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Experimental Analysis Of Single Cylinder Diesel Engine Fuelled With Methyl Ester Of Palm Kernel Oil Blending With Eucalyptus Oil

P.Srinivasa Rao.[1] K.Srinivas [2]

[1]P.G student, Department of Mechanical Engineering, V.R Siddhartha Engineering College, Vijayawada, A.P,India.

[2]Assistant professor, Department of Mechanical Engineering, V.R Siddhartha Engineering College, Vijayawada, A.P .India.

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 complete replacement of diesel fuel with bio-fuels is studied, where the bio-fuels, namely, methyl ester of palm kernel oil and eucalyptus oil were chosen and used as fuel in the form of blends. Various proportions of palm kernel oil and eucalyptus oil are prepared 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 is considered as an ignition improver. The results show a 50% reduction in smoke, 34% reduction in HC emissions and a 37.5% reduction in CO emissions for the MePKo50-Eu50 blend with a 2.7% increase in NOx emission at full load. There was a 2.6% increase in brake thermal efficiency for the MePKo50-Eu50 blend at full load. The characteristics of Me PKo-Eu blends are comparable with those of standard diesel.**

Keywords-- Diesel engine; palm kernel oil; eucalyptus oil; combustion; emission; performance; blend*;*

I. INTRODUCTION

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. Many alternative fuels are identified and tested successfully in the existing engine with and without engine modification. However, research is still continuing in this field to find the best alternative fuel for the existing petro fuel.

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 petro fuel completely. However, the various admission techniques experimented by the researchers are giving good solution to apply larger fraction of replacing fuel in the existing engine.

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 two bio-oils called Eucalyptus oil; distilled oil from leaves of eucalyptus and methyl ester of palm kernel oil, a distilled oil from palm seed oil in a DI diesel engine, as an alternate fuel for diesel oil. But, the insufficient Cetane number of Eucalyptus oil prevents the complete replacement of diesel fuel from the diesel engine. However, the blended form of methyl ester of palm kernel oil and Eucalyptus oil displace diesel fuel to large extent and does not require any engine modification. Hence, this investigation mainly focused on the complete replacement of diesel fuel using Eucalyptus oil and methyl ester of palm kernel oil.

In this work, bio mass derived eucalyptus oil was chosen as the major constituent and the methyl ester of palm kernel oil was used as an ignition improver to enhance the performance of the blends. The performance, emission and combustion characteristics of bio fuel blends were evaluated using a naturally aspirated direct injection diesel engine.

II. POTENTIAL CHARACTERIZATION OF PALM KERNEL OIL AND EUCALYPTUS OIL

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. Each fruit which is reddish and is made up of an oily, fleshy outer layer (the pericarp), with a single seed (the palm kernel), also rich in oil. 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.

A few eucalyptus species, mainly mallees produce leaf oil. The botanical name is *eucalyptus globulus*. These oils are composed of mixture of volatile organic compounds including hydrocarbons, alcohols, aldehydes, keytones, acids, ethers and esters. 1-8 cineole or simply cineole is active component of eucalyptus oil. Cineole is a cyclic ether with empirical formula $C_{10}H_{18}O$ and systematic name1,3,3-trimethyl-2-oxabicyclo octane (Ramesh B et al (1994)).

It is sometimes traded commercially as eucalyptol. It is a colourless liquid over the temperature range 0^0C to 177^0C with a vapour pressure of 69mmHg at 20^0C and a strong characteristics odour.

III. PROPERTIES ANALYSIS

The properties of methyl ester of palm kernel oil and eucalyptus oil are compared with diesel and given in table1.It is observed that both the oils have important properties comparable with those of diesel fuel. Viscosity, calorific value and density of blends of methyl ester palm kernel oil and eucalyptus oils are given in table 2. When eucalyptus oil which has high volatility and low viscosity, blended with MePKo; it resulted in a fuel with reduced viscosity and increased volatility. The reduction in viscosity and increase in heating value would result in better engine performance. The volatility of the blend also increased which results in fine atomization and better spray formation. The properties of blend like lower calorific value, flash point and viscosity are comparable with those of diesel oil, Eucalyptus oil

Table 1.Properties of diesel, palm kernel oil and Eucalyptus oil

Properties	Diesel	Palm kernel oil	Eucalyptus oil
Kinematic viscosity at 40^0C (mm^2/sec)	2-4	4.839	1.6-2.1
Calorific value KJ/kg	42,700	37,250	43270
Pour point(^{0}C)	-17	2	-12
Flash point(^{0}C)	76	167	54
Density (kg/m^3) at 15^0C	840	883	913

Table 2.Variation of calorific value and viscosity with respect to addition of eucalyptus oil.

