Overview Of CI Engine Fueled With Biodiesel-kerosene Blends

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ABSTRACT

Kerosene in small amount mixes with diesel in rural region is regular feature to derive financial benefit resulting from the price difference between two fuels. Density of the kerosene-diesel even at higher blend fuel tests is within the prescribed value, while considerable decrease in kinematic viscosity than baseline diesel is observed with increase in blend ratio. Blends of kerosene and diesel has advantages in performance because of longer ignition delay , lower emissions and also lower soot emissions at low load as compared to neat diesel, while at high load soot emission was similar to that of diesel fuel. Diesel engines have some advantages like high thermal efficiency, torque capacity, reliability, adaptability, low HC and CO emissions and cost effectiveness, but high emission of NO_x due to high temperature and particulate emissions. The addition of oxygenated fuels into diesel fuels especially those that are originally bio-resources are the best ways to reduce emissions of diesel engines. On the basis of investigations by different researchers ,this paper reviews about Di-ethyl Ether (DEE) as oxygenated additives mixed with diesel- and biodiesel blends and compares its effect on parameters such as performance and exhaust gas emission of compression ignition engine along with addition using kerosene. The BTE is highest with 15% DEE, NO_x emitted by all DEE-diesel blends are lower than the neat diesel fuel with no stability problems of engine operation.

keywords ***: kerosene, diesel,*** *BD*, ***DEE, performance, exhaust emissions, CI engine.***

INTRODUCTION

Day by day prices of oil increases and because of more no of vehicle on road, environmental pollution problems increases this leads to investigation of alternative fuels,for internal combustion engines. This Review article presents the possibility of using kerosene blends in CI engines. In Rural part of any country Kerosene is common blend for mixing with diesel and petrol. Kerosene, as a fuel source, is a cheaper alternative to blend with diesel. Even though kerosene's thermal efficiency is more than that of diesel fuel, kerosene will give slightly lower engine performance results [1]. Kerosene can be used as an alternative diesel fuel by mixing it with vegetable oils due to its low viscosity and high thermal valu

Though CI engines have advantages like good performance and emission characteristics like high thermal efficiency, High torque, low CO and HC emissions, But suffer from high amount of NO_X, smoke and particulate matter emissions when using diesel fuel . Alternative fuel like Biodiesel (BD) in CI engines have advantages of substantial reduction of un-burnt HC,CO and particulates. However, disadvantage of higher viscosity, cold starting problems and increasing nitrogen oxides (NO_X) emission in comparison with that of mineral diesel. Formation of smoke in diesel engine is due to heterogeneous combustion as well as poor mixing of the air fuel ratio. Introducing oxygen enrichment can control the smoke formation [2]. Using highly oxygenated additive with high cetane number, one of these candidates is diethyl ether (DEE) as it has a very low self ignition temperature, a high cetane number and wide flammability limit.

Diesel and Kerosene blended fuel has low viscosity and density hence reduce lubricity and makes wear problems in sensitive fuel injection pumps and fuel injector designs, hence upto 15% kerosene (by volume) in the blends could be used, other than effect of reduced viscosity on the spray.[3] The viscosity of biodiesel is nearby 10 times more than that of diesel, and hence, at low temperatures biodiesel can becomes very viscous. High viscosity of fuel can affect the volume flow and injection spray characteristics in the CI engine [4].

The physicochemical properties of base fuels are given in the table below.

Properties	Diesel	Biodiesel	DEE	Kerosene
Density (Kg/m3)	823	850	713	790
Calorific value (MJ/Kg)	43000	40800	36840	45400
Viscosity @40°C (cst)	3.9	9.2	0.23	1.4
Cetane number	48	42-48	125	39
Auto ignition temperature °C	315	-	160	-
Oxygen content %	0	11	21.6	0
Flash point	56	140	-40	39
Boiling point at 1 atm (°C)	146–374	-	34.6	148–282

Physicochemical properties of base fuels [2,5,7,11,]

PERFORMANCE ANALYSIS

Engine performance and exhaust emissions are considered as performance parameters and on the basis of different experimental analysis by the different researchers the following results are summarized.

