Effect of Ethanol and Tetra Hydro Furan on Performance and Emission Characteristics of CI Engine Fuelled with Methyl Ester of Jatropha

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***Abstract*— The use of biodiesel is rapidly increasing around the world, making it imperative to understand the impacts of biodiesel on the diesel engine performance and reduce the emissions. This paper is aimed to investigate the performance and emission characteristics of a direct injection (DI) diesel engine when fuelled with methyl ester of jatropha oil (MEJO). The ignition improver tetra hydro furan (THF) and ethanol are added to methyl ester of jatropha oil to examine the performance and emissions of the diesel engine. The experimental results show that the maximum brake thermal efficiency was obtained with 20%Etanol-2%THF blended with MEJO when compared with pure MEJO and methyl ester of jatropha oil blends. Among the THF-Ethanol blends, the minimum brake specific fuel consumption was observed with 20% Ethanol-2%THF. The lowest carbon monoxide (CO) and unburned hydrocarbons (HC) with 20%Ethanol-2%THF blend. The smoke density of 20%Ethanol-2%THF with MEJO was reduced by 21.79% when compared with diesel. Hence, the 20%Ethanol-2%THF blended with MEJO could improve the performance and reduce the emissions of the diesel engine.**

Keywords: Biodiesel, Diesel Engine, MEJO, Performance, Emissions.

I. INTRODUCTION

Biodiesel is an alternative to petroleum-based diesel fuel and it is made from renewable resources such as vegetable oils, animal fats or algae. A lipid transesterification production process is used to convert the base oil to the desired ester and to remove free fatty acids [1]**.** After this processing, the end product, biodiesel, unlike the straight vegetable oil has combustion properties very similar to fossil diesel. Biodiesel is non-flammable and in contrast to fossil diesel, it is non-explosive, with a flash point of 150°C as compared with 64°C for fossil diesel [2].

Unlike fossil diesel, it is biodegradable and non-toxic, and it reduces toxic and other emissions when burned as a fuel. It is a clear amber-yellow liquid with a viscosity similar to fossil diesel [2].Biodiesel can be mixed with petroleum diesel at any concentration in most modern engines, although it has the disadvantages of degrading rubber gaskets and hoses in older Vehicles, vehicles prior to 1992 . It is a better solvent than fossil diesel and has been known to break down deposits of residue in the fuel lines of vehicles, which usually run on petroleum. Consequently, fuel filters may become clogged with particulates if a quick transition to pure biodiesel is made, but the biodiesel cleans the engine in the process.

Biodiesel also eliminates sulphur emissions (SO2), because it does not include sulphur. Also, it has a higher cetane rating than fossil diesel, and therefore ignites more rapidly when injected into the engine [3]. It contains fewer aromatic like Benzo fluo ranthene and nzopyrenes. It is one of the substitutes to replace fossil fuels as the world's primary transport energy source, because it is a renewable fuel that can replace fossil diesel in current engines and can be transported and sold using today's infrastructures. Diesel derived from vegetable oil have good potential as an alternative diesel fuel because it's energy content, viscosity and phase changes are similar to those of fossil diesel. It has been estimated that the annual consumption of fossil fuel is an amount that took nature, on average, about one million years to produce and since energy consumption will triple over the next 50 years, with enormous demand arising particularly in the so-called developing countries like Nigeria. This demand will include the use of carbon-free source of energy [4-7].

Bio-fuels provide us with completely emission-free energy cycle [8, 9]. The initial energy of the biomass oxygen system is captured from solar radiation in photosynthesis and when released in combustion, the bio-fuel energy is dissipated. The elements of the material should be available for recycling in natural, ecological, or agricultural processes. Thus, the use of industrial bio-fuels when linked carefully to natural ecological cycles may be nonpolluting and sustainable [10-12]. Although there is no energy source that is completely environmentally safe, energy must be used more wisely in order to minimize the environmental hazard and optimize the efficiency with which it is produced [13-16].

In the present investigation the performance and emission characteristics of a diesel engine were studied by using (5-25%) Ethanol-(1-2%) THF with MEJO blends and compared with that of the diesel fuel.

