Evaluation of Engine Performance and Emission by Using Diesel and It's Blend with Tyre Pyrolysis Oil, and DEE on Four Stroke Single Cylinder Diesel Engine

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Abstract—*This paper describe an experimental study using pyrolysis oil from tyre waste and DEE (Diethyl Ether) as a blended fuel in a Diesel engine. Test have been carried out to evaluate the performance and emission characteristics for single cylinder four stroke diesel engine fueled with 10%,15% and 20% pyrolysis oil obtain from tyre waste as a blended fuel with Diesel. The best blend of pyrolysis oil and diesel were found and DEE is added to achived blend in the concentration of 5%,10% and 15% to improve the performance and emission characteristics. Results shows that the brake thermal efficiency of engine fueled with tyre pyrolysis oil slightly increased compared to diesel fuel. CO,HC, NOx emission also found higher compared to Diesel fuel. It is concluded that it is possible to use tyre pyrolysis oil in a diesel engine.*

Keywords: -Diesel, Tyre pyrolysis Oil, DEE, Performance Analysis, Emission Analysis

I. INTRODUCTION

World today facing challenge of energy depletion and environmental pollution.World is facing problem of shortage of fossil fuel. The energy crisis and environmental degradation are the main problems mankind is facing today. The transport sector in India is major energy consuming sector.Many researchers have studied the use o f wasteoilsindieselengines. The waste oils like waste plastic oil, waste cooking oil, waste lubrication oil etc. are considered as potential alternative fuels for diesel engines.

D.C. Rakopoulos [1] et al have been studied Exhaust emissions with ethanol or n-butanol diesel fuel blends during transient operation. They present work reviews the literature concerning the effects of alcohol/diesel blends on the exhaust emissions of diesel engines operating under transient conditions. The main mechanisms of transient emissions were identified and discussed for all exhaust pollutants, with many of those mechanisms being interrelated with the inherent discrepancies observed during transients, most notably turbocharger lag.

Although biodiesel is nowadays considered the primary alternative fuel for diesel engines, ethanol and normal butanol show promising emission results during real driving conditions, particularly with respect to PM reduction and hence the flexibility in controlling the PM/NOx trade-off. Therefore, it is believed that they can be considered as further alternative options for compression ignition engines in the near future, at least for small (up to 20%) percentages in the fuel blend. However, issues related to the storage and stability for ethanol, and production rate/cost for n-butanol need first to be solved, with extensive durability and wear tests on various types of engines and injection system.

Mishra Chinmaya [2] et al have been presented Combustion, Emission and Performance Characteristics of a Light Duty diesel Engine Fuelled with Methanol Diesel Blends. Combustion, emission and performance characterization of a single cylinder diesel engine using methanol diesel blends was carried out. The blends were 5% (v/v) methanol in diesel (MD05) and 10% (v/v) methanol in diesel (MD10).

The problem of solubility of methanol and diesel was addressed by an agitator placed inside the fuel tank to prevent phase separation. The results indicated that total combustion duration was reduced by15.8% for MD05 and 31.27% for MD10 compared to the baseline data. Ignition delay was increased with increasing methanol volume fraction in the test fuel. Total cyclic heat release was reduced by 1.5% for MD05 and 6.7% for MD10 as compared to diesel baseline. Emissions of carbon monoxide, hydrocarbons along with smoke were reduced and that of nitrogen oxides were increased with rising methanol contents in the test fuel. Full load brake thermal efficiency was marginally reduced with increased methanol composition in the blend.

OrhanArpaet [4] et al found that The DLF is produced from waste engine lubrication oil purified from dust, heavy carbon soot, metal particles, gum-type materials and other impurities. A fuel production system mainly consisting of a waste oil storage tank, filters, a reactor, oil pump, a product storage tank, thermostats and control panel is designed and manufactured. The DLF is produced by using the system and applying paralytic distillation method. It is observed from the test results that about 60 cc out of each 100 cc of the waste oil are converted into the DLF. Characteristics and distillation temperatures of the DLF are close to those values of a typical diesel fuel sample. It is observed that the produced DLF can be used in diesel engines without any problem in terms of engine performance. The DLF increases torque, brake mean effective pressure, brake thermal efficiency and decreases brake specific fuel consumption of the engine for full power of operation.