Oils\Blends	**Viscosity (cst)**	**Calorific value (KJ/kg)**	**Density (kg/mm^3)**
Diesel	3.25	42,700	0.840
Palm kernel oil	4.839	37,250	0.883
Eucalyptus oil	2	43,270	0.913
MePKO 50-Eu50	3.82	41,820	0884
MePKO 40-Eu60	3.48	42,160	0.880
MePKO 30-Eu70	3.15	42,470	0.886
MePKO 20-Eu80	2.87	42,750	0.893

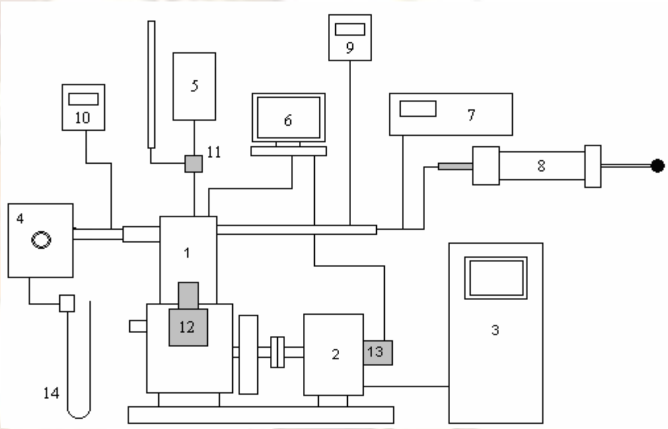

Figure 1. Experimental Set up

1-Diesel Engine; 2- Eddy current Dynamometer; 3- Dynamometer Control; 4- Anti pulsating Drum; 5- EU 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 an eddy current 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 Bio fuel blends. A 64 bit DAQ system is also provided with the test rig to acquire crank angle and cylinder pressure data.

IV. PERFORMANCE ANALYSIS

A. Brake Thermal Efficiency

Figure 2 shows comparatively higher brake thermal efficiency for MePKO50-Eu50 blend than that of diesel fuel, at all loads. This may be due to the presence of high volatile eucalyptus oil in the blend. Basically cineole is major component of eucalyptus oil, it decomposes easily at low temperature and release more intermediate compounds immediately after injection. This may be the reasons for better performance of MePKo50-Eu50 blend than that of std. 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 presence of eucalyptus 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. This leads to higher cylinder pressure and higher brake thermal efficiency. The brake thermal efficiency of MePKo50-Eu50 at full load is 31.5% and it is 2.6% higher than that of standard diesel operation.

