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Performance And Emission Characteristics Of Biodiesel-Butanol Blended Fuel In Ci Engine

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Abstract
The use of biodiesel as an alternative diesel engine fuel is increasing rapidly. However, due to technical deficiencies, they are rarely used purely or with high percentages in diesel engines. Therefore, in this study, we used butanol as an additive to research the possible use of higher percentages of biodiesel in a diesel engine. B100 (100% biodiesel) was prepared as the baseline fuel. Butanol was added to biodiesel as an additive by volume percent of 10%, 20%, 30%, 40% (denoted as PME90 B10, PME80 B20, PME70 B30, PME60 B40) were used in a single cylinder, four strokes direct injection diesel engine. The effect of test fuels on brake specific fuel consumption, brake thermal efficiency, exhaust gas temperature, and NO_X, smoke opacity emission was investigated. The experimental results showed that the performance and emission of CI engine we can use of the 100% biodiesel PME70 B30, PME60 B40. Besides, the exhaust emissions for PME60 B40were fairly reduced.

1. Introduction

In research topics that have main importance concerning petroleum fuels in vehicle engines were power and energy. However, over last 30 years air pollution due to engine exhaust has become a social problem and the achievement of low pollution combustion has become a research subject. Diesel engines are used in a wide range of industry such as agriculture, transportation, building and energy production due to their high efficiency. Besides, with the development in electronics technology diesel engines are being more and more used in automobiles. Because a good many of diesel engines are being used, we are in need of petroleum more than ever. On the other hand, it is also commonly recognized today that the world petroleum energy resources are finite, thus many researches have been carried out to find suitable alternative fuels to petroleum products.

They are generally used as a blend with conventional diesel fuel with low percentages. But there is a possibility of using higher percentages of biodiesel with solvent additives. Therefore, in this study, we used butanol as an additive to research the possible use of higher percentages of biodiesel in a diesel engine

It is important for an alternative diesel fuels to be technically acceptable, economically competitive, environmentally acceptable and easily available. Among these alternative fuels, biodiesel and its derivatives, have received much attention in recent years for diesel engines. Biodiesel is an oxygenated diesel engine fuel that can be obtained from palm oil by conversion of the triglycerides to esters via transesterification. It has similar properties to those of fossil diesel. Therefore, researches on biodiesel derived from palm oil lead the studies that of aimed to alternate petroleum based diesel fuels. It has been reported by the results of many studies that biodiesel can be used in diesel engines with little or no modifications [1], and with almost the same performance. Besides it reduces no_x and smoke emissions[2, 3]. The results vary according to the palm oil, the process of biodiesel production as well as biodiesel fuel properties. Therefore different based biodiesels and their blends with various fuels were tested in diesel engines with different engines as well as test conditions. On the other hand, disadvantages of biodiesel include the higher viscosity and pour point, as well as the lower calorific value and volatility. For all above reasons, it is generally not accepted that blends of standard diesel fuel with 10% or up to 20% biodiesels can be used in existing diesel engines without any modifications[1]. Consequently, in many cases the presence of a solvent additive in the biodiesel blend becomes necessary.

Many engine performance tests have been conducted using biofuels such as Butanol as a supplementary fuel. Various techniques have been developed to introduce butanol into a compression ignition engine. However, the use of butanol-diesel blends, usually named as b-diesel, has also some limitations: it has lower viscosity and lubricity, reduced ignitability and cetane number, higher volatility and lower miscibility which may lead to increased unburned hydrocarbons emissions. Alcohol fuels have low cetane number. Therefore, little researches have been done on their use in diesel engines. butanol, for example, has a cetane rating of 25 and methanol a rating of 35. The cetane number for diesel fuels ranges from 45 to 55. Straight alcohol fuels can not be used in diesel engines. However, there are possible uses for alcohol, ester and diesel fuel blends. butanol-methyl ester blend fuel was used in diesel engine and it was reported that engine performance with methyl ester and ethanol blend was similar to that with diesel. It was also reported that blending butanol with biodiesel had the advantage of reducing the viscosity as well as reducing crystallization of biodiesel. The main objective of this study is to improve the fuel characteristics of biodiesel by using a fuel extender to utilize pure biodiesel in diesel engines. Properties value of butanol is near to diesel. so that the butanol was selected for this purpose.