1. ENGINE PERFORMANCE

- **Brake specific fuel consumption (BSFC):**

As load increases, BSFC increases with the increase blend of BD in BD–diesel blends and BD additive blends; but BSFC of kerosene–BD blends decreased gradually while neat kerosene has a reduction in BSFC. This is due to more volatility of the kerosene, mixes properly with air at more temperature. The results from this test suggested that 50 % and higher up to 100 % kerosene are the best blends to improve efficiency and lower BSFC.

Same was observed at medium load which can be seen in the fig 1. At low load condition, higher BSFC with neat kerosene might be due to that, kerosene is more volatile in nature than BD-diesel; consequently at low load condition where a lot of excess air exists in the cylinder [5], kerosene-air mixture produces much poor mixture than stoichiometric ratio,

It was observed that the BSFC of B30 (30% BD and 70% diesel) is slightly higher than that of BE-1(5% diethyl ether, 25% BD and 70% diesel), and almost similar to BE-2(5% ethanol, 25% BD and 70% diesel).The main reason could be due to more volatility of diethyl ether which improves up the swirling velocity of air and fuel mixture, improves the combustion and increases the combustion efficiency.[6]

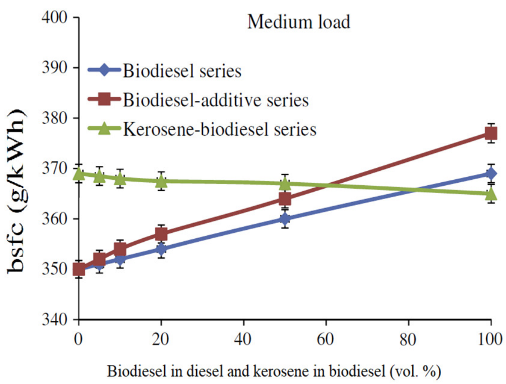

Fig 1. BSFC for different fuel blends at medium load.[2]

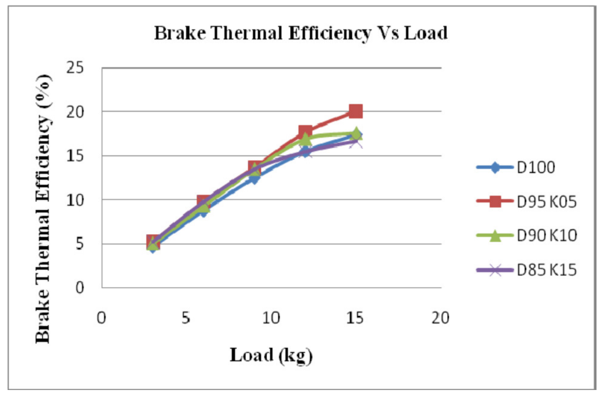

Fig 2. Brake thermal efficiency and load[17]

It was observed that the BSFC of the lower blends DEE–diesel was higher than the neat diesel.[7] DEE blends gives the best performance due to its high calorific value when compared to BSFC is low for D EE at all levels of blending and injection timings [8].

- **Brake power**

Brake power increases with increase in engine load for all blends. The brake power at 100% rated load was 19.8% higher at 30% kerosene blend as compared with that obtained when the engine was run on diesel fuel.[9]

The Brake power of B-20 (80% Diesel and 20 % Jatropha BD) + 20% DEE is found to be higher than that of other BD blends but lower than the B-0 (100% pure diesel). The higher Power after the addition of DEE to JOME(Jatropha oil methyl ester) is due to its oxygen content and effect on lowering the viscosity of the blend, which led to an improvement in the combustion.[10]

- **Specific fuel consumption**

Specific fuel consumption decreased as engine load increased. This decrease in the sfc rate due to the higher calorific value of kerosene as compared to diesel fuel .In other words, less quantity of fuel is needed in order to produce the same amount of energy. Decrease in sfc of the blended fuels was due to faster evaporation rate and combustion of the blend particles when compared with diesel fuel. It was analysed that sfc at full load was 7.5% lower at 30% kerosene blend as compared with sfc value when the engine was run on diesel fuel [11]. The blended fuel gives good fuel economy and power output.

With the percentage increase in DEE, sfc reduced significantly ,the reason being calorific value of DEE is much lower than diesel fuel [12].

