Reduction of Exhaust Emissions on a Biodiesel fuelled Diesel Engine with the Effect of Oxygenated Additives

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Abstract- This paper investigate the use of neat biodiesel on a large scale is raising certain constraints, both in terms of long-term availability of feed stock, and high NOx emissions. However, HC and NOx emissions of neat biodiesel are still on the higher side. The main aims of the present work is to carry out an experimental evaluation of single cylinder diesel engine by adding 10% di-ethyl ether (DEE) with Karanja methyl ester (KME) in order to further improve performance and emission characteristics of biodiesel. The results showed that the brake thermal efficiency slightly increased and the exhaust emissions are significantly decreased with DEE with biodiesel at full load conditions.

Keywords— Biodiesel, diethyl ether, emissions, performance, Karanja methyl ester,

1. INTRODUCTION

Diesel engines are more preferred for use in light, medium and heavy duty applications owing to their high fuel conversion efficiency. Of late, with the stringent emission norms being promulgated periodically, it has become imminent to switch over to cost intensive exhaust gas after treatment methods or adopting alternate fuels. The nature of diesel engine combustion process is unsteady, turbulent, diffusion and heterogeneous [1]. The combustion process is highly influenced by the way of fuel-air mixing in the engine cylinder.

One approach is to adopt a good fuel injection system as it plays a crucial role to bring fuel and air in intimate contact with each other. High injection pressures with small nozzles are common in the modern diesel engine as they reduce injection duration and improve combustion efficiency [2]. Another approach followed widely by the researchers to tackle the problems of burden on conventional fuels and reduction in pollution problems was adopting alternate fuels such as biomass and biodiesel. Among various biofuels, biodiesel has occupied prominent position due to its thermo-physical properties being close to petro-diesel [3]. Biodiesel is attractive as it is biodegradable, sulfur-free, nontoxic and can significantly reduce exhaust emissions from the engine.

Experimental investigations to optimize parameters for effective use of vegetable oil fuels like the effect of injection parameters on performance and emission characteristics of a diesel engine fuelled with pongamia methyl ester–diesel blend [4, 5]; the effect of supercharging and fuel injection pressure on the performance of a diesel engine with cotton seed oil [6] and the influence of compression ratio and injection pressure by adopting karanja methyl ester [7, 8] were studied. Among the oxygenated alternatives which could work as ignition improvers are dimethyl ether (DME) and diethyl ether (DEE) with advantages of high cetane number and oxygen content. DEE is liquid at the ambient conditions, is produced from ethanol by dehydration process which makes it attractive for fuel storage and handling. It can also assist to improve engine performance and reduce the cold starting problem and emissions when using as a pure or an additive in diesel fuel. The performance and emission characteristics of a diesel engine using fuels like DME and DEE offered promising alternatives [9]. Many researchers have confirmed through their investigations that B20 could be better option for the countries which are in the early stage of adoption of biodiesel program both looking at the availability and benefits accrued thereof with biodiesel [10,11].

It is observed from the literature that there were efforts to make use of neat biodiesel and to further make it feasible and effective. The objective of the present experimental study is to improve the performance and emissions of a biodiesel fuelled diesel engine, with addition of 10% diethyl ether (DEE) at various load conditions.

2. Preparation of Bio-Diesel

Transesterification is a chemical process of transforming large, branched, triglyceride molecules of vegetable oils and fats into smaller, straight chain molecules, almost similar in size to the molecules of the species present in diesel fuel. The process takes place by the reaction of vegetable oil with alcohol in the presence of a catalyst.

In transesterification process, Karanja oil react with methyl alcohol in the presence of catalyst (NaOH) to produce glycerol and fatty acid ester. The methyl alcohol (200 ml) and 8 gram of sodium hydroxide were taken in a round bottom flask to form sodium methoxide. Then the methoxide solution was mixed with Karanja oil (1000 ml). The mixture was heated to 65°C and held at that temperature with constant speed stirring for 2 hours to form the ester. Then it was allowed to cool and settle in a separating flask for 12 hours. Two layers were formed in the separating flask. The bottom layer was glycerol and upper layer was the methyl ester. After decantation of glycerol, the methyl ester was washed with distilled water to remove excess methanol. The transesterification improved the important fuel properties like specific gravity, viscosity and flash point. The properties of diesel, methyl ester of Karanja oil are listed in Table.1.

