Performance Analysis of Vegetable Oil Blended With Diesel Additive

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Abstract

Biomass derived fuels are preferred as alternative Fuels for IC engine due to its abundant availability and renewable nature. In **the present work, the performance and emissions of diesel and diesel additive blended with palm kernel oil is studied, where the fuel, namely, methyl ester of palm kernel oil and diesel with additive were chosen and used as fuel in the form of blends. Various proportions of palm kernel oil and diesel are prepared and blended with additive on a volume basis and used as fuels in a single cylinder, four-stroke DI diesel engine, to study the performance and emission characteristics of these fuels. In the present investigation a methyl ester derived from palm kernel oil used as a vegetable oil and additive used is considered as an ignition improver. The results show a 19% reduction in smoke with B25 and 23.8% reduction with B25+Additive, 13.3% reduction in HC emissions with B25 and 16% reduction with B25+Additive and a 14.16% reduction in CO emissions with B25 and 22.22% reduction with B25+additive for the 25% PKO blend and Additive with a 5.4% increase for B25 blend and 1% decrease when Additive added to blend in NOx emission at full load. There was a 2.18% increase in brake thermal efficiency for B25 blend and 2.73% increase with Additive to blend for MePKO25-diesel75 blend at full load.**

Index Terms-- diesel engine; palm kernel oil; diesel; diesel additive; emission; performance; blend;

I. INTRODUCTION

Biodiesel is the name of a clean burning alternative fuel, produced from domestic, renewable resources. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend. It can be used in compression-ignition (diesel) engines with little or no modifications.

Biodiesel is made through a chemical process called transesterification whereby the glycerin is separated from the fat or vegetable oil. Biodiesel is better for the environment because it is made from renewable resources and has lower emission Compared to petroleum diesel. Transesterification is achieved with monohydric alcohols like methanol and ethanol in the presence of an alkali catalyst. The advantages of biodiesel are that it displaces petroleum thereby reducing global warming gas emissions, tail pipe particulate matter, hydrocarbons, carbon monoxide, essentially free of sulfur & aromatics and other air toxics. Biodiesel improves lubricity and reduces premature wearing of fuel pumps there by increased life of moving parts.

Most of the alternative fuels identified today are bio-fuels and are having one or few undesirable fuel characteristics which are not permitting them to replace the existing fuel completely. However, the various admission techniques experimented by the researchers are giving good solutions to apply larger fraction of replacing fuel in the existing engine and run accurately.

Bio fuels are renewable, eco-friendly (Robert et *al., 1995) and are obtained from bio resources* such as plants and animals. Compared to animals, plants are the major contributors in supplying of bio fuels. Generally, plants yield two types of oils namely triglyceride oils (TG oils) and turpene oils (light oil). Of which, the triglyceride oils are obtained from plant seeds but Eucalyptus oils are obtained from leaves and young twigs of the plant (Devan P.K. and Mahalakshmi N. V.; 2010).

The present investigation used the performance and emissions of diesel and diesel additive blended with palm kernel oil is studied and the best performances of oil blends were identified. The blended form of palm kernel oil and diesel does not require any engine modification. Hence, this investigation mainly focused on the performance and emissions of diesel and diesel additive blended with palm kernel oil in the proportionate ratios.

In this work, the palm kernel oil is vegetable oil mixed with diesel at different blends and these blends are further tested by adding diesel additive. The performance and emissions of bio fuel blends were evaluated using a naturally aspirated direct injection diesel engine and these are plotted on graphs. Ever increasing fuel price, continuous addition of on road vehicles, fast depleting petroleum resources and continuing accumulation greenhouse gases are the main reasons for the development of alternative fuels.

II. POTENTIAL CHARACTERIZATION OF PALM KERNEL OIL AND DIESEL ADDITIVE

The Oil Palm *Elaeisguineensis* (*guineensis* referring to its country of origin) is native to West Africa**.** Mature trees are single-stemmed, and grow to 20 m tall. The palm fruit takes five to six months to mature. Oil is extracted from both the pulp of the fruit and the kernel. For every 100 kilograms of fruit bunches, typically 22 kilograms of palm oil and 1.6 kilograms of palm kernel oil can be extracted.