II. MATERIALS AND METHODS

In the present investigation, tests have been conducted on diesel engine using pure diesel and MEJO. The experimental investigation has been carried out on diesel engine using diesel, methyl ester of Jatropha oil (MEJO) and MEJO with ignition improver and Ethanol. The ignition improver used in this investigation is Tetra Hydro Furan (THF). The ignition improver, THF is added to the methyl ester of jatropha oil at different proportions such as 1 to 3%, Ethanol is added to the methyl ester of jatropha oil at different proportions such as 5 to 25%. The performance parameters such as brake thermal efficiency, brake specific fuel consumption are studied with respect to load. The exhaust emissions such as carbon monoxide, carbon dioxide, hydrocarbons, oxides of nitrogen and unused oxygen and smoke opacity were studied with respect to load. The experimental set up consists of a diesel engine, engine test bed, fuel and air consumption metering equipments, gas analyzer, and smoke meter. The specifications of the diesel engine are given in Table 1. The schematic diagram of the engine test rig is shown in Figure. 1.

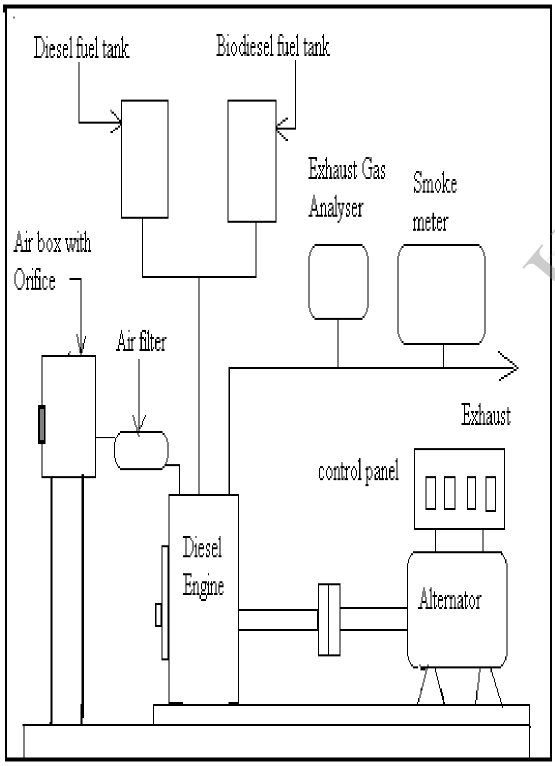

Figure 1: Schematic Diagram of Engine Test Rig

Table 1 Specifications of the diesel engine.

Type	Four- stroke, single cylinder, Compression Ignition engine, with variable compression ratio.
Make	Kirloskar, AV-1
Rated power	3.7 KW, 1500 RPM
Bore and stroke	80mm×110mm
Compression ratio	16.5:1, variable from 13.5 to 20
Cylinder capacity	553cc
Dynamometer	Electrical-AC Alternator P.F.=0.8
Exhaust Gas Analyzer	Make :MARS Technologies Inc., Banglore Model :MN-05 Principle: Non-dispersive infrared based technology. Measurement:CO,CO_2,O_2 in % of volume NOx & HC in PPM Measuring Range: CO (0-10%vol in res of 0.01%)CO_2(0-20%vol in res. of 0.1%)HC(0-1500ppm res. of 1ppm) NOx(0-1500ppm res. 1ppm)O_2(0-25% in res. 0.01%) Gas flow rate:1000ml/min Zero Calibration: every 25 min

The engine was initially operated by using diesel with no load for few minutes at rated speed of 1500 rpm until the cooling water and lubricating oil temperatures comes to 85˚C. The same temperatures were maintained throughout the experiments with all the fuel modes. The baseline parameters were obtained at the rated speed by varying 0–100% of load on the engine with an increment of 20%. The engine was tested with MEJO and blends of MEJO Ethanol and THF. The tests were conducted with these blends by varying the load on the engine. The brake power was measured by using an electrical dynamometer. The exhaust gas temperature was measured by using an iron-constantan thermocouple. The exhaust emissions such as CO, CO_2, oxides of nitrogen (NOx), HC, and unused oxygen (O_2),were measured by AVL Di Gas 444 exhaust analyzer and the smoke opacity by AVL smoke meter 437ºC at all load conditions.

The results of the engine operating on MEJO and its Ethanol-THF blends were compared with the baseline parameters obtained during engine fuelled with diesel at rated speed of 1500 rpm.

III. RESULTS AND DISCUSSION

A. Brake Thermal Efficiency:

The variation of Brake Thermal Efficiency (BTE) with Brake Power (BP) is shown in Figure2.