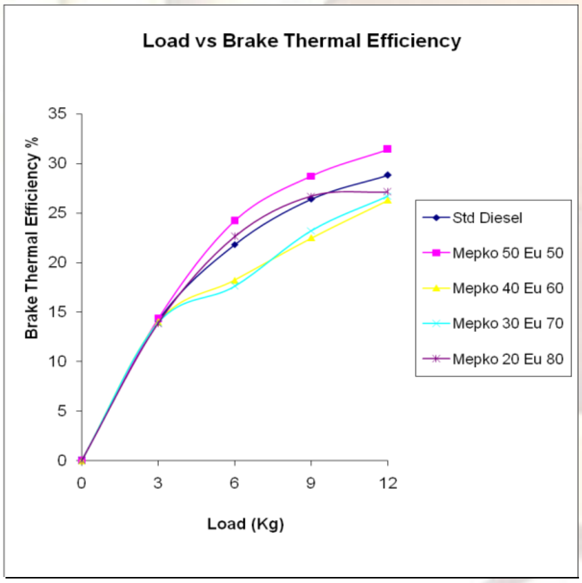

Fig. 2 Load Vs Brake Thermal Efficiency

B. Brake Specific Energy Consumption (BSEC)

From figure 3 it is seen that at low load the BSEC is 27MJ/KW hr for diesel and for MePKo50-Eu50 blend is 26MJ/KW hr. At full load the BSEC is 13.8MJ/KW hr for diesel and for MePKo50-Eu50 blend is 12.2 MJ/KW hr. The brake specific energy consumption of the MePKo50-Eu50 blend was lower than that of all other This may be due to better combustion and an increase in the energy content of the blend.

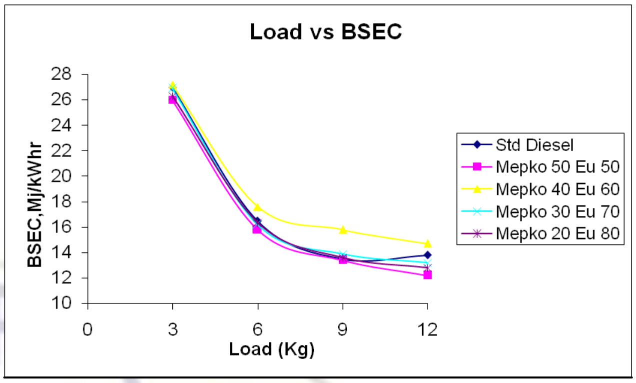

Fig. 3 **Load vs BSEC**

C Exhaust gas temperature (EGT)

Figure 4 shows that the exhaust gas temperature of the MePKo20-Eu80 blend is higher than that of all other blends. 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 eucalyptus oil content in the fuel. The exhaust gas temperature of the MePKo50-Eu50 is closer to the std. diesel fuel at lower loads as well as at higher loads

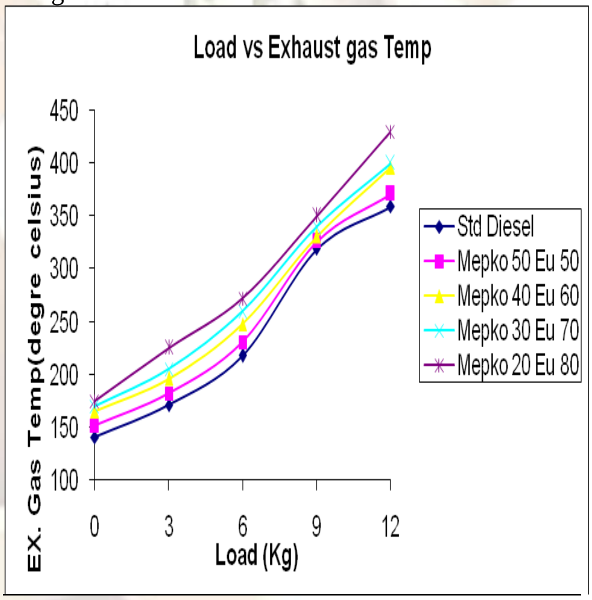

Fig. 4 Load vs exhaust gas temperature

V. EMISSION ANALYSIS

A. CO Emission

The figure 5 shows the CO emission of MePKo-Eu blends with various loads. At low and medium loads, CO emissions of the blends were not much difference from std. diesel fuel operation. The CO emission of MePKo-Eu blends decreased significantly at full load. This may be due to the enrichment of oxygen in the eucalyptus oil and methyl ester palm kernel oil addition, in which an increase in the proportion of oxygen promotes further oxidation of CO during the engine exhaust process. There was a 37.5% reduction of CO emission for the MePKo50-Eu50 blend at full load.