S. Saravanan [5] et al in that investigation an attempt was made to test the feasibility of crude rice bran oil methyl ester (CRBME) which is derived from high free fatty acid (FFA) crude rice bran oil (CRBO) by a two-step transesterification process as a fuel for a heavy-duty automotive compression ignition (CI), i.e. diesel engine in blended form. While running with CRBME blend significant reductions in CO, UBHC and particulate emission were observed with a marginal increase in NOx emission than that of diesel. It was found that the hourly fuel cost of CRBME blend is higher than CRBO blend and diesel. It was also concluded that as a fuel for a heavy-duty diesel engine CRBME blend shows better emission characteristics than diesel with a marginal increase in NOx emission. Hence efforts can be taken to utilize it effectively.

Roy [6] et al conducted experiments on the recycling of scrap tyres to oil and carbon black by vacuum pyrolysis. In this work, a step-by-step approach has been used, from bench-scale batch systems, to a process development unit and finally a pilot plant, to experiment and develop vacuum pyrolysis of used tyres. It was reported that the yield is 55% oil, 25% carbon black, 9% steel, 5% fiber and 6% gas. The maximum recovery of oil is obtained at 415 °C below an absolute pressure of 2 k Pa. The specific gravity of this oil was 0.95 and its gross heating value was 43 MJ/kg and total sulphur content about 0.8%. It was rich in benzyl and other Petrochemical components. The heat of pyrolysis for the reactions is low and is estimated to be 700 kJ/kg.

S. Murugan [7] et al conducted test to evaluate the performance, emission, and combustion characteristics of a single cylinder direct injection diesel engine fueled with 10%, 30%, and 50% of tyre pyrolysis oil (TPO) blended with diesel fuel (DF).The combustion parameters such as heat release rate, cylinder peak pressure, and maximum rate of pressure rise also analyzed. Results showed that the brake thermal efficiency of the engine fueled with TPO–DF blends increased with an increase in blend concentration and reduction of DF concentration. NOx, HC, CO, and smoke emissions were found to be higher at higher loads due to the high aromatic content and longer ignition delay. The cylinder peak pressure increased from 71 bars to 74 bars. The ignition delays were longer than with DF. It is concluded that it is possible to use tyre pyrolysis oil in diesel engines as an alternate fuel in the future.

II. Comparison Of Properties Of Pyrolysis Oil And Diesel

Table 1.

PROPERTY	DIESEL	Pyrolysis oil
Heating Value (KJ/Kg)	42,900	38000
Density (Kg/l)	0.830	0.9239
Flash point ^{o}C	50	43
Viscosity (mm^2/s)	2.58	3.77

III. Experimental Set Up

Fig.1: Experimental set up

Fig.1 shows the experimental set up. A single-cylinder, 4-Stroke, water-cooled diesel engine of 5 hp rated power is considered for the experimentation. The engine is coupled to a rope brake dynamometer through a load cell. The schematic layout of the experimental set up is shown in below Fig. a stationary, 5 hp direct injection diesel engine is used to conduct experiments. Its specifications are given in Table II. Concentrations of CO and UHC are measured using Exhaust gas analyzer. Air suction rate and exhaust airflow rates are measured with the help of an air velocity meter. Temperatures at the inlet and exhaust valves were monitored using thermocouples. Automatically increases with increase of speed and vice versa so that steady speed conditions are more easily achieved.

IV. Experimental Procedure

The performance test is carried out on diesel engine with diesel fuel at different loading condition. The pyrolysis oil is added in the concentration of 10%, 15% and 20% with Diesel. The best blends were selected and DEE is added in the best achived blend with the concentration of 5 %, 10 % and 15%. DEE used as oxygenated additives to improve efficiency and to reduce emission.