Mfeel-Diesel additive is a catalyst for fuel, it saves fuel consumption and pollution control increases.

The Mfeel-Diesel Additive is mixed to blends at a rate of 2ml per liter.

It is Petroleum based Fuel Additive. It is a liquid blend of organic chemicals in a petroleum base. The ingredients of Additive include detergents, combustion catalyst, and chemicals. The rest of the ingredients are simply trace amounts of Aromatic Hydrocarbons (in other words, that Naphtha wasn't well refined).

The Mfeel-Diesel additive has following benefits

1. It helps the environment with substantial reductions in the hazardous emissions from engines, motor vehicles, chimneys, fuel-based power generators, etc. And thereby controls pollution at Grade "A" level.
2. It also the most cost-effective fuel additive, saving fuel costs.
3. Also eases the pressure on non-renewable fuel resources by saving Fuel Consumption.
4. It washes out Carbon Deposits and extends engine life.
5. It is easily mixable and fully compatible with all varieties of Petroleum based fuel oil. It can be used to treat fuels like Petrol, Diesel, Furnace Oil and Kerosene with equal benefits.

Table 1.Compositions of Mfeel-Diesel additive

Composition	Percentage (%)
Solvent naphtha	5-10
Naphthalene	0.1-1
Pseadocumene	0.1-1
Mesitylene	0.1-1
Poly Sulfone	5-25
Polymeric Polymine	5-25
Oil-Soluble sulfonic acid	5-30

III. PROPERTIES ANALYSIS

The properties of methyl ester of palm kernel oil are compared with diesel and given in table2.It is observed that both the oils have important properties comparable with each other. Viscosity, calorific value and density of blends of methyl ester palm kernel oil and diesel oils are given in table 3. The properties of palm kernel oil like lower calorific value, flash point and viscosity are comparable with diesel oil.

Table 2.Properties of diesel, palm kernel oil

Properties	Diesel	Palm kernel oil
Kinematic viscosity at 40^0C(cst)	3.25	4.839
Calorific value (KJ/kg)	42700	37250
Pour point (^{0}C)	-17	2
Flash point (^{0}C)	76	167
Fire point (^{0}C)	78	172
Density(kg/ mm^3) at 15^0C	0.845	0.883
Cetane number	45	55

Table 3.Variation of calorific value and viscosity
With respect to palm kernel oil

Oils\Blends	Viscosity (cst)	Calorific value (KJ/kg)	Density (kg/mm^3)
Diesel	3.25	42700	0.845
Palm kernel oil	4.839	37250	0.883
Diesel 90% -PKO 10%	3.408	42155	0.844
Diesel 85% -PKO 15%	3.488	41882.5	0.846
Diesel 80% -PKO 20%	3.567	41610	0.848
Diesel 75% -PKO 25%	3.647	41337.5	0.850
Diesel 70% -PKO 30%	3.726	41065	0.852

IV.EXPERIMENTAL SETUP

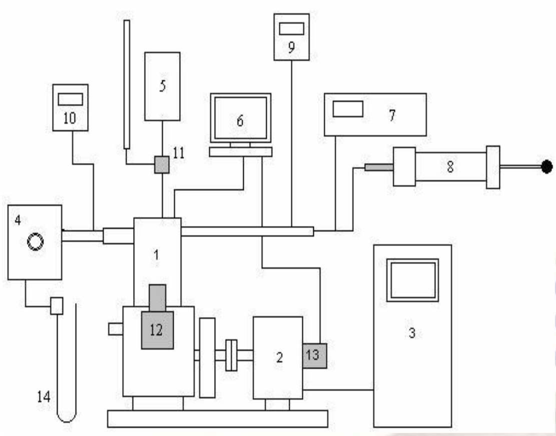

Figure 1.Experimental Set up

1-Diesel Engine; 2-Eddy current Dynamometer; 3- Dynamometer Control; 4-Anti pulsating Drum; 5-Oil Blends; 6-P-IV computer with DAQ; 7-Gas Analyzer Fumigator; 8-Smoke sampling pump; 9-Exhaust Temperature indicator; 10- Air inlet temperature indicator; 11-Two way valve; 12-Fuel Injection Pump; 13- Crank angle Encoder; 14-manometer.