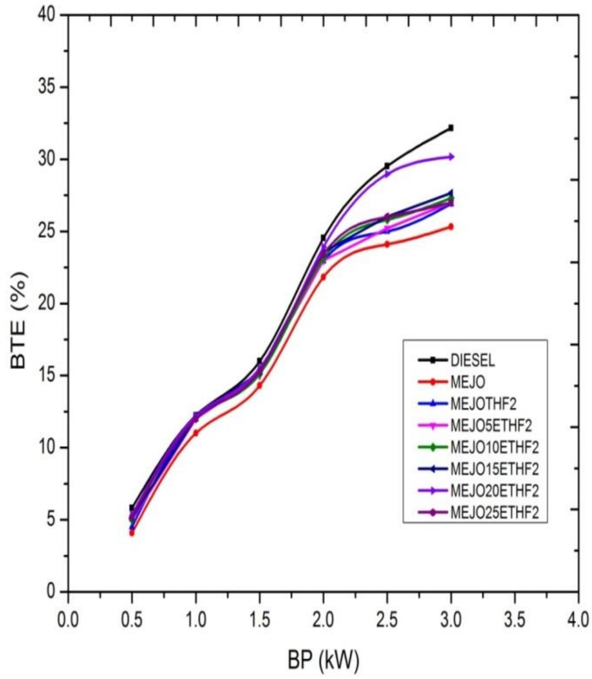

Figure 2. Variation of brake thermal efficiency with brake power

It is observed from the results that brake thermal efficiency increased with load. The brake thermal efficiency of MEJO, MEJOTHF2, and all biodiesel – ignition improver blends (5% to 25%) was less than diesel fuel over the entire range of the load. The BTE was lower by 21.26%, 16.38%, 16.01%, 15.08%, 14.02%,6.15% and 15.88% respectively with MEJO, MEJOTHF2,MEJO5ETHF2,MEJO10ETHF2, MEJO15ETHF2, MEJO20ETHF2 and MEJO25ETHF2 blends compared with diesel fuel. The maximum BTE 30.18% was observed with MEJO20ETHF2. The Brake Thermal Efficiency of Biodiesel ignition improver (MEJOTHF2) increases with increasing ethanol percentage. It is due to the presence of oxygenated molecules in the ethanol so that complete combustion takes place.

B. Brake Specific Fuel Consumption:

The variation of brake specific fuel consumption (bsfc) with brake power is shown in Figure 3.

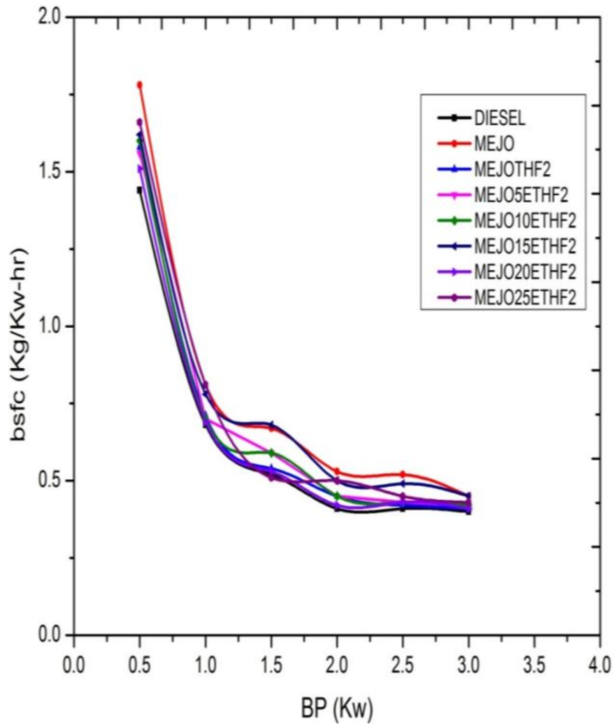

Figure 3. Variation of brake specific fuel consumption with brake power

C. Carbon Monoxide:

The variation of carbon monoxide (CO) with brake power is shown in Figure 4.