TABLE 2 ENGINE SPEFICATION

Parameter	Details
Engine	Single Cylinder High Speed Diesel Engine
Cooling	Water cooled
Bore × Stroke	80 mm × 110 mm
Compression ration	16 : 1
Maximum Power	5 hp or 3.7 kw
Rated speed	1500 rpm
Capacity	553 CC

V. Results

A. Performance Analysis.

1) Fuel Consumption:

The fuel consumption at different loading condition is shown in fig. 2 indicates that the fuel consumption increase with increase in brake power. If pyrolysis oil is added, the

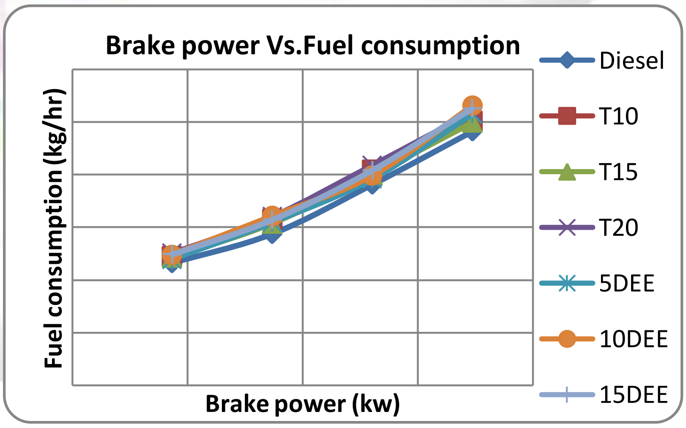

Fig.2: Fuel Consumption VS Brake Power

Fuel consumption found increased at different loading condition compared to Diesel fuel. Fuel consumption of T15 blend found less compared to T10 and T20 blend... This may be due to proper mixture. DEE (Diethyl Ether) is added in the concentration of 5%, 10% and 15% to the mixture of pyrolysis oil and Diesel. The fuel consumption of 5% DEE blend found less compared to 10% DEE and 15% DEE because DEE is a good oxygenated additive so it improves the combustion characteristics.

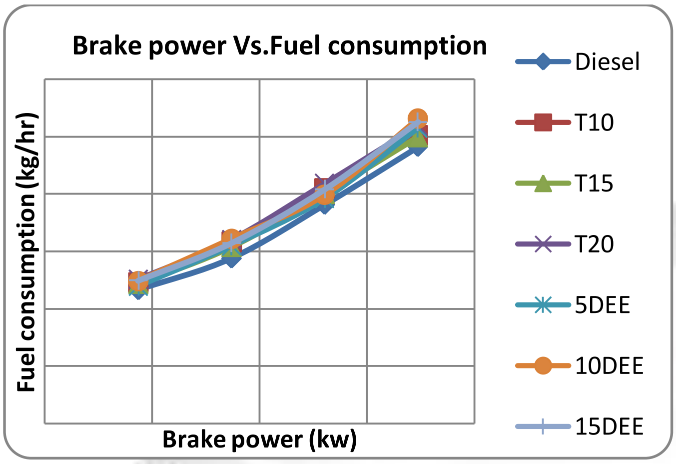

Fig.2: Fuel Consumption VS Brake Power

2) Specific Fuel Consumption:

The specific fuel consumption decrease with increase engine power. The SFC increase compared to Diesel because more fuel is require for producing same power produced by Diesel fuel. The SFC of T15 found lower compared to T10 and T20 but found higher compared to Diesel. Diesel fuel have low SFC compared to other blends of Tyre pyrolysis oil.DEE is added than the SFC of 15DEE found less compared to other DEE blend as indicated in fig. 3

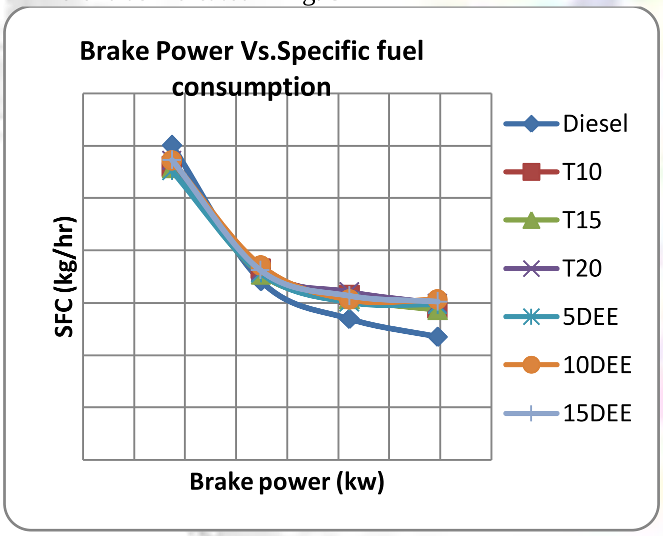

Fig.3: Specific Fuel Consumption VS Brake Power.