2. Material and method

2. 1 Catalyst preparation:

potassium hydroxide(KOH) catalyst amount was weighed using an electronic weighting machine. Methanol measured using the measuring jar according to the molar ratio was taken in a conical flask. The weighted catalyst was put in the conical flask containing methanol and was mixed well using, the magnetic stirrer for 5 minutes for complete dissolution of KOH in the methonal

2. 2 Transesterification process:

The palm oil is taken in conical flask kept in the heater to heat the oil. Then oil heat is heated to 70°c. The methanol and catalyst(potassium hydroxide) mixed is pour into the preheat palm oil. The reaction flask is then placed in the magnetic stirrer with hot plate and the measurement of time is started at this point. The reaction mixture remained for 1½ hours at a temperature of 65°c and with a constant stirring. heating and stirring are continued for reaction time at atmospheric pressure. It is then stirred well for 1½ hours using magnetic stirrer. Molar ratio of methanol to palm oil used was 15:1.

2. 3 Separation process:

After the completion of the transesterification process. The methyl ester mixture pour in to the separating flask. Then ester mixture formed at the upper layer and the glycerol form in the lower layer. Then separated the ester and glycerol form the separating flask..

3. Experimental setup and procedure:

The experiments were carried out on a naturally aspirated, water-cooled, single cylinder, diesel engine. The specifications of the engine are shown in Table 2. The engine was connected to an eddy current dynamometer, and running at constant speed of 1500 rpm. A schematic diagram of the engine setup is shown in Fig. 1. The test was started firstly with diesel fuel and when the engine reached the operating temperature, it was loaded with a eddy current dynamometer. The load is varied from 0 to 3 kw. The number of cylinder used is one. The properties value of biodiesel and butanol is shown in table 1.

Table 1 fuel properties

Properties	**Biodiesel**	**butanol**
Chemical formula	$C_{55}H_{96}O_6$	$C_4H_{10}O$
Density (kg/m^3)	882	810
Kinematic viscosity @ 40˚C (10^{-6} m^2/sec)	4. 63	3. 64
Flash point (˚C)	128	35

The performance tests were carried on a single cylinder, four strokes and water cooled, kirloskar diesel engine. The engine was directly coupled to an eddy current dynamometer. The engine was run at a constant speed of 1500 rpm, Continuous water supply is given to the engine for the cooling. The air box with an orifice meter and water manometer is used to measure the flow rate of air supplied to the engine. Two separate fuel tanks were used; one for diesel and the other for biodiesel The volumetric flow of fuel is measured using burette and a stop watch

Smoke is measured by AVL make Hatridge type smoke meter. The NO_X emission is measured by Technovation make NO_X meter which uses chemical sensor. Experiment were conducted at five engine loads. The emission parameter measured are NO_X and smoke opacity. The Compression ratio is 16. 5:1. The exhaust gas temperature was measured using digital temperature indicator.

Table 2 Engine specifications

Make	kirloskar
Speed	1500 RPM
No. of cylinder	One
Bore m	80mm
Stroke mm	110mm
Rated output	3 kW
Compression ratio	16. 5:1
Orifice diameter	20mm
Type of ignition	Compression ignition
Method of loading	Resistance loading
Method of starting	crank start
Method of cooling	water cooled

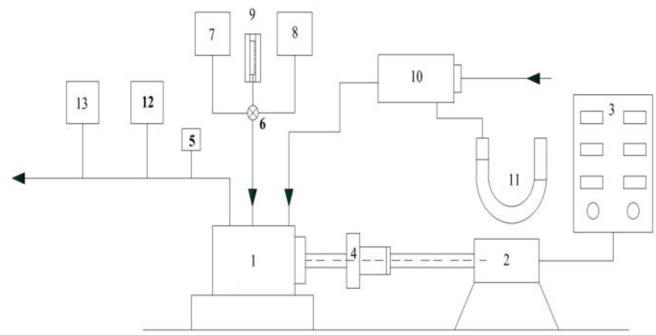

Fig. 1 Experimental Setup. 1. Engine 2. Alternator 3. Loading device 4. Coupling 5. Thermocouple 6. Two way valve 7. Fuel tank for diesel 8. Fuel tank for biodiesel 9. Burette 10. Air tank with orifice plate 11. U-tube manometer 12. NO_x meter 13. Smoke meter

we used butanol as an additive to research the possible use of higher percentages of biodiesel in a diesel engine. B100 (100% biodiesel) was prepared as the baseline fuel. Butanol was added to biodiesel as an additive by volume percent of 10%, 20%, 30% 40%(denoted as PME90 B10, PME80 B20, PME70 B30, PME60 B40), were used in a single cylinder, four strokes direct injection diesel engine.

