Evaluation of biodiesel as a fuel for diesel Engine

And Analysis of smoke level at different injection Pressures

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Abstract*— In view of the threat of unstable supply and cost escalation of petroleum fuel in near future, this being a nonrenewable source of energy, the search for alternate fuel, for compression ignition has assumed great significance. Use of renewable vegetable oil or animal fat based biodiesel appears to be viable alternate to the commercial petroleum diesel. Amongst various biomass based fuel option being searched for diesel, biodiesel blends have considerable promise because of their comparable fuel properties to that of diesel. Biodiesel is an oxygenated, nontoxic, sulphur free, biodegradable and renewable fuel. In this project, evaluation of food based and non-food based biodiesel has been made for four biodiesel blends. Fuel injection pressure plays a very important role in the combustion process of diesel engine and hence affects the engine performance. The injection pressure in diesel engines is usually set at a level recommended for petroleum diesel. Effect of variation of injection pressure on the performance of biodiesel blends and smoke levels at respective pressure is analysed in this project. This will give important perspective on how biodiesels blends can give performance comparable to petroleum diesel.

Index Terms— **Diesel Engine, palm seed biodiesel, karanja seed biodiesel, castor seed biodiesel, smoke meter**

I. INTRODUCTION

Biofuels are derived from plant materials – are entering the market, driven by factors such as oil price spikes and the need for increased energy security. Bioethanol is an alcohol made by fermenting the sugar components of plant materials and it is made mostly from sugar and starch crops. With advanced technology being developed, cellulosic biomass, such as trees and grasses, are also used as feedstock for ethanol production. Ethanol can be used as a fuel for vehicles in its pure form, but it is usually used as a gasoline additive to increase octane and improve vehicle emissions. Bioethanol is widely used in Brazil (Ethanol fuel in Brazil, where 100% of the gas stations sell it and all gas contains 25% of bioethanol) and in the USA. Biodiesel is made from vegetable oils, animal fats or recycled greases. Biodiesel can be used as a fuel for vehicles in its pure form, but it is usually used as a diesel additive to reduce levels of particulates, carbon monoxide, and hydrocarbons from diesel-powered vehicles. Biodiesel is produced from oils or fats using transesterification and is the most common biofuel in Europe. Biofuels provided 1.8% of the world's transport fuel in 2008. Investment into biofuel production capacity exceeded $4 billion worldwide in 2007 and is growing.
Biodiesel is produced from oils or fats using transesterification and is a liquid similar in composition to fossil/mineral diesel. Its chemical name is fatty acid methyl (or ethyl) ester (FAME).
Oils are mixed with sodium hydroxide and methanol (or ethanol) and the chemical reaction produces biodiesel and glycerol. One part glycerol is produced for every 10 parts biodiesel. Feedstock for biodiesel include animal fats, vegetable oils, soy, rapeseed, jatropha, mustard, flax, sunflower, palm oil, hemp, field pennycress, pongamia pinnata and algae. Pure biodiesel (B 100) is by far the lowest emission diesel fuel. Although liquefied petroleum gas and hydrogen have cleaner combustion, they are used to fuel much less efficient petrol engines and are not as widely available. Biodiesel can be used in any diesel engine when mixed with mineral diesel. The majority of vehicle manufacturers limit their recommendations to 15% biodiesel blended with mineral diesel. Blends of biodiesel 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 biodiesel in any fuel mix: fuel containing 20% biodiesel is labeled B 20, while pure biodiesel is referred to as B 100. Blends of 20 % biodiesel with 80 % petroleum diesel can generally be used in unmodified diesel engines. Biodiesel can also be used in its pure form, but may require certain engine modifications to avoid maintenance and performance problems.