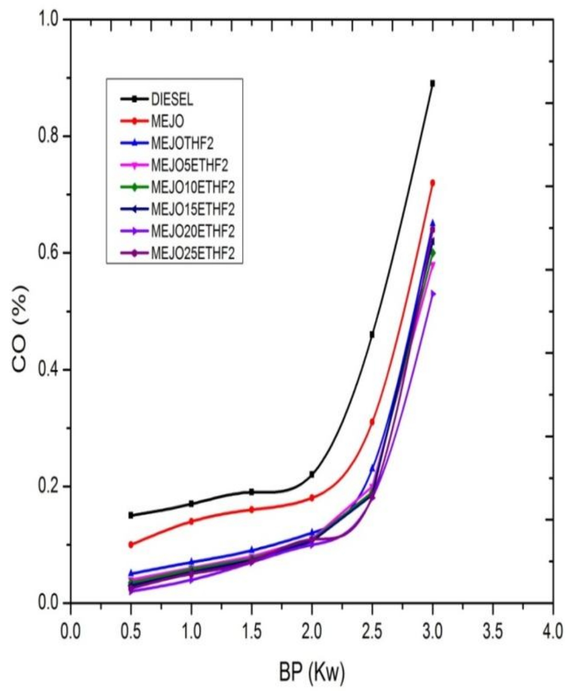

Figure 4. Variation of carbon monoxide emissions with brake power

The results show that the CO emissions slowly increased at low and medium loads and rapidly increased at high load for all the fuel samples. The CO emissions reduced with the increasing ethanol percentage in diesel-ethanol blends. The CO emissions of diesel-ethanol blends were significantly lower than the corresponding diesel fuel at high loads of the engine. The CO emissions were decreased by 19.10%, 34.83%, 32.58%, 30.33%, 40.44% and 28.08% respectively with, MEJO5ETHF2, MEJO10ETHF2,MEJO15ETHF2,MEJO20ETHF2 and MEJO25ETHF2 when compared with diesel fuel at full load condition. The CO emission reduced with increasing of ethanol percentage in the biodiesel – ignition improver blend. It is due the presence of oxygenated molecules in the ethanol so that proper combustion takes place.

D. Unburned Hydrocarbon Emissions:

The variation of unburned hydrocarbon (HC) emissions with brake power is shown in Figure 5.

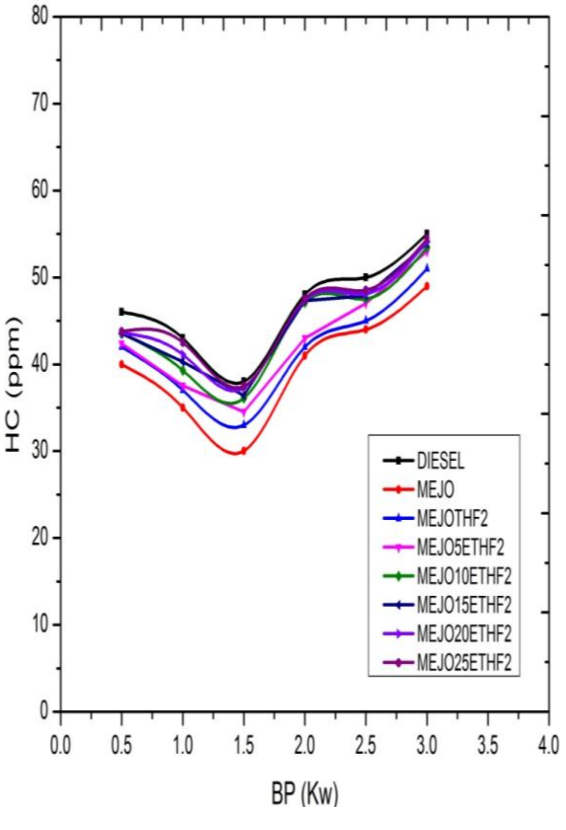

Figure 5: variation of hydrocarbon emissions with brake power

E. Oxides of Nitrogen:

The HC emissions of biodiesel – ignition improver – ethanol blends were decreased by 41.5%, 18.18%, 23.63%, 30.90%, and 27.27% respectively with MEJO5ETHF2,MEJO10ETHF2,MEJO15ETHF2, MEJO20ETHF2 and MEJO25ETHF2 when compared with diesel fuel full load. The HC emissions were decreased with increasing percentage of ethanol to MEFOTHF2.

The variation of oxides of nitrogen emissions (NO_X) with brake power is shown in Figure 6.