The performance and emission characteristic of a constant speed, single cylinder 5 hp diesel engine was determined using various fuel blends. The engine performance such as Brake specific fuel consumption, total fuel consumption, brake thermal efficiency and exhaust gas temperature, smoke opacity and NO_x emission were determined. The fuel consumption was determined by measuring the time taken for a fixed volume of fuel to flow into the engine. The air was supplied to the engine through an air box with an orifice plate placed on one of its sides. The air flow rate to the engine was determined by measuring the pressure across the orifice plate with the aid of a U-tube manometer. The exhaust gas temperature was measured using copper-constantan thermocouples connected to a temperature indicator. Smoke opacity is analyzed using the smoke meter. The exhaust gas was analyzed to find out the NO_x emission. The content of NO_x in parts per million (ppm) was measured using a NO_x analyzer consisting of an electrochemical sensor.

The observations made during the test included the brake load, engine speed, and time taken for consumption of fuel, drop in air pressure across the orifice meter, exhaust gas temperature, smoke opacity and exhaust gas emissions of NO_x. The performance parameters such as brake specific fuel consumption and brake thermal efficiency were calculated.

4. Results and discussions:

4. 1 Brake Specific fuel consumption:

Fig. 2 shows the variation of specific fuel consumption (BSFC) for the engine using diesel, biodiesel, biodiesel-butanol blend with different volume basics as (90 +10), (80 + 20), (70 + 30), (60 + 40) with respect to BMEP. The BSFC is defined as the ratio of mass fuel consumption to the brake power. Due to the reduction effect of butanol on the energy content of the blends, there is usually increase in BSFC. Among the fuels tested the lowest BSFC values are obtained with diesel fuel due to low fuel consumption rate and high brake power. There are significant increases in BSFC especially when the engine is fuelled with blends having high butanol content because of higher fuel consumption rates and reduction in brake power.

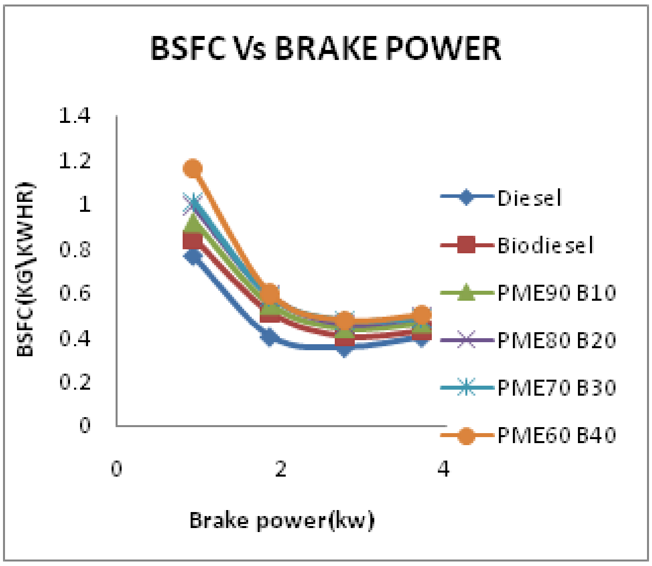

Fig 2 brake specific fuel consumption Vs brake power

4. 2 Brake Thermal Efficiency:

Fig. 3 compares the brake thermal efficiency using biodiesel and butanol to that of blends (10, 20, 30 & 40) butanol respectively. It is evident that thermal efficiency with butanol was lower than diesel at all brake mean effective pressure. The possible reasons for the reduction in thermal efficiency may be the lower heat content, higher viscosity and poor volatility of butanol compared to diesel. There are very slight decrease in BTE with the use of blend (n-but 10%), and (n-but 20%) as compared to biodiesel fuel. The graph is drawn between the brake mean effective preesure and brake thermal efficiency.