3) Brake Thermal Efficiency:

Fig.4 shows variation of brake thermal efficiency with brake power. The break thermal efficiency increased with increased in the break power. If Pyrolysis oil is added, the break thermal efficiency found increased with increase in pyrolysis oil concentration compare to Diesel fuel. The brake thermal efficiency of T15 blend found 15%, 24%, 27% and 29% which better compared to T10 and T20. There is a slight variation found in brake thermal efficiency of T10 and T20. The brake thermal efficiency of 5DEE found batter than 15DEE and 10DEE.There may be a better fuel mixture and complete combustion due to addition of DEE.

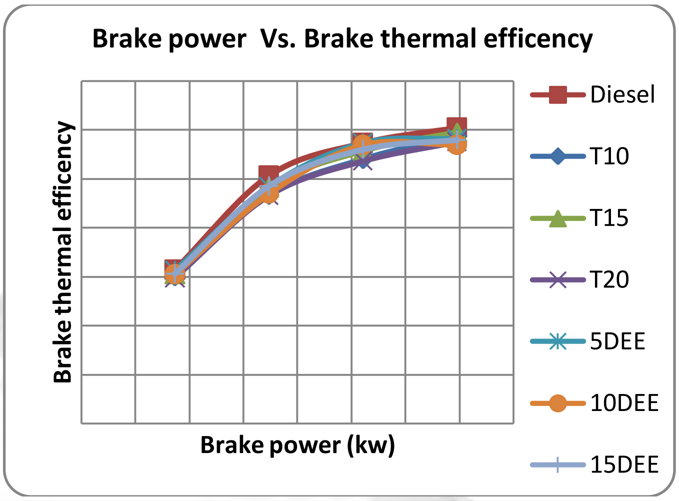

Fig.4: Brake Thermal Efficiency VS Brake Power.

4) Mechanical Efficiency:

The mechanical efficiency of T15 blend found higher compare to T10 and T20.If 5% DEE is added to the mixture of pyrolysis oil and diesel blend, the mechanical efficiency found 39%, 56%, 66% and 72% which is higher than 10DEE and 15DEE blend.It is also found higher compared to Diesel.

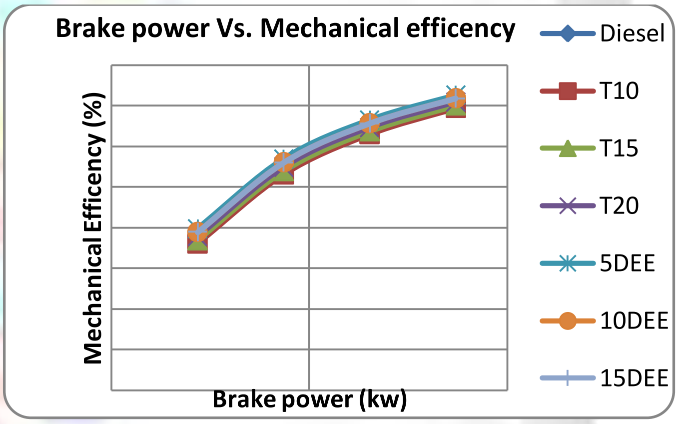

Fig.5: Mechanical Efficiency VS Brake Power

B. Emission Analysis.

1) Exhaust Gas Temperature:

Fig.6 shows the exhaust gas temperature variation with brake power. It may be seen that exhaust gas temperature increases with increasing load and increasing pyrolysis oil