It is capable of developing 3.72 kW at a constant speed of 1500 rpm and coupled to Pony brake dynamometer. The Inlet side of the engine consists of anti-pulsating drum, air Heater and air temperature, measuring device. The exhaust Side of the engine consists of EGT indicator, Exhaust gas Analyzer and smoke sampler. The setup also consists of a Separate fuel measuring device for measuring consumption of Diesel-oil blends.

V. PERFORMANCE ANALYSIS

A. Brake Thermal Efficiency

Figure 2 shows comparatively higher brake thermal efficiency for MePKO25-diesel 75 blend and with additive. When they are added the viscosity is reduced and moderate calorific value. This may be the reasons for better performance of MePKo25-diesel75 blend than that of standard Diesel operation. The reduction in viscosity leads to improved atomization, fuel vaporization and combustion. It may be also due to better utilization of heat energy and better air entrainment. The mixing of additive oil in the blend causes longer ignition delay and rapid combustion. During longer ignition delay engine accumulate more fuel before commencement of combustion and release more heat during premixed phase of combustion. The brake thermal efficiency of MePKo25-Diesel75 is 31.01% and it is 2.18% higher than that of standard diesel operation. On the other hand, the mixing of diesel additive to diesel has the efficiency of 29.94 and it is 1.11% higher than that of standard diesel. And when Additive is added to B25 blend it has the efficiency of 31.56 and it is 0.55% higher than that of efficiency obtained from B25 (PKO25%+diesel75%). The Brake Thermal efficiency is decreased when the load was increasing to maximum i.e. from 12kgs to 15kgs.

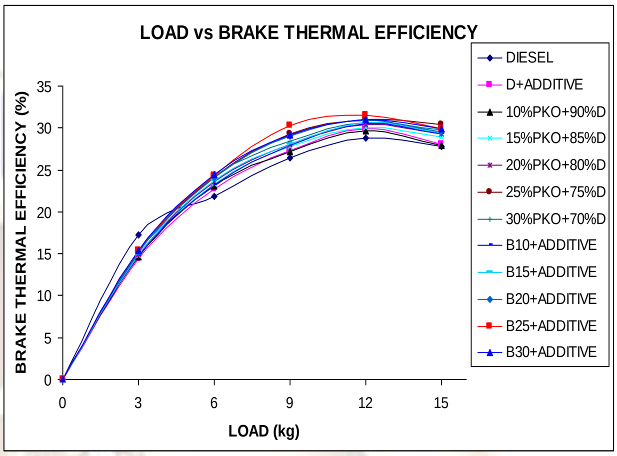

Fig. 2 Load Vs Brake Thermal Efficiency

B. Brake Specific Fuel Consumption (BSFC)

From figure 3 it is seen that at low load the BSFC is 0.597 KG/KW hr for diesel and for B25 blend is 0.578KG/KWhr. At full load the BSFC is 0.312 KG/KW hr for diesel and for B25 blend is 0.289 KG/KW hr. The brake specific fuel consumption of the B25 blend and the BSFC after mixing Additive was lower than that of all other. This may be due to better combustion and an increase in the energy content of the blend. Additive mixed blend and diesel have low BSFC.