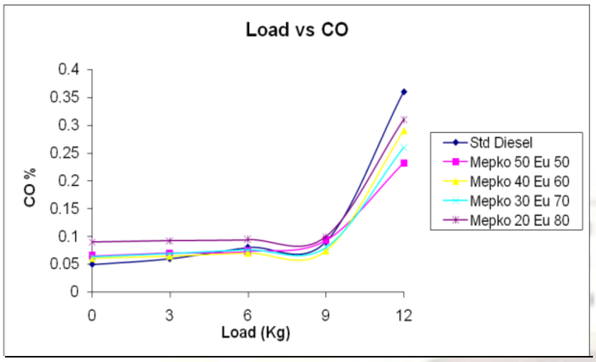

Fig. 5 Load vs CO Emissions

B. HC Emission

The Fig. 6 shows that the variation of HC emission of MePKo-Eu blends fuel under various engine load. 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 MePKo50-Eu50 blend it is 37ppm at low load and 74 ppm at full load. For MePKo-Eu 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. As the ignition delay period lengthens, for example, due to a reduction in the fuel cetane number, a portion of the mixture may become over mixed with air and leaner than lean combustion limit. This may be the reason for the reduction in HC emission for blends than the diesel fuel operation.

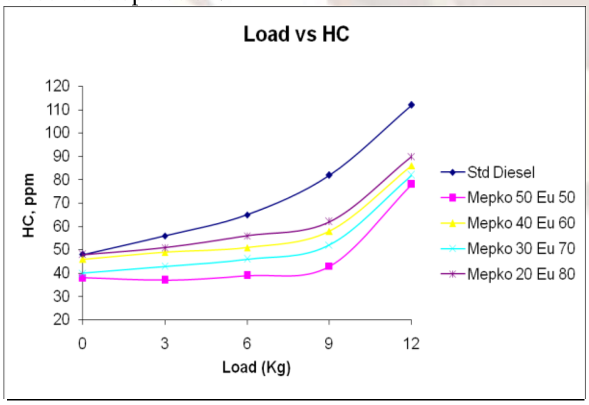

Fig. 6 Load Vs HC Emissions

C. Smoke Intensity

The smoke emission with various load condition is shown in Fig. 7. It compares the Bosch smoke number (BSN) of various MePKo-Eu blends with std. diesel operation. It is observed that the MePKo50-Eu50 blend shows higher reduction of smoke at all loads. More specifically, at full load, it offers 50% lower smoke than that of std. diesel operation. This is due to the production of higher combustion temperature and rapid release of intermediate compounds.

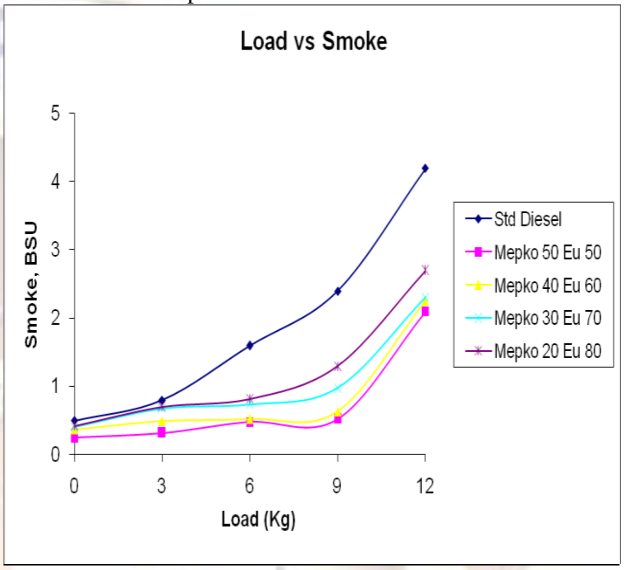

Fig. 7 Load Vs Smoke Intensity

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 ofMePKo50-Eu50 blend.

D. Oxides of Nitrogen(NO_x)

Fig. 8 shows that the variation of NO_x emission for MePKo-Eu blends and std. diesel for different engine load. The increase in trend may be due to the presence of oxygen in both methyl ester of palm kernel oil and eucalyptus oil. Many researchers reported that oxygenate fuel blends can cause an increase in NO_x 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 eucalyptus oil. Usually, low cetane fuels offer longer ignition delay and release more heat during the premixed phase of combustion. For MePKo50-Eu50 blend, the NOx emission was 1258ppm compare to 1225ppm of std. diesel.