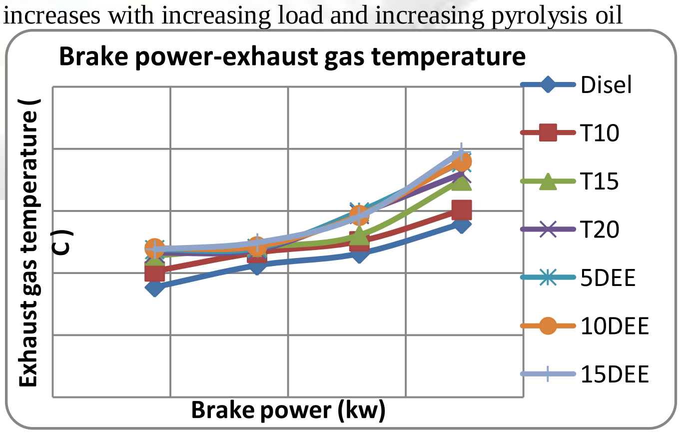

Fig.6: Exhaust Gas Temperature VS Brake Power.

concentration of pyrolysis oil in Diesel. The main reasons for higher exhaust gas temperature are Poor volatility and high viscosity. The increase may also be due to higher heat release rate of Diesel –pyrolysis oil blends developed in the premixed combustion.

2) Carbon Monoxide (CO) Emission:

The emission of CO increase with increase in load for DF. If pyrolysis oil is added than CO emission again increase with increase in pyrolysis oil concentration compared to Diesel fuel. The reason may be, during the combustion processes, the presence of low molecular compounds that affect the atomization process result in rich mixture that produce higher CO emission. It is also due to the poor mixture preparation, insufficient combustion due to higher viscosity and poor volatility. With the addition of DEE to the Diesel-Pyrolysis oil blend, the CO emission slightly decrease. The CO emission found less in 15DEE compared to 5DEE and 10DEE. The reason is during power and exhaust stroke, most of the CO oxidizes to CO_2. If there is sufficient oxygen available, CO will continue to convert to CO_2 Because DEE is a good oxygenated additives.

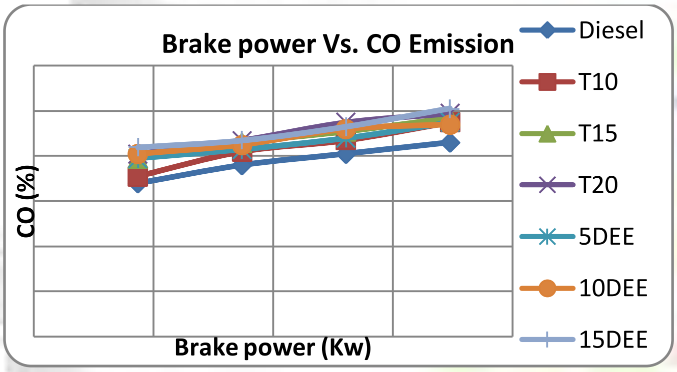

Fig.7: Carbon Monoxide Emission VS Brake Power.

C. HC Emission:

From the Fig.8 It is seen that HC increase with Load. HC found higher in Diesel-Tyre pyrolysis oil blend compared to Diesel. Higher HC emissions are probably due to higher viscosity, density and poor volatility and rich fuel mixture. DEE is a good oxygenated additives. So if DEE is added , HC emissions slightly decrease with increase in concentration of DEE in the mixture of Diesel-Pyrolysis blend. The emission of HC found lower in 5DEE compared to 10DEE and 15DEE.There is a complete combustion process due to the addition of DEE.

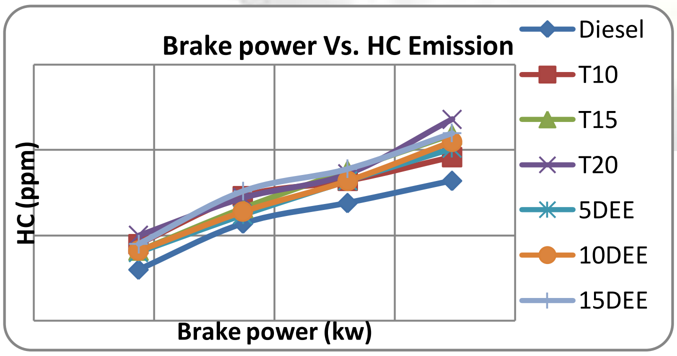

Fig.8: HC (Hydro Carbon) Emission Vs Brake Power.