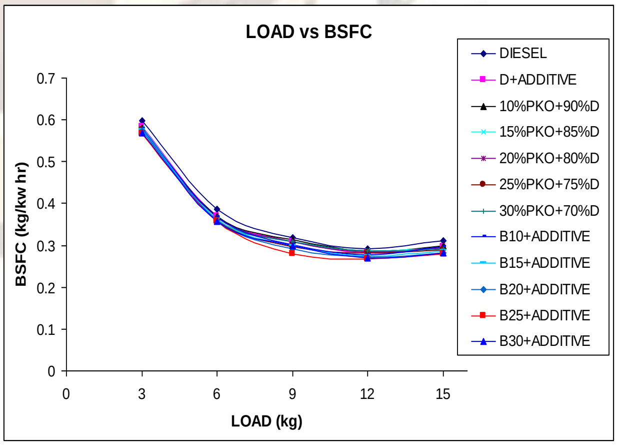

Fig. 3 Load vs BSFC

C. *Exhaust gas temperature (EGT)*

Figure 4 shows that the exhaust gas temperature of the B25 blend is higher than that of diesel. This may be due to the lower cetane number and higher ignition delay of the blend. The cetane number of the fuel was reduced with an increase of the diesel oil content in the fuel. The exhaust gas temperature of the B25 blend is higher than the standard Diesel fuel. But the temperature after mixing additive to diesel and diesel+Palm kernel oil blends is little bit lower. The graph clearly shows that the increase of exhaust gas temperature in all palm kernel oil and diesel oil blends. At the maximum load operation diesel has the exhaust gas temperature 398**°C** and at the same load Palm kernel oil (at 25% blend) has the temperature of 479**°C,** it was an increment of 81**°C**. It is observed that the increase in exhaust gas temperature in all the palm kernel oil to diesel blends, but slight decrease in the temperature when the mixing of additive to the diesel as well as to diesel-palm kernel oil blends. The blends have little bit difference in exhaust gas temperatures of blends at lower loads and there is a greater increase in temperature when load is increasing.

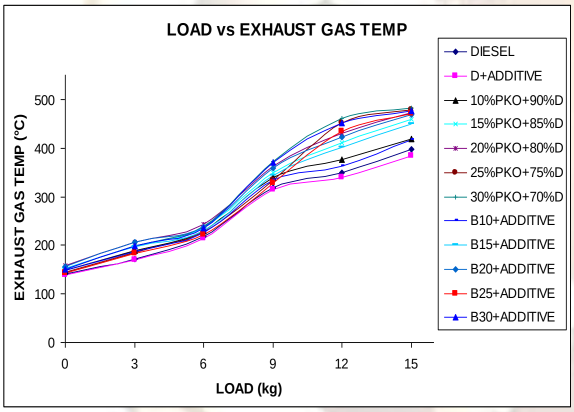

Fig. 4 Load vs exhaust gas temperature

VI. EMISSION ANALYSIS

A. *CO Emission*

The figure 5 shows the CO emission of blends with various loads. At low and medium loads, CO emissions of the blends were not much difference from standard diesel fuel operation. The CO emission of B25 blends decreased significantly at full load. This may be due to the enrichment of oxygen in the Palm kernel oil, in which an increase in the proportion of oxygen promotes further oxidation of CO during the engine exhaust process. There was a 14.1% reduction of CO emission for the B25 blend at full load. The mixing of Additive to diesel and B25 blend has 22.22% reduction in co emissions when compared to diesel. At no load the diesel has very low CO emission and it is goes on increasing as the load is increasing from 0 to 15 kegs. Similarly B25 blend also has low emissions on low load and increasing it by load on an engine. All the blends have low CO emissions at all loads compared to diesel. The value of CO percentage in exhaust gas is nearer to all blends at lower loads and it is much more difference at higher loads.