II. EXPERIMENTAL CALCULATIONS

There is need for using nonfood based biodiesel and also to obtain a reasonable performance in a diesel engine while using biodiesel blend as a fuel. The main factor attracting our attention towards nonfood based biodiesel sources is mainly the competition between food and fuel, which has been held as a crucial negative point by the detractors of biodiesel. It has been found that a nonfood based biodiesel source like Jatropha or Karanja gives better performance in terms of brake power and CO emissions. But on the other hand, there is an increase in the maximum temperature attained by the engine during operation using Jatropha and Karanja which subsequently leads to higher NO_X emissions. To counter these problems, one of the novel ways reached was blending of the food based and nonfood based biodiesel with one another and studying the performance characteristics of the resulting blends. Hence we focused our attention on blending food based biodiesel obtained from sources like Castor and Palm with nonfood based biodiesel obtained from Karanja. The injection pressure in diesel engines is usually set at a level recommended for
petroleum diesel. As the properties of biodiesel blends to be used as alternatives to petroleum diesel in diesel engines are different than that of diesel like the specific gravity, calorific value, fire point, flash point etc., it is important to study whether these blends

can give better performance at an injection pressure other that the one recommended for petroleum diesel. Hence we performed the tests at three different injection pressures to find out optimum injection pressure for the effective use of biodiesel.

III. MATERIALS AND METHODOLOGY

In this project, three different biodiesel fuels prepared from Palm oil, Castor oil and Karanja oil have been used to prepare blends. Castor oil is extracted from the seeds of Palma Christi. Seeds are approximately 46% oil. This oil is highly viscous, its coloration ranges from a pale yellow to colorless. It has a soft and faint odor and a highly unpleasant taste. Castor biodiesel has very low poured and cloud points which make this biofuel a good alternative in winter conditions. Palm oil is edible plant oil derived from the pulp of the fruit of the oil Palm Elaeis guineensis. Palm is also used to make biodiesel, as either a simply-processed Palm oil mixed with petroleum diesel, or processed through transesterification to create a Palm oil methyl ester blend. Karanja or Pongamia pinnata, a plant native to India, appears to have good potential for biodiesel. Considered less exotic than Jatropha, there is a good chance that its oil is cheaper as well. However, only recently has this plant come into the research arena for biodiesel. As the use of food based biodiesel may lead to increase in food prices, we
are using blends of food based (Palm) and nonfood based (Karanja) biodiesel fuels to combine their advantages. The blends used and the nomenclature adopted for them is given in Table given below.

Table 3.1 Nomenclature and composition of biodiesel blends tested

Nomenclature	Composition
PCB40	Palm20%,Castor 20%,Diesel 60%
PCB60	Palm30%,Castor30%,Diesel 40%
PKB40	Palm20%,Karanja 20%,Diesel 60%
PKB60	Palm30%,Karanja30%,Diesel 40%

Various physical properties of the above mentioned blends are given in Table 3.2.

Table 3.2 Physical properties of various blends

	PKB 40	PKB 60	PCB 40	PCB60
Cal.value (kj/kg)	41236	40937	42050	41600
Sp. Gravity	0.857	0.866	0.84	0.853
Viscosity @ 40ºC	5.3	5.9	4.9	5.7
Flash Point (ºC)	77	80	79	82
Fire Point (ºC)	84	87	84	87
Cloud Point (ºC)	-4	-4.5	-4	-4.5
Pour Pont (ºC)	-15	-15.8	-13	-14

IV. EXPERIMENTAL SETUP

The specifications of the engine on which the tests were performed are given in Table 4.1.

Table 4.1 Engine Specifications

V. FUEL INJECTOR SETTING AND TESTING

Injection pressure can be changed by tightening or loosening the injector screw for increasing or decreasing the injection pressure respectively. The injection pressure can be checked with manual injector pressure setting machine. The diesel engine performance was tested at fixed speed and varying loads at 3 different injection pressures 190 bar, 210 bar (recommended setting for petroleum diesel) and 220 bar.