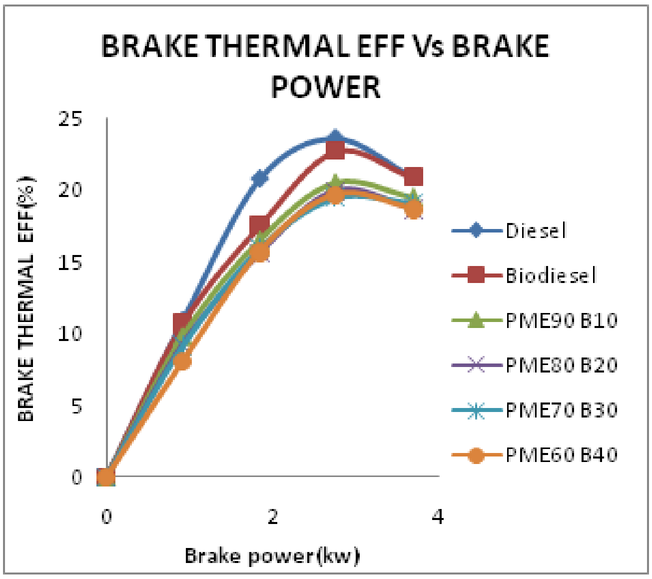

Fig 3 brake power Vs brake thermal efficiency

4. 3 Exhaust Gas Temperature:
Fig. 4 shows the variation of exhaust gas temperature with respect to brake mean effective pressure for the engine using biodiesel-butanol blends (10, 20, 30 & 40) of butanol. The difference in the exhaust gas temperature of the engine with biodiesel-butanol as fuel is shown in the above graph. The exhaust gas temperatures with the blends are lowered than that with diesel. This may attributed to the lower energy content of the blend as a result of the oxygen content and their lower cetane number.
Having oxygen and a low energy content, oxygenated fuels usually cause lower combustion temperatures. The highest decrease in the exhaust temperature was observed in the 100% biodiesel and in the blend of but 30, but 40 which has lowest energy content among the fuels tested.

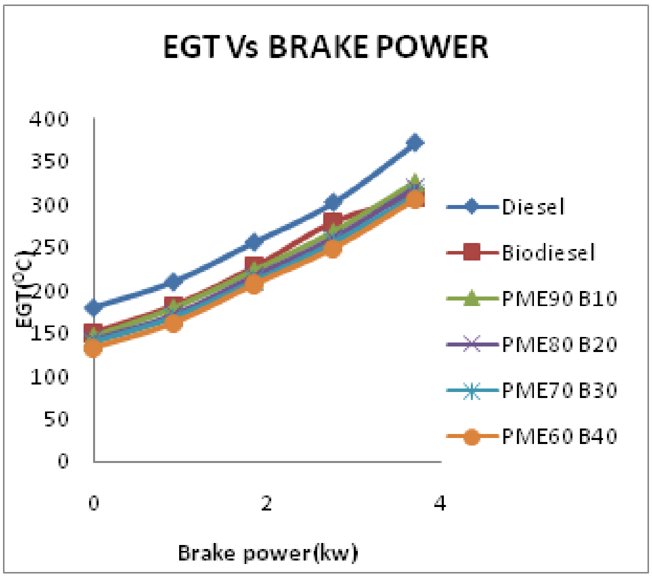

Fig 4 brake power Vs Exhaust gas temperature

4. 4 NO_X Emission:
Fig. 5 shows the NO_x emission biodiesel-butanol blend with different volume basics as (90 + 10), (80 + 20), (70 + 30), (60 + 40) with respect to Brake mean effective preesure. It can be seen the NO_x emission was a direct function of engine power outputs. It is seen that there is a decreasing tendency in NO_x emissions with the use of the blends as compared to diesel fuel, the decrease in NO_x emissions is usually proportional to the butanol content in the blends. NO_x emissions from the diesel engine depend on various reasons such as fuel properties and engine operating conditions
It is known that NO_x emissions are caused by higher combustion temperature and higher oxygen concentration in the cylinder. Alcohols usually produce lower combustion temperature due to their lower heating value and oxygen content. Fig. 5 also indicates that the NO_x emission was lowered with the substitution of butanol as fuel