1) Carbon Dioxide (CO_2) Emission:

Fig.9 shows that there is an increase in Carbon dioxide (CO_2) with Load. If pyrolysis oil is added, (CO_2) emission again increases with the increase in the pyrolysis oil concentration compared to Diesel. If DEE is added than (CO_2)V emission slightly decrease in 5DEE blend compared to 10DEE and 15DEE blend. Because there is a better combustion due to the addition of DEE.

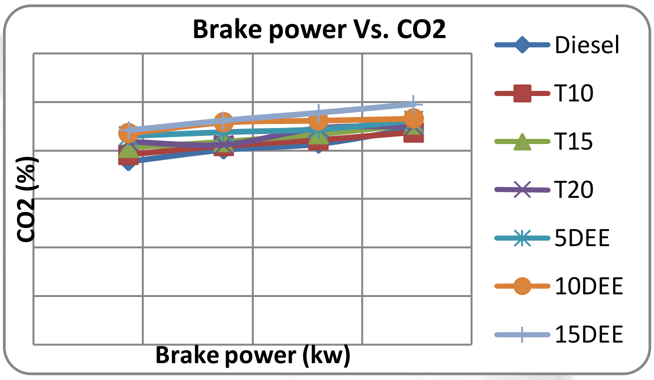

Fig. 9: Carbon Dioxide Emission VS Brake Power.

6.1.9 Nitrogen oxide (NOX) Emission

Fig.10 shows that NO_x emission increase with increase in load. The NO_x emission found higher in tyre pyrolysis oil blend compared to Diesel fuel. The reason for higher NO_x may be a higher aromatic content. The other reason may be a higher heat release rate due to longer ignition delay. If DEE is added, The NO_x emission slightly decrease compared to T15 blend but it is found higher compared to diesel fuel.

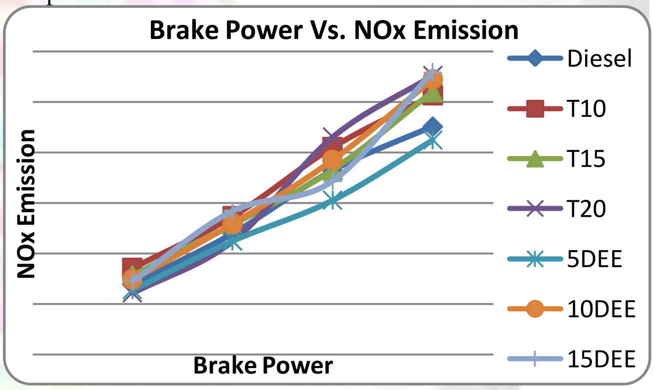

Fig.10: Variation of Nitrogen oxideEmission with Brake Power

VI. Conclusions

- It is concluded that the performance characteristic of pyrolysis oil-diesel blend decrease and emission increase compared to Diesel fuel.
- The fuel consumption of T15 blend found less compared to T10 and T20.
- Brake thermal efficiency of T15 blend also found higher compared to T10and T20.
- If DEE is added to T15 blend, the fuel consumption of 5DEE also found less compared to 10% and 15% DEE blend.
- If DEE is added to T15 blend, the emission of 5DEE also found less compared to 10% and 15% DEE blends. The CO, HC,CO_2 emissions are slightly reduced. The reason may be DMC is a good oxygenated additive.

A. Abbreviations and Acronyms

D	Diesel
T	Tyre pyrolysis oil
DEE	Diethyl Ether
T10	Blend of 10% Tyre pyrolysis oiland 90% Diesel
T15	Blend of 15% Tyre pyrolysis oil and 85% Diesel
T20	Blend of 20% Tyre pyrolysis oil and 80% Diesel
5DEE	5 % DEE blend with 95% Tyre pyrolysis oil-Diesel blend
10DEE	10 % DEE blend with 90% Tyre pyrolysis oil-Diesel blend
15DEE	15 % DEE blend with 85% Tyre pyrolysis oil-Diesel blend

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