Engine Parameter	Value
Make	Kirloskar
Details	4-Stroke. Water cooled, DI
No. of cylinders	1
Bore and Stroke	80x100 mm
Compression Ratio	16.5:1
Rated Power	3.7 kW at 1500 rpm
Recommended Injection Pressure	210 Bar

VI. RESULTS OF TESTS ON DIESEL ENGINE

GRAPHICAL ANALYSIS

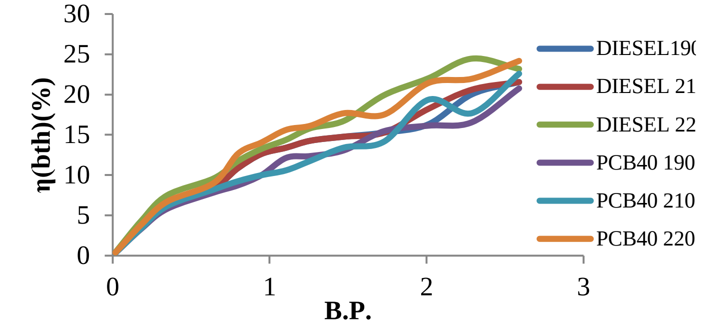

Figure 6.1 η(bth) (%) vs B.P (kw) at different pressures between Diesel and PCB40

PCB40 and Diesel at 220 bar gives good performance.

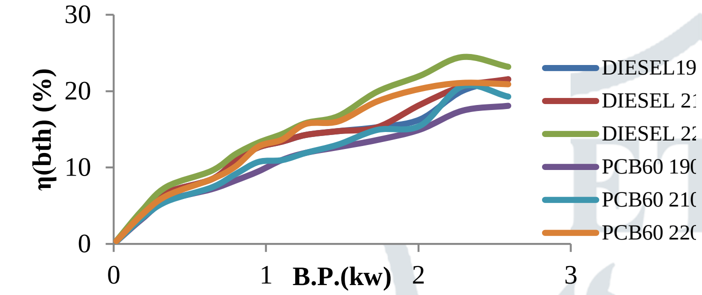

Figure 6.2 η(bth) (%) vs B.P (kw) at different pressures between Diesel and PCB60

PCB60 and Diesel giving good performance.

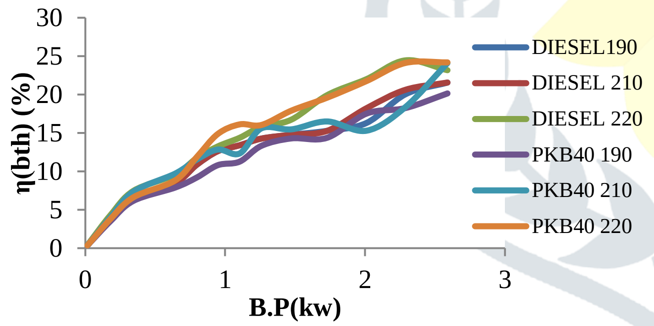

Figure 6.3 η(bth) (%) vs B.P (kw) at different pressures between Diesel and PKB40

At 220 bar getting good performance.

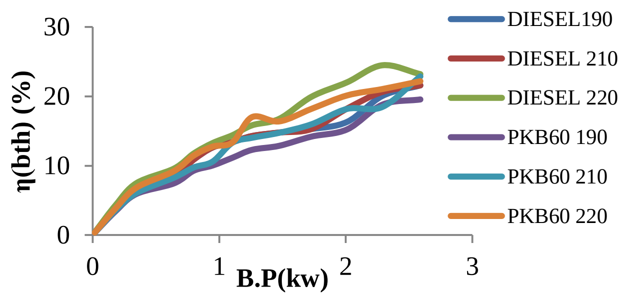

Figure 6.4 η(bth) (%) vs B.P (kw) at different pressures between Diesel and PKB60

PKB60 and Diesel at 220 bar giving good performance.

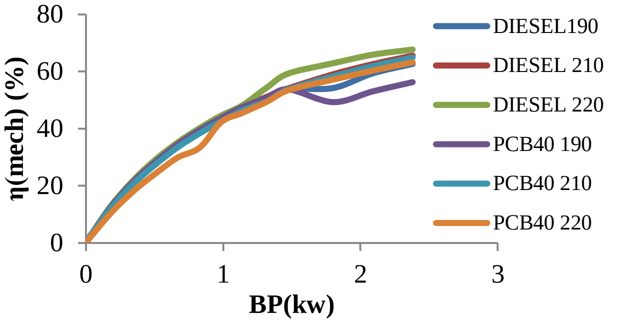

Figure 6.5 η(mech) (%) vs B.P (kw) at different pressures between Diesel and PCB40

Mechanical efficiency curves are similar at all pressures.