- **Brake Thermal Efficiency**

BTE slightly increased with addition of DEE to the blend as overall trends displayed. The BTE is highest with 15% DEE ,except for the full load condition. At this blending ratio there is an increase in thermal efficiency of 5.5% for BD and 9.2% in average for diesel blend compared to the baseline fuels.[13]

Mixing diethyl ether to BD will decrease viscosity of blends and helps improvement in the atomization. These fuel droplets tend to mix properly with air and hence improving the combustion [14]. The BTE for BD5 (5% DEE) was found at higher level than that of neat BD and other blends at full load. With the use of BD10 (10% DEE) blend, the BTE decreases because of lower calorific value of the blend as compared to BD5. In case of BD15(15% DEE), the BTE increases due to the fluctuations in engine speed and power output.[15]

Brake thermal efficiency was higher slightly for diesel with various blends of kerosene than that of diesel alone as seen in fig. 2.[16]

2. EMISSIONS CHARACTERISTICS:

- **Carbon Monoxide**

CO emissions with BD–diesel blends with or without additive decreased which is due to oxygen content in BD. The CO emission increased with the increase in kerosene content in BD. Neat kerosene emits 97% higher CO than base fuel. Due to higher volatility of K100, it lowers temperature in cylinder and decline oxidation of CO to CO2, resulting in higher CO emissions.[5,17]

CO emission by all DEE Diesel fuel blends is lower than neat diesel fuel, with the reduction in percentage the higher the percentage of DEE in the blend.[18] The variation in carbon monoxide (CO) emissions with brake power is shown in Fig. 4. At full load, the CO emission decreases by 25% for BD5 (diethyl ether blended BD) blend comparing to that of BD. This is due to proper fuel–air mixing. The improvement in spray atomization and fuel–air mixing decreases the rich region in the cylinder and decreases the CO emission. Moreover, the high temperature promotes the CO oxidation in the cylinder [19]. The CO emissions of BD10 are higher than those of BD at lower and medium loads and same as BD at full load.

- **HC**

BD–diesel-additive series emits the lowest HC; B100A (Neat canola BD with additive) has about 65% reductions, whereas B100 (Neat canola BD) reduces HC about 56%. Here again HC increases with K100 (neat kerosene), which is about 56% increase than that of K0 (Neat canola BD). [5] HC emitted by all DEE/diesel fuel blends is higher than the corresponding neat diesel fuel case, with the increase being higher the higher the percentage of DEE in the blend and may be due to the higher heat of evaporation of the DEE blends causing slower evaporation and so slower and poorer fuel-air mixing [11] Variations of HC emissions at varying BMEP is shown in fig. 3.

Also the HC emissions of kerosene blends with DE15D were increased at full load condition than DE15D and neat diesel.[7]

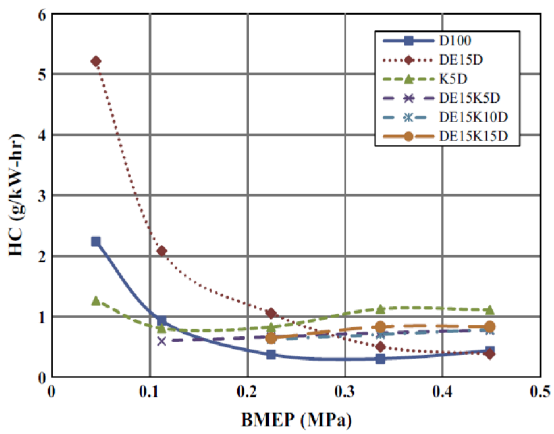

Fig 3.HC vs. BMEP at 1500 rpm speed.[3]