Table 1. Properties of diesel and Karanja oil methyl ester and DEE

S.N	**Properties**	**Diesel**	**KME**	**DEE**
1.	Density(kg $^{-3}$)	830	890	713
2.	Calori1c value (MJ kg^{-1})	42.490	37.91	33.9
3.	Viscosity (cSt)	4.59	6.87	0.23
4.	Cetane number	45 –50	49	>125
5.	Flash point (˚C)	50	187	-
6	Auto ignition Temperature(˚C)	260	≥300	160

2.2 Experimental setup

The performance and exhaust emission tests were carried out in a constant speed, direct injection diesel engine. The specifications of the test engine are listed in Table 2. The engine was coupled with rope dynamometer consisting of a loading platform to provide the brake load. Two separate fuel tanks were used for the diesel fuel and fried cooking oil methyl ester. The fuel consumption was determined by measuring the time taken for a fixed volume of fuel to flow into the engine. The exhaust emissions were measured by the AVL 444 five gas analyzer and the smoke opacity were measured by Bosch smoke meter. The schematic of the experimental set up as shown in fig.1

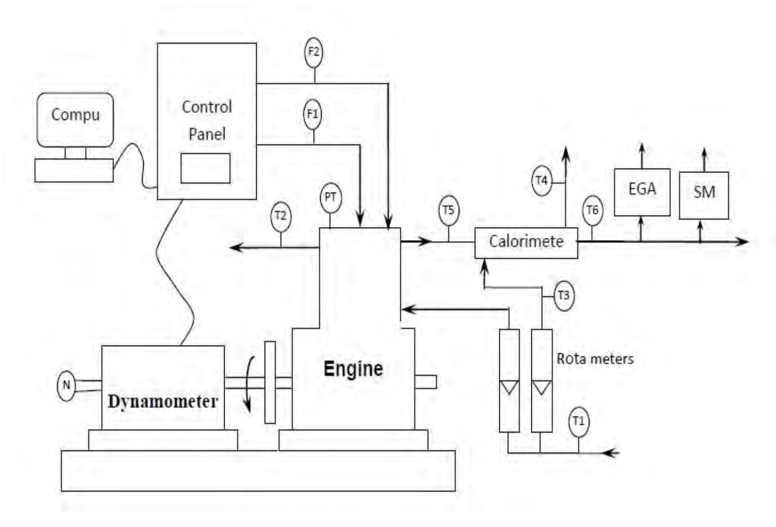

Figure 1. Schematic of the experimental setup

Table 2.Test engine specifications

Engine	**Kirloskar, AV-I,**
Power	4.44 kW
Bore (mm)	87.5
Stroke(mm)	110
Compression ratio	17.5:1
Speed (rpm)	1500
Injection pressure(bar)	200
Injection timing	23^{o}bTDC