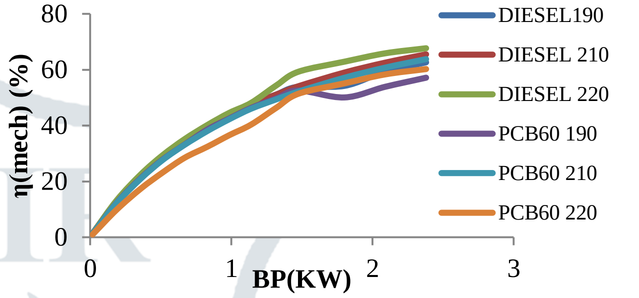

Figure 6.6 η(mech) (%) vs B.P (kw) at different pressures between Diesel and PCB60

PCB60 giving lowest Mechanical efficiency at 190 bar

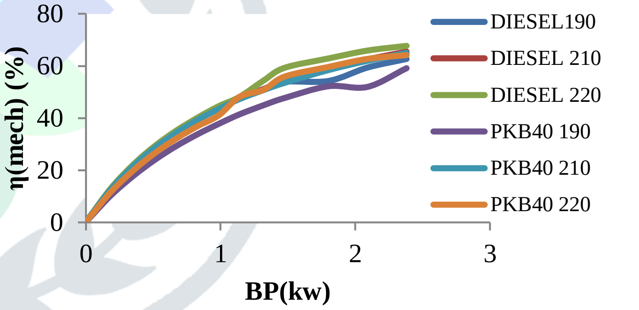

Figure 6.7 η(mech) (%) vs B.P (kw) at different pressures between Diesel and PKB40

PKB40 at 190 bar giving lowest performance.

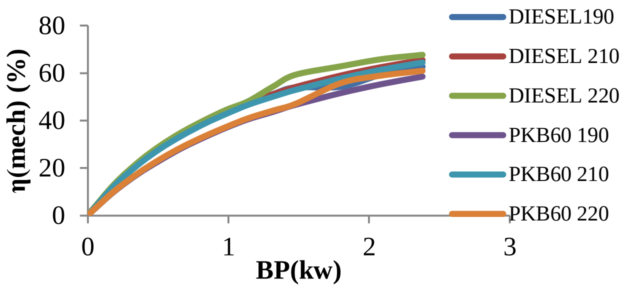

Figure 6.8 η(mech) (%) vs B.P (kw) at different pressures between Diesel and PKB60

At 210 bar and 220 bar graphs are superimposed.

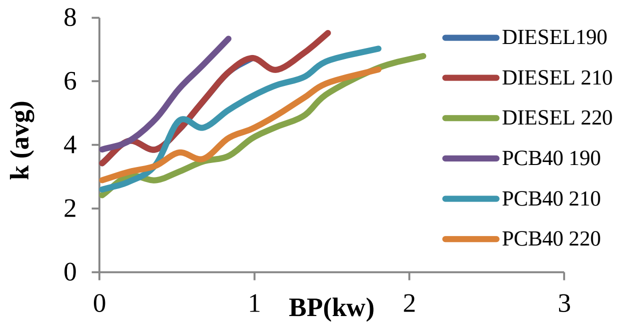

Figure 6.9 k(avg) vs B.P (kw) at different pressures between Diesel and PCB40

PCB40 at 190 bar giving highest smoke level.

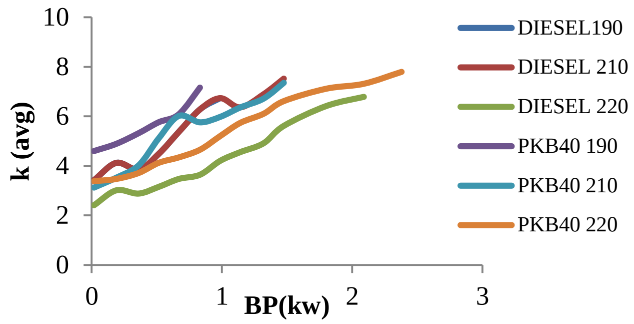

Figure 6.11 k(avg) vs B.P (kw) at different pressures between Diesel and PKB40

PKB40 at 220 bar gives lower smoke levels.