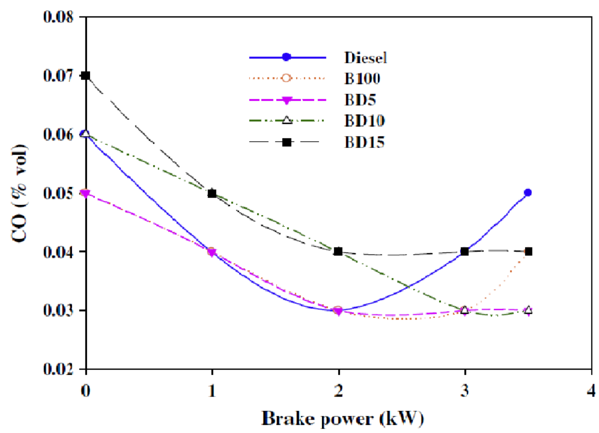

Fig 4. Carbon monoxide vs. brake power. [14]

- **NO_x**

NO_x formation depends on two factors: in-cylinder temperature and oxygen concentration. Higher temperature and oxygen will increase the NOx emissions. For B100 and B100A it was observed that total NO_x increased about 31% and 51%, at low loads. whereas the total NO_x increases approximately 7% and 10% at medium loads respectively , NO_x reduction with K100 was approximately 17% than diesel. NO_x production with K100 was still 11% less than that with diesel at medium load operation. whereas no appreciable change was found for NO_x when B100 and B100A were considered but reduction by 3% was observed for K100. [5]

NO_x emission by all DEE-diesel blends are lower than the neat diesel fuel, with the reduction the percentage of DEE in the blend. This could be due to the engine running overall leaner and the temperature lowering effect of the DEE having the dominating influence, [18] 15% and 20% DEE have greater effect on the reduction of NO_x.[13]

At low load conditions with B100 and B100A, compared with the neat diesel, NO_2 increases about 25% and 33%, respectively but K100 has about 62% reduction than K0.

At medium load, NO_2 increases only 3% and 6%,respectively, than neat diesel also NO_2 emission with K100 is about 12% higher than diesel.

At high load, No change of NO_2 is observed for B100, but B100A and K100 can reduce NO2 by about 9% and 5%, respectively, with the comparison of diesel.[5]

- **EXHAUST GAS TEMPERATURE**

It was observed that the exhaust gas temperature (EGT) increases with of kerosene in the fuel for different conditions of load. The exhaust gas temperature at full load rated load was 16.7% higher at 30% kerosene blend with the exhaust gas temperature when the engine was run on diesel fuel. This may be due to the oxygen content of kerosene, which improves combustion and thus may increase the exhaust gas temperature[9].The comparison for various diesel-kerosene blends for EGT vs loads is shown in fig. 5.

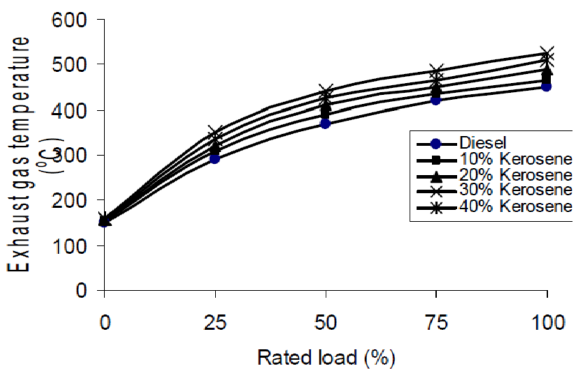

Fig 5. EGT vs. Rated load. [9]

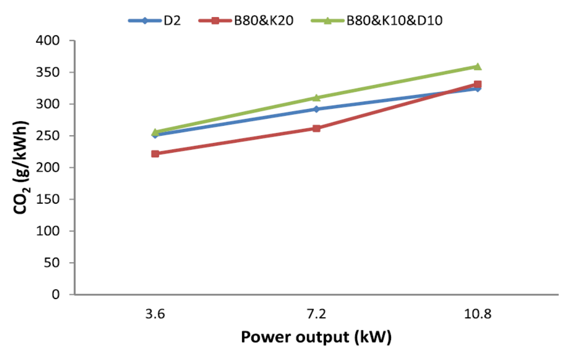

Fig 6. CO_2 vs. Power output. [2]

EGT decreased with DEE - diesel blends than diesel fuel and it further reduced with increase in composition of DEE. At standard injection pressure of 20MPa, there was 10% decrease with E15D85 (15% Diethyl ether) than diesel and as the injection pressure increases, the exhaust gas temperature increases. 20% reduction in exhaust gas temperature was noticed at 24MPa pressure with E15D85 than diesel. This is due to the higher calorific value and high latent heat of vaporization of DEE. [21]