3. RESULTS AND DISCUSSION

a) Brake Thermal Efficiency

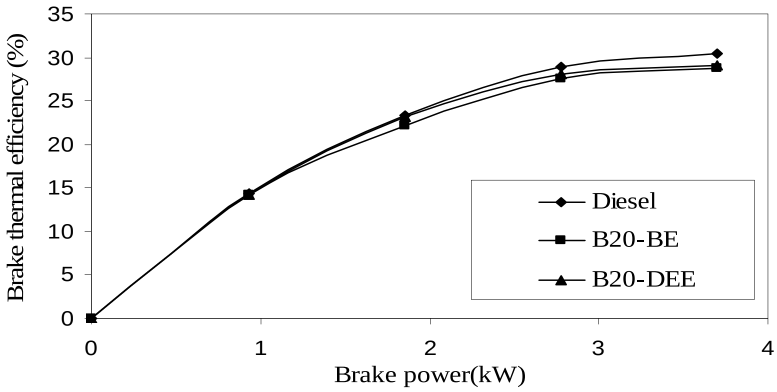

Figure 2 Variation of Brake thermal efficiency with BP

Figure 2 shows the variation of the brake thermal efficiency with brake power for diesel, B20 and B20 with DEE fuels. The brake thermal efficiency is increased for B20 with DEE as compared to B20 blend full load. The thermal efficiency obtained for diesel and B20 are 30.45%, 28.72% respectively at full load, whereas for B20 with DEE it is 29.12% at full load. The increase in BTE may be due to better evaporation of DEE that mixes with air and forms a homogeneous mixture,and results in combustion, creating a hotter environment to assist the combustion of B20 fuel, whch leads to higher thermal efficiency.

b) Brake Specific Fuel consumption

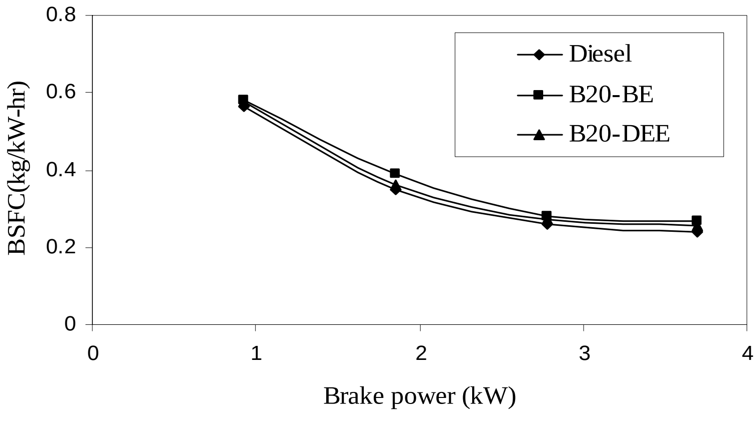

Figure 3 Variation of BSFC with BP

Figure 3 depicts the variation of the brake thermal efficiency with brake power for diesel, B20 and B20 with DEE fuels. The BSFC values obtained for diesel with B20 are 0.240 kg/kWh and 0.267 kg/kWh respectively, whereas for the B20 with DEE it is 0.256 kg/kWh at full load. The increase in BSFC for B20 may be due to high density and viscosity,which affects the mixture formation, leading to slow combustion.When a small quantity of DEE is added, it enhances the combustion of biodeisel, resulting in lower BSFC compared with B20 fuel.

c) Exhaust gas temperature

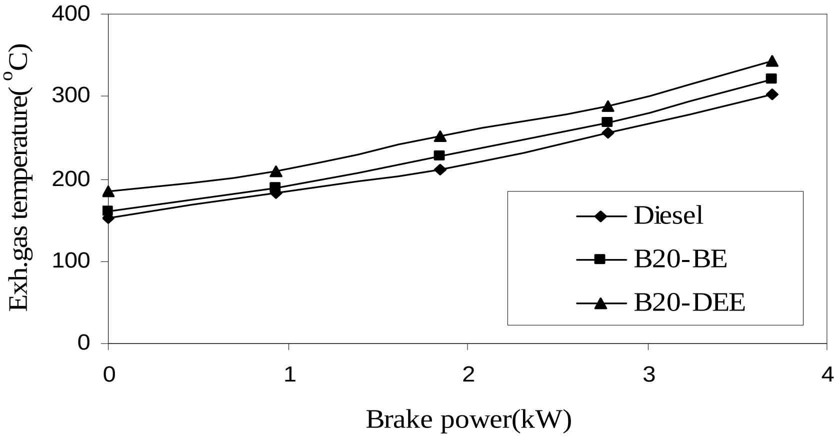

Figure 4 Variation of Exhaust gas Temperature with BP

Figure 4 shows the variation of the exhaust gas temperature with brake power for diesel, B20 and B20 with DEE fuels. The exhaust gas temperature obtained for diesel and B20 are 302°C and 320°C respectively at full load. For the B20 with DEE it is 314 °C at full load. The reduction in temperature may be due to faster combustion rates of DEE with biodiesel blend. Due to the improvement in the diffusion combustion rate, late burning of biodiesel is reduced and thus results in a reduced exhaust gas temperature. Also DEE has high latent heat of vaporization property which cools the charges and thus reduced the peak combustion temperature. Hence lower exhaust gas temperature.

