodiesel derived from Edible sources of oil then it costs about 80-85 INR per liter. So if we comparing alls cost then we got cost benefited by using non-edible oils only.

IV. CONCLUSION

Non-edible biodiesel considered most potential source and less costly then conventional diesel fuel and edible oils biodiesels. A four stroke, single cylinder direct injection diesel engine of 5 HP output was used to test jatropha curcas biodiesel blends, and compared with conventional diesel fuel for the different parameters. The fuel properties of jatropha biodiesel were very much similar to the conventional diesel fuel. A single cylinder compression ignition engine was operated successfully using methyl ester of Jatropha oil as the soul fuel with additives. Methyl ester of Jatropha oil results in a slightly increased thermal efficiency as compared to that of diesel. By the analysis at different blend we found that the performance of engine at 20% blend with diesel gives better value in comparison to other blends & closer to diesel fuel. It is much economical than other blends so tends to Reduces cost.

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