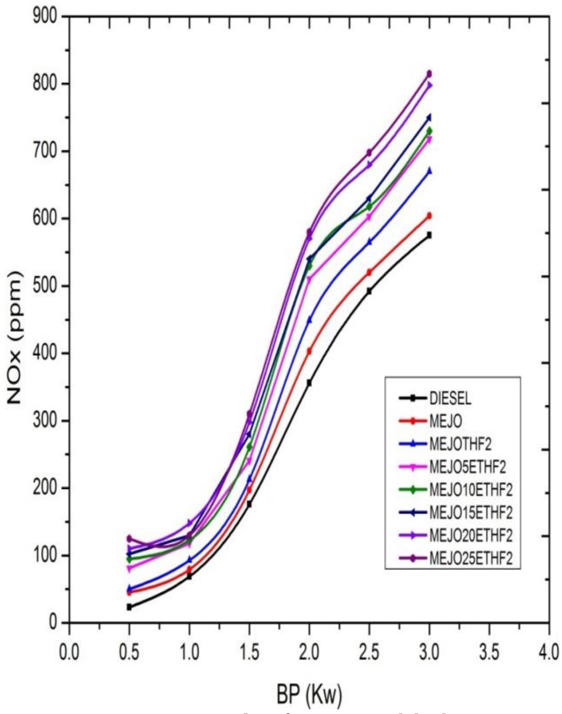

Figure 6: Variation oxides of nitrogen with brake power

The NOx emissions are increased as the engine load increases due to increase in combustion temperature. The NOx emissions of biodiesel-ignition improver-ethanol blends were higher than MEJO, MEJOTHF2 and diesel fuel at full load condition. The NOx emissions of MEJO5ETHF2,MEJO10ETHF2,MEJO15ETHF2, MEJO20ETHF2 and MEJO5ETHF2 were respectively 24.86%, 26.95%, 30.43%, 38.78% and 41.73% higher than diesel fuel at full load condition. The lower NOx emissions were produced by MEJO20ETHF2 among biodiesel-ignition improver-ethanol blend.

F. Carbon Dioxide Emissions:

The variation of carbon dioxide emissions with brake power is shown in Figure 7.

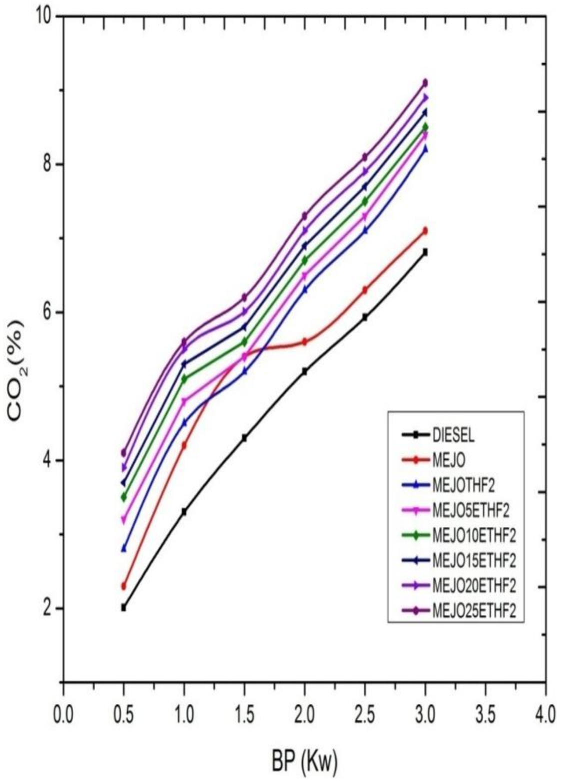

Figure 7: Variation of carbon dioxide emissions with brake power

The carbon dioxide emissions increased with brake power for all fuel modes. The CO_2 emissions of biodiesel-ignition improver-ethanol were higher than the, biodiesel, biodiesel-ignition improver and diesel fuel. The CO_2 emissions of MEJO5ETHF2, MEJO10ETHF2,MEJO15ETHF2,MEJO20ETHF2 and MEJO5ETHF2 were respectively 23.34%, 24.81%, 27.75%, 30.69% and 33.62% higher than diesel fuel at full load of the engine.

G. Unused Oxygen:

The variation of unused oxygen with brake power is shown in Figure 8.