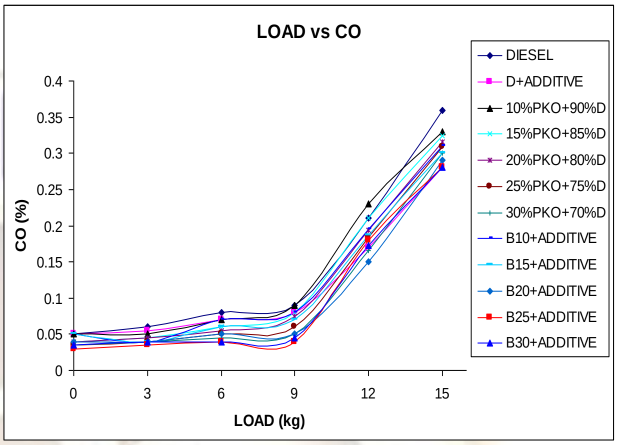

Fig. 5 Load vs CO Emissions

B. *HC Emission*

The Fig. 6 shows that the variation of HC emission of Diesel- PKO blends fuel under various engine loads. The HC level reduces with increase in load for diesel as well as blends. It is seen that HC emissions for diesel fuel is 48 ppm at low load and 112 ppm at full load and for B25 blend it is 45 ppm at low load and 97 ppm at full load. For B25 blends, the HC emissions are lower than that of diesel fuel, and this may be due to complete combustion. There are normally some regions within the combustion chamber of an engine fueled with methyl ester where the mixture is either too rich to ignite the partially decomposed and oxidized fuel in the exhaust. Those un-burnt species are collectively known as un-burnt hydrocarbon emissions. The mixing of Additive to diesel have HC emission 47 at low load and 92 at full load, similarly adding additive to B25 blend has the HC emission 44 at low load and 94 at full load. Always there was reduction in HC emissions in both B25 blends and mixing of additive to fuels. The reduction in HC Emissions is goes on increasing with increase in load from no load to high load. It is better to use 25% palm kernel oil and 75% diesel blended fuel for reduced emissions of HC. It is observed that the reduction in HC emission at 15kg load running on B25 blend was 13.3%, but at low loads the reduction in emissions is less compared to the diesel. The graph clearly shows that there is a decrement in HC emission in diesel and palm kernel oil blends and diesel and palm kernel oil blends tested by mixing diesel additive.

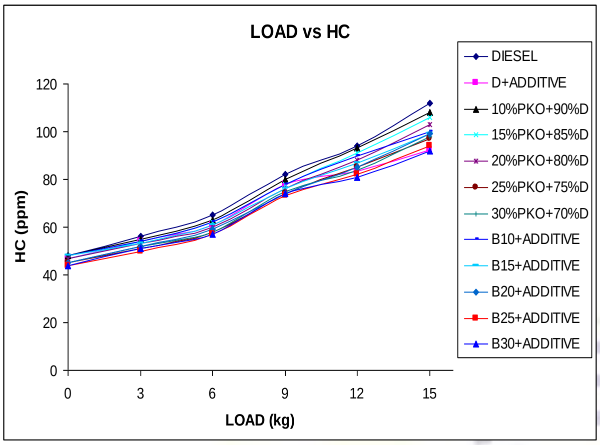

Fig. 6 Load Vs HC Emissions

C. Smoke Intensity

The smoke emission with various load conditions is shown in Fig 7. It compares the Bosch smoke number (BSN) of various blends with standard diesel operation. It is observed that the B25 blend shows higher reduction of smoke at all loads. More specifically, at full load, B25-additive offers 23.8% lower smoke than that of standard diesel operation. This is due to the Production of higher combustion temperature and rapid release of intermediate compounds. The diesel has a smoke of 4.2 and it is reduced to 3.8 by mixing diesel additive to diesel, it is 3.4 with B25 blend and 3.2 with additive mixed to B25 blend (25% palm kernel oil-75%diesel-additive). The additive mixed to diesel and diesel with palm kernel oil blends enables the smoother combustion. Additive mixed to fuel blends act as an ignition improver.

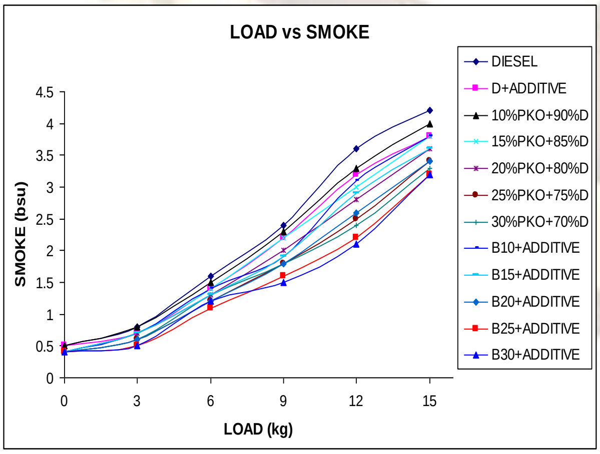

Fig. 7 Load Vs Smoke Intensity

The production of intermediate compounds splits the spray Particle into finer one and provides least chances for formation of soot. This may be the main reason for lower smoke emission of B25 blend.