- **SMOKE AND SOOT EMISSIONS**

With DEE addition, Smoke emission decreases, but there are some fluctuations in some parts especially at higher loads. Since the smoke is mainly produced in the diffusive combustion phase, the addition of oxygenated fuel can overcome poor mixing of the fuel with air and leads to improvement in diffusive combustion .The reason for the fluctuations may be explained by the fact that the properties of DEE such as its oxygen content and its latent heat of vaporization (LHV) are in competition. In the other words, its oxygen content leads to smoke reduction and its high LHV decreases the combustion temperature and consequently UHC increases due to wall quenching effects[13]

The soot emitted by all DEE/diesel fuel blends is lower than the corresponding neat diesel fuel case, with the reduction being higher the higher the percentage of DEE in the blend. This due to the engine runs on leaner mixture, with the combustion being now assisted by the presence of the fuel-bound oxygen of the DEE even in locally rich zones, which seems to have the dominating influence .The decrease in smoke emissions is for the higher load and with increasing percentage of DEE (with diesel fuel) in the blend (5 %, 10%, 15%) [18

- **CO_2**

CO_2 emissions of test fuels in the engine, for various load conditions are presented in Fig. 6. CO_2 is an emission product related to the complete combustion of the fuel. After combustion temperatures and presence of enough oxygen increase the amount of CO_2. It is seen in Fig.6 that CO_2 increases when the load increases because of increased mass fuel consumption, for all test fuels.CO_2 emissions were a bit higher for D2 (Diesel fuel with 50 ppm sulphur content) when compared to B80&K20 fuel probably due to more complete combustion of D2.Since the combustion temperature remains quite lower, burning of BD blends gets worse and thus lowers CO_2. However, BD produced less emissions of CO_2 than petroleum based fuels because of the full BD production and consumption life cycle of oil that consumes the natural CO_2[2].

Normally all exhaust emissions like CO, CO2, HC and smoke are reduced greatly with the addition of oxygenated additives to biodiesel fuels especially iso butanol, ethanol and diethyl ether[22].

CONCLUSION

In this study, the performance and emission characteristics operated at different engine loads with different combination of blends (diesel-BD-kerosene-DEE) are reviewed, the conclusions as follows:

- BSFC increases with the increase of BD content in BD–diesel and BD–diesel-additive blends; but BSFC of kerosene–BD blends decreased gradually while neat kerosene has a significant reduction in BSFC. BSFC of the low DEE–diesel blends was higher than the neat diesel.
- Brake power increased with increase in engine load for all fuel blends. The brake power at 100% rated load was 19.8% higher at 30% kerosene, The Brake power of B-20 (80% Diesel and 20 % Jatropha BD) + 20% DEE is found to be higher than that of other BD blends but lower than the B-0 (100% neat diesel).
- Decrease in the SFC rate can be attributed to the higher calorific value of kerosene as compared to diesel fuel, With the percentage increase in DEE SFC reduced significantly ,the reason being calorific value of DEE is much lower than diesel fuel.
- BTE slightly increased with addition of DEE to the blend as overall trends displayed. The BTE is highest with 15% DEE ,except for the full load condition. Brake thermal efficiency was slightly higher for diesel with various blends of kerosene than that of diesel.
- CO emissions with BD–diesel blends with or without additive decreased which can be attributed to inherent oxygen content in BD. The CO emission increased with the

increase in kerosene content in BD. Neat kerosene emits 97% higher CO than base fuel.

- ❖ BD–diesel-additive series emitted the lowest HC. Also the HC emissions of kerosene blends with DE15D increased at full load condition than DE15D and neat diesel.
- ❖ It was found that the NO_x emitted by all DEE-diesel blends are lower than the neat diesel fuel.
- ❖ Combustion temperature was found to be quite lower, burning of BD blends gets worse and thus lowers CO_2.
- ❖ The smoke emission significantly reduced with the use of the DEE/diesel fuel blends with respect to that of the neat diesel fuel, with this reduction being higher the higher the percentage of DEE in the blend.

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