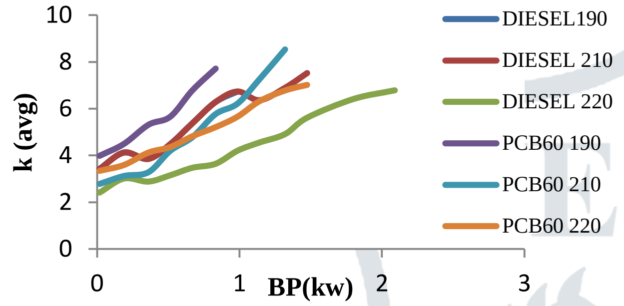

Figure 6.10 k(avg) vs B.P (kw) at different pressures between Diesel and PCB60

PCB60 giving lowest smoke levels at 220 bar

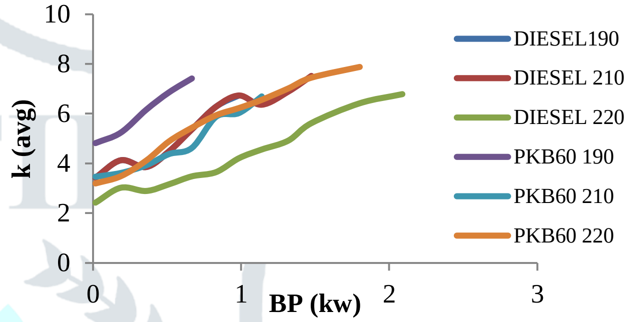

Figure 6.12 k(avg) vs B.P (kw) at different pressures between Diesel and PKB60

PKB60 at 190 bar gives higher smoke levels.

VII. Discussion

From the graph, it can be said that at 210 bar pressure, which recommended for current diesel engine, we get higher mechanical efficiency for all samples. We are getting highest brake thermal efficiency for PCB 40 sample and all other sample giving satisfactory values of brake thermal efficiency. PCB 60 giving highest exhausts emissions. At this injection pressure PCB samples are giving more smoke than PKB samples due to higher viscosity of PCB samples.

At injection pressure of 190 bar, values of both the efficiency viz brake thermal and mechanical are lower. Petroleum diesel giving highest brake thermal efficiency as well as mechanical efficiency. Smoke levels are higher for biodiesel blends than petroleum diesel.

The above graphical analysis shows satisfactory results at 220 bar. Here mechanical efficiency is highest petroleum diesel. Except for PCB 60 and PKB 60 all other samples giving better performance. Smoke levels are higher for PKB samples than PCB samples.

VIII. CONCLUSION

It is seen from the analysis that biodiesel is a feasible source of fuel for CI engine. The competition between food and fuel has forced us to search for nonfood based source of biodiesel. It was shown that a blend of nonfood based and food based biodiesel can be effectively used to overcome the shortcomings of both. After finding biodiesel to be a feasible alternative as a fuel for diesel engine, efforts were made to increase its performance to a level comparable to that obtained from ordinary petroleum diesel. For this purpose, effect of variation of injection pressure on engine performance when using various blends was studied. It was found that the optimum level of injection pressure for biodiesel blends is at a value higher than the level recommended by the manufacturer for petroleum diesel. At lower injection pressure, the blends gave better performance than petroleum diesel in terms of brake thermal efficiency and mechanical efficiency. Also, at lower injection pressure, the exhaust gas temperatures were considerably lower for both the blends which indicate better combustion and less wastage of heat to the atmosphere. This may also result in less NO_x emissions and make biodiesel a greener fuel. So, it can be safely said that biodiesel blends prepared from mixtures of food based and non-food based sources when used at lower injection pressure will prove to be very practical alternatives in terms of performance, cost and the load on food based sources. The exhaust gas emissions were also found to increase at low pressures due to incomplete combustion and ineffective atomization.

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