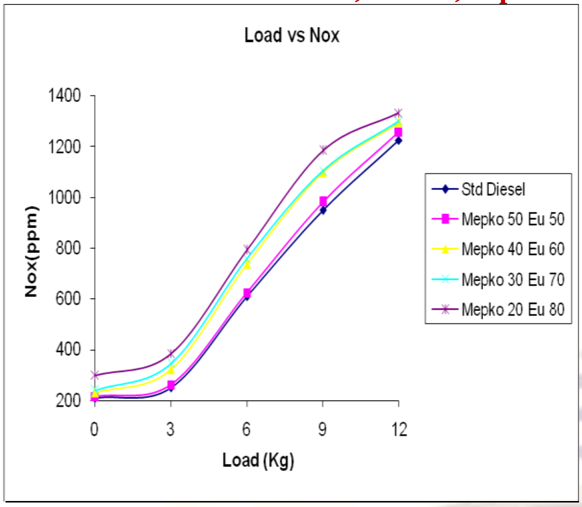

Fig. 8 Load Vs Nox Emissions

VI. COMBUSTION ANALYSIS

The variation of cylinder peak pressure with load for methyl ester palm kernel-eucalyptus oil blends and diesel is shown in figure9. Combustion rate is mainly depends on peak pressure in the initial stages, which is influenced by the fuel taking part in uncontrolled heat release phase. The presence of eucalyptus oil in the blend decreases its viscosity and improves volatility which leads to better atomization and mixture preparation with air during the ignition delay period.

It is also observed that the cylinder peak pressure of all blends increases from no load to full load. This may be due to the low cetane value of the blend longer ignition delay. Normally low cetane fuel is more volatile and has a high latent heat of vaporization. Hence the fuel absorbs more amount of heat from the cylinder immediately after injection and results in longer ignition delay. Therefore the slope of the high eucalyptus oil is comparatively higher than that of std.diesel. Cylinder peak pressure decreases slightly with an increase in the proportion of eucalyptus oil at low load whereas it increases slightly with an increase in the proportion of eucalyptus oil at medium and high loads

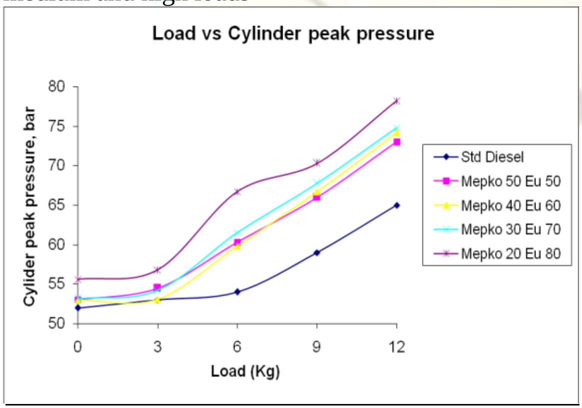

Fig. 9 Load vs Cylinder peak pressure

VII. CONCLUSION

Based on the experimental investigation conducted on a single cylinder DI Diesel engine using methyl ester Palm kernel oil-eucalyptus oil blends. 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 low cetane fuel of eucalyptus oil up to 50% increases brake thermal efficiency by 2.6 percentage from the std. diesel fuel.

2. Increased volatility and reduced viscosity are the benefits of these blends, which led to fine atomization and better spray formation.

3. Approximately 50% smoke reduction was achieved with MePKo50-Eu50 operation.

4. The result shows a 34% reduction in HC emission and 37.5% reduction in CO emissions for MePKo50-Eu50 blend.

5. Comparatively a slighter increment in NOx emission was found while working with MePko50-Eu50 blend at all loads.

6. The added advantage of this eucalyptus oil is that, it can be blended with any oil without any modification.

The results also proved that the blending of methyl ester Palm Kernel oil with eucalyptus oil up to 50% increases the engine performance without much deteriorating its emission. So the MePKo50-Eu50 blend can be used as an alternative fuel in DI diesel engine.

VIII. ACKNOWLEDGMENT

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