d) Carbon monoxide emission (CO)

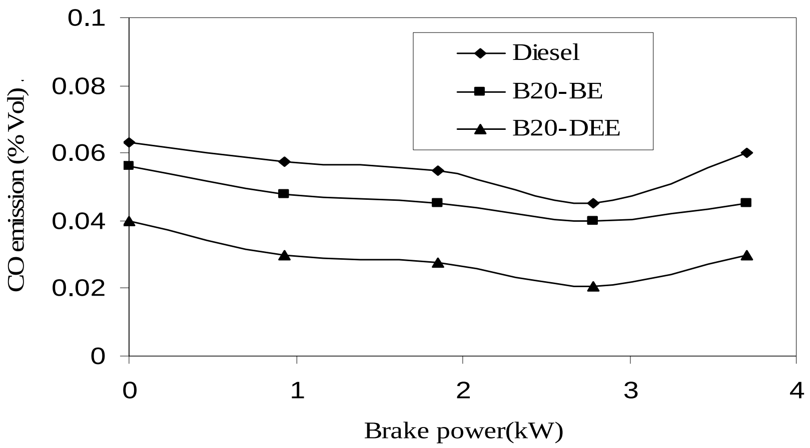

Figure 5 Variation of CO emissions with BP

Figure 5 depicts the variation of the carbon monoxide emission with brake power for diesel, B20 and B20 with DEE fuels. The CO values obtained for diesel and B20 are 0.06%Vol and 0.045 %Vol respectively at full load, whereas for B20 with DEE it is 0.035 %Vol at full load. The decrease in CO with DEE may be due to better evaporation of DEE that mixes with air and forms a homogeneous mixture and results in better and complete combustion, creating a hotter environment to assist the combustion of B20 fuel, whch leads to lower CO emissions.

e) Hydrocarbon emission (HC)

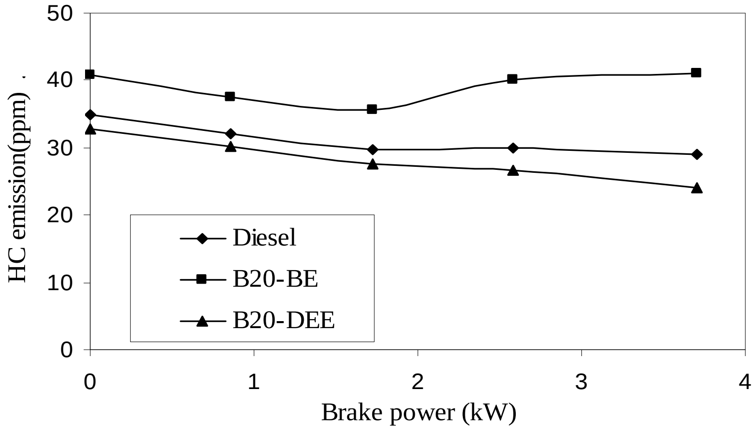

Figure 6 Variation of HC emissions with BP

Figure 6 shows the variation of the hydrocarbon emission with brake power for diesel, B20 and B20 with DEE fuels. The hydrocarbon emission for diesel and B20 are 29 ppm and 42 ppm respectively for the base engine at full load. For the ceramic coated piston with B20, it is 24 ppm at full load. The reduction in HC emission is due to addition of DEE that makes the mixture homogeneous, which results in better combustion. The ignition improver (DEE) forms a number of ignition centers in the combustion chamber, which results in complete combustion.

f) Nitrogen oxide emission (NO)