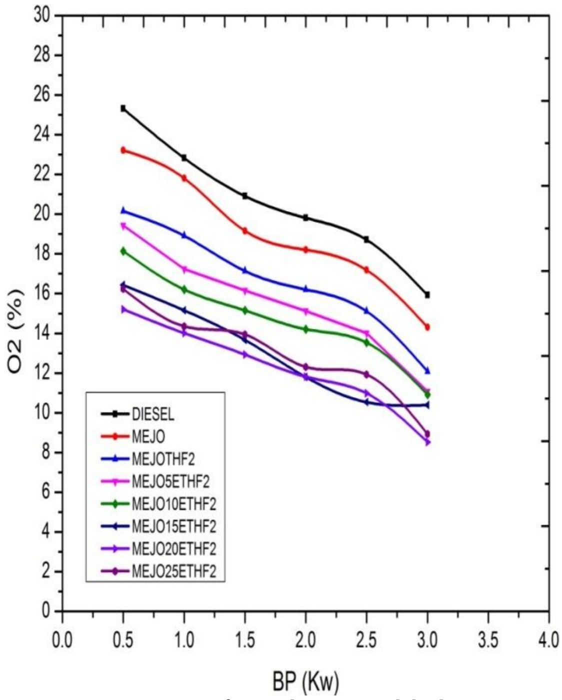

Figure 8. Variation of unused oxygen with brake power

The unused oxygen emissions reduced with brake power for all the fuels. These emissions are lower than diesel fuel for all biodiesel, biodiesel-ignition improver-ethanol lends. These emissions reduced by10.16%,24.23%,30.44%,88.01%,34.83%,46.51%and43.94 %respectivelywith MEJO,MEJOTHF2, MEJO5ETHF2,MEJO10ETHF2, MEJO15ETHF2, MEJO20ETHF2 and MEJO25ETHF2 when compared with diesel fuel at full load. Among the biodiesel-ignition improver-ethanol blends the lowest emissions was produced by MEJO20ETHF2.

H. Smoke Opacity:

The variation of smoke opacity with brake power is shown in Figure 9.

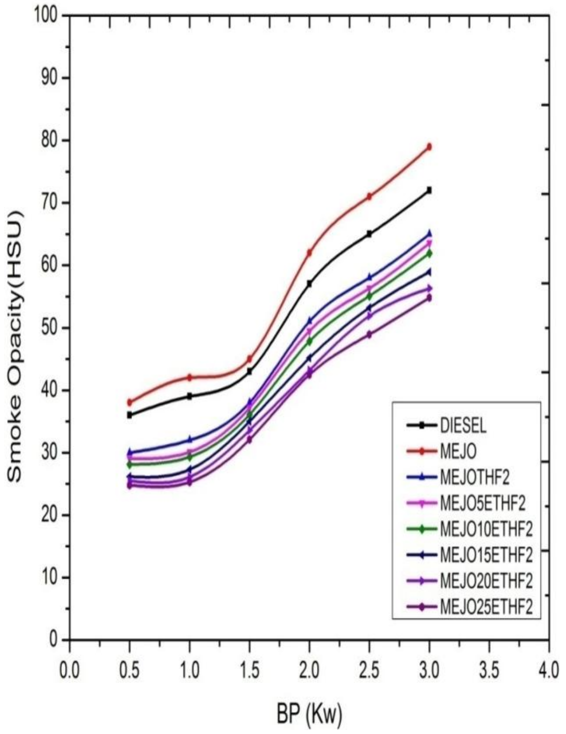

Figure 9. Variation of smoke opacity with brake power

The smoke opacity increased with brake power for all the fuel modes. The smoke produced by MEJO was 8.86% higher than diesel fuels at full load of the engine. . The smoke opacity reduced with the increased percentage of ethanol in biodiesel-ignition improver-ethanol blends at all load conditions of the engine. The emissions of MEJO5ETHF2,MEJO10ETHF2, MEJO15ETHF2, MEJO20ETHF2 and MEJO25ETHF2 were respectively 11.68%, 14.01%, 18.18%, 21.79% and 23.87% when compared with diesel fuel at full load of the engine.

IV. CONCLUSION

The above results reveal that the performance parameters such as brake thermal efficiency, brake specific fuel consumption increased with the increasing percentage of ethanol to biodiesel-ignition improver blend. The emission parameters such as CO, unused oxygen and smoke intensity reduced with ethanol addition. The CO_2, NO_x increased with increasing percentage of ethanol in biodiesel-ignition improver blend. The blend MEJO20ETHF2 is an optimum blend with respect to both performance and emissions. Hence ethanol can be added up to 20% to the methyl ester of Jatropha oil to improve the performance of the diesel engine.

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