D. Oxides of Nitrogen (NOx)

Fig. 8 shows that the variation of NO_x emission for Diesel-palm kernel oil blends and standard diesel for different engine loads. The increase in trend may be due to the presence of oxygen in methyl ester of palm kernel oil. Many researchers reported that oxygenate fuel blends can cause an increase in NOx emission. Normally complete combustion causes higher combustion temperature which results in higher NO_x formation. Another reason for the increase in NOx emission is the cetane suppressing property of oil. Usually, low cetane fuels offer longer ignition delay and release more heat during the premixed phase of combustion. For MePKo25-Diesel 75 blend, the NOx emission was 1292 ppm compare to 1225 of Standard diesel. It decreases slightly by adding additive. It is observed that the decrease in NOx is more at maximum loads compared to low and no loads. At maximum load diesel has NOx emission 1225 ppm, where as it is 1102 ppm when additive is mixed to diesel and operated at same load and same compression ratio. At B25 blend the NOx emission is 1292 it is higher than the emission recorded when the engine is running on diesel fuel. For diesel and Diesel-Palm kernel oil Blends there was a reduction in NOx emissions. The increase in NOx emission is observed in not only Palm kernel oil but also in all vegetable oils due to the presence of oxygen in the oil extracted from vegetable products. From the figure 8,it is observed that there is no much more increase in NOx emission at lower loads but greater increase may observe when the load on engine is increasing to maximum value. In the graph NOx value is less and it is closer for diesel, diesel-palm kernel oil blends and additive mixed to all the fuel blends between 0kgs to 9kgs load. Diesel has lower NOx emission level when additive is mixed to it. The reduction in NOx emission observed in palm kernel oil-diesel blends when additive mixed is very low because of additive properties those allows little bit changes in fuel used in engines to reduce NOx emissions.

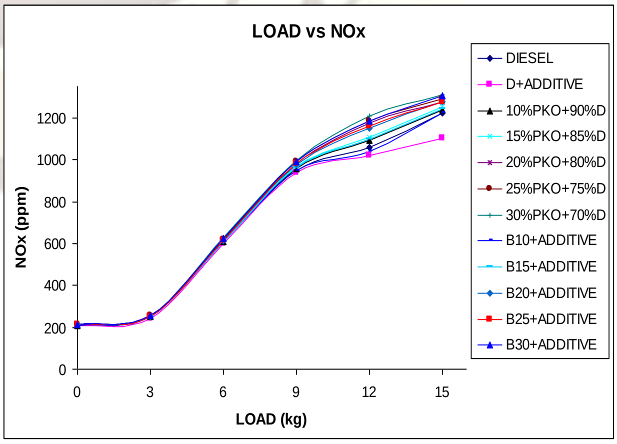

Fig. 8 Load Vs Nox Emissions

VII. CONCLUSION

Based on the experimental investigation conducted on a single cylinder DI Diesel engine using methyl ester Palm Kernel oil-Diesel blends and additive the following major Conclusions are arrived.

1. The results showed that the mixing of high cetane fuel of methyl ester of palm kernel oil with diesel oil up to 25% increases brake thermal efficiency by 2.18 percentage from the standard diesel fuel and 1.11% by adding additive to diesel and 2.73% by adding additive to B25 blend.

3. Approximately 19% smoke reduction was achieved with B25 operation, 9.52% by additive mixing and 23.8% by mixing Additive to B25 blend.

4. The result shows a 13.4% reduction with B25, 17.8% by adding additive to diesel in HC emission and 22.2% reduction in CO emissions with additive to diesel, 16.7% by B25 and 22.2% for MePKo25-Diesel 75-additive blend.

5. Comparatively a slighter increment in NOx emission was found while working with MePko25-Diesel 75 blend at all loads. And there is a slight decrease by adding additive.

6. The added advantage of this Palm kernel oil is it can blended to diesel and used as fuel without any modification. The results also proved that the blending of methyl ester Palm Kernel oil with diesel up to 25% increases the engine performance without much deteriorating its emission. The additive is blended at 2ml per liter improves engine performance and decreases the emissions. So the MePKo25-Diesel 75 blend can be used as an alternative fuel in DI diesel engine.

VIII. ACKNOWLEDGMENT

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