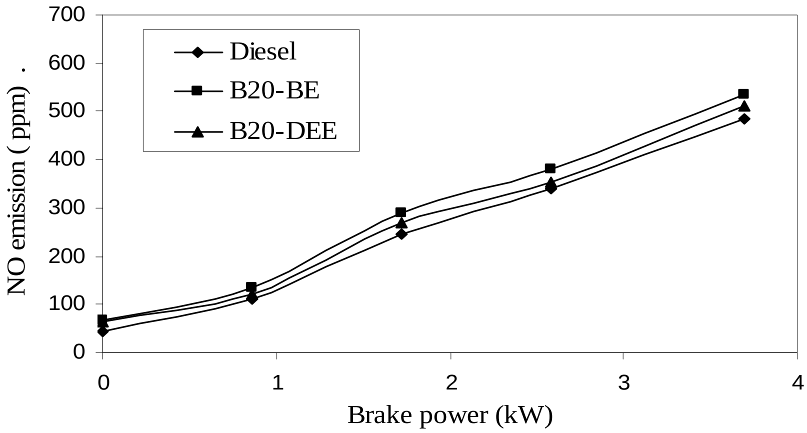

Figure 7 Variation of NO emissions with BP

Figure 7 illustrates the variation of the nitrogen oxide emission with brake power for diesel, B20 and B20 with DEE fuels. The NO forms by oxidation of atmospheric nitrogen at sufficiently high temperatures. The NO values obtained for diesel and B20 are 486 and 536ppm, respectively at full load, whereas for B20 with DEE, it is 512ppm at full load. The decrease in NO level for B20 with DEE may be due to the evaporation of DEE and it has lowered the charge temperature, resulting in decreased the NO level compred to B20 at full load.

g) Smoke emission

Figure 8 depicts the variation of the smoke density with brake power for diesel, B20 and B20 with DEE fuels. The smoke values obtained for diesel and B20 are 3.6 BSU and 2.8 BSU respectively, whereas for the B20 with DEE, it is 3.0 BSU at full load. The decrease in smoke for the B20 with DEE may be due to better combustion of biodiesel blend and more oxygen content present in the biodiesel and DEE are also the reasons for lower smoke levels.

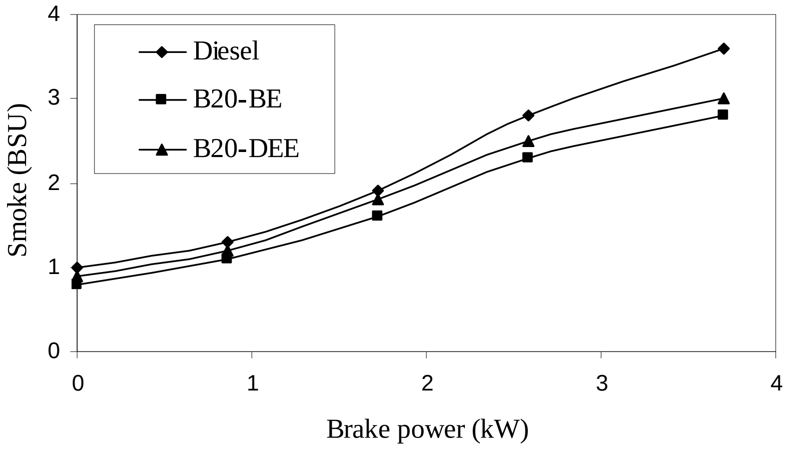

Figure 8 Variation of Smoke emissions with BP

CONCLUSIONS

The experiments were conducted with Karanja methyl ester (PME) using Diethyl ether (DEE) has been studied extensively through performance, emissions and combustion parameters. The following are the important conclusions drawn from the present investigations with the effect of DEE additives with biodiesel on a direct injection diesel engine.

The brake thermal efficiency for 10% DEE additive with 20% KOME increased by about 1.4 % compared to that of the 20% PME at full load.

The CO emissions decreased by 42% and the HC emissions decreased by about 26 % for 10% DEE additive with 20% KME at full load compared to that of the base engine with diesel at full load.

The NO emissions were almost equal for 10% DEE additive 20% KME at full load conditions compared to that of diesel fuel at full load, while the smoke emissions decreased by about 17% for 10% DEE additive with 20% KME at the full load compared to that of diesel with the base engine.

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