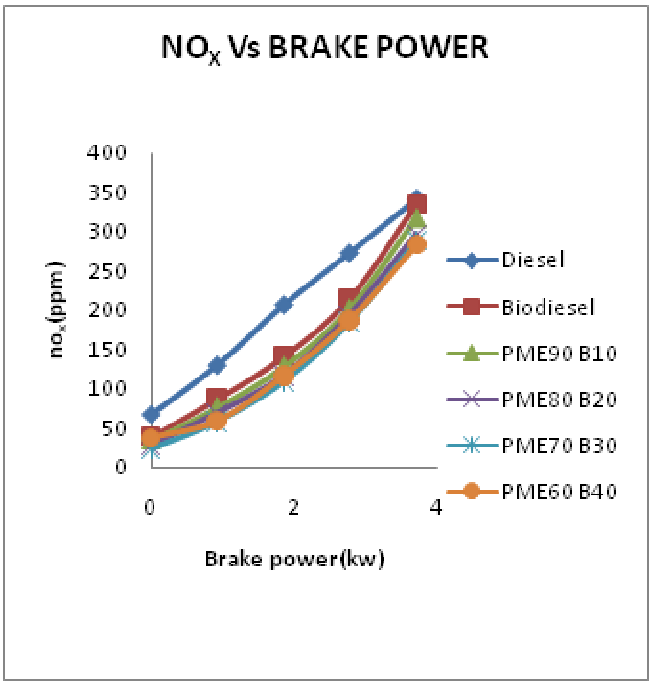

Fig 5 brake power Vs NO_x

4. 5 Smoke opacity:
Smoke opacity defines as darkness of smoke due to carbon content. Fig 6 shows the comparison of smoke opacity for different percentage of butanol in biodiesel. For all BMEP it is found that smoke opacity gradually decreases as percentage of butanol in biodiesel increases. The maximum decreases in the smoke opacity are seen at the blends of but30% and but40%.

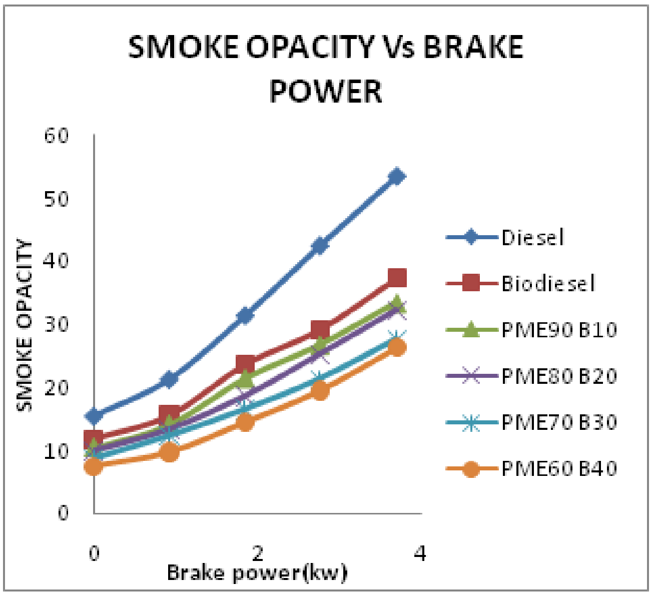

Fig 6 brake power Vs smoke opacity

5. Conclusion:
The engine performance and exhaust emissions of a diesel engine using biodiesel-butanol blends were investigated and

compared to those with baseline fuel. The blends containing (B90 + but10), (B80 + but20), (B70 + but30), (B60 + but40) were prepared and tested in a direct injection diesel engine. Considering the experimental results

There are significant increases in BSFC especially when the engine is fuelled with blends having high butanol content because of higher fuel consumption rates and reduction in brake power. The brake thermal efficiency of the fuel blends is very close to the biodiesel. The use of biodiesel-butanol fuel blends caused a decrease in $N0_X$ emissions. The formation of exhaust emissions was heavily affected by the butanol content of the blend. The exhaust gas temperatures with the blends are lowered than that with diesel. For all BMEP it is found that smoke opacity gradually decreases as percentage of butanol in biodiesel increases. The maximum decreases in the smoke opacity are seen at the blends of but30% and but40%

Although the blends containing as much as 40% butanol can be employed, 30% butanol was found to be an optimum blends in terms of performance and exhaust emissions.

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