Performance & Emission Studies of Diesel Engine Using Blends of Diesel, Tyre Pyrolysis Oil & Dibutyl Maleate

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Abstract— The experiment have been carried out to evaluate performance and emission characteristics of single cylinder four stroke diesel engine fueled with 10%, 15% and 20% tyre pyrolysis oil which is made from tyre waste through pyrolysis process. Result showed that the brake thermal efficiency of engine fueled with pyrolysis oil-Diesel blend decrease with increase of pyrolysis oil concentration in Diesel fuel. In Pyrolysis oil-Diesel blend, HC,CO NOx emission found higher with increase in load compared to Diesel fuel.DBM (Dibutyl maleate was added as an oxygenated additives to the tyre pyrolysis oil-Diesel blend in the concentration of 5%, 10% and 15%. The best results were found in 5% DBM added blend. It is concluded that it is possible to use tyre pyrolysis oil in diesel engine as an alternative fuel without any engine modification.

I. INTRODUCTION

The fast depletion of petroleum fuel and the environmental issues have led to an intensive search for alternate fuels for internal combustion engines. On the other hand, due to the rapid growth of automotive vehicles in transport sector, the consumption of oil keeps increasing. And also, the disposal of used tyre from automotive vehicles becomes inexhaustible. The use of tyre pyrolysis oil as a substitute for diesel fuel provides an opportunity to minimize the utilization of natural sources.

So many investigations have been done on Diesel engine using tyre pyrolysis oil. S. Murugan at. al test have been carried out to evaluate the performance, emission, and combustion characteristics of a single cylinder direct injection diesel engine fueled with 10%, 30%, and 50% of TPO blended with 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. HC emissions are higher for TPO-DF blends than for DF at full load. 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 by reducing aromatic content and viscosity of TPO. No engine seizing or injector blocking was found during the entire operation of engine running [1].

Gong Yanfeng et. al methoxyethyl acetate (MEA) can be used to decrease exhaust smoke as a new oxygenated additive of diesel. Several fuel blends which containing 10%, 15% and 20% MEA were prepared. The effects of MEA on engine's power, fuel economy, emissions and combustion characteristics were studied on a single cylinder DI diesel engine. Under the same speed and load conditions, the maximum cylinder pressure decreases when fueled with the blends, while the ignition delays and the combustion duration becomes shorter. The engine emissions of smoke, HC and CO are reduced when MEA is added in diesel. However, MEA has a little effect on NOx emissions. When fueled with MEA15, the coefficient of light absorption of smoke opacimeter decreases about 50% with expense of 5% power, and the engine's thermal efficiency increases about 2%.Because of the lower energy density of the blends, it is necessary to increase the mass of the delivery blends to gain the same power. The smoke density can be reduced by more than 50% and 60% when fueled with MEA15 and MEA20 respectively. The emissions of CO and HC also decrease with the increase of MEA in the blends. Considering the engine power, fuel economy and emissions, blend containing 15% MEA is preferred when the engine runs on the same parameters [2].

Er. Sandeep Singh et. al. DBM-diesel blends can be used as a fuel in compression ignition engine, using an easily modified fuel system. The engine operates in a similar manner with the DBM-diesel blend as with the diesel fuel. DBM has been shown to reduce particulate emissions from a DI diesel engine. This has lead to conclude this lower level of CO prevents the formation of soot precursors in the pre-mixed flame, which then reduces the formation of particulates. And also after complete combustion the % of CO reduces as it converts into CO_2. The smoke content reduces by 35 % at full load conditions using DBM20 blend. The blend of 15 % DBM has great impact on smoke emission and other gases and engine performance is also not much affected using DBM15. [3]

S. Murugan et. al studies on the performance, emission and combustion characteristics of a single cylinder four stroke air cooled direct injection diesel engine running with the Distilled Tyre pyrolysis oil (DTPO). From the experimental work carried out it is observed that the engine is able to run up to 90% DTPO and 10% DF. Engine failed to run satisfactorily with 100% DTPO. Brake thermal efficiency increase in percentage of DTPO blends but lesser than DF. NOX is lowered by about 22% and 18% in DTPO 20 and DTPO 90, respectively than that of DF operation. HC emission is higher by about 7% and 11% for DTPO 20 and DTPO 90, respectively at full load than of DF operation. Smoke is higher compared to DF. Ignition delay is longer for DTPO-DF blends compared to DF at full load. Higher rate of heat release in the initial stages and rate of pressure rise are observed in the DTPO 90 blends compared to DF [4].

Orhan Arpa et. al studied on diesel-like fuel (DLF) on four stoke air cooled engine. They were studied of performance and exhaust emission experimentally. The DLF is produced from waste engine lubrication oil purified from dust, heavy carbon soot, metal particles, gum-type materials and other impurities. Characteristics and distillation temperatures of the DLF are close to those values of a typical diesel fuel sample. It is observed that the DLF can be used in diesel engines without any problem in terms of engine performance. The DLF increase torque, brake mean effective pressure, brake thermal efficiency and decrease brake specific fuel consumption of the engine for full power of operation. Observed that torque, brake mean effective pressure and brake thermal efficiency were higher than those to the diesel sample while the brake specific fuel consumption was lower. Torque and brake specific fuel consumption was minimums at 2200rpm [5].

II. COMPARITION OF PROPERTIES

Table I

Properties	Diesel	DBM	TPO
Calorific Value(MJ/kg)	42.5	29	38
Density(kg/m^3)	0.832	0.988	0.9239
Flash point(° C)	50	95	43
Boiling point(° C)	180-360	205-207	210º
Kinematic viscosity	2.59	2.78	3.77

III. EXPERIMENTAL PROCEDURE

First of all, the experiment is done on single cylinder diesel engine fueled with Diesel fuel at different loading condition. Than tyre pyrolysis oil is used as a blended fuel with Diesel in the concentration of 10%, 15% and 20% and readings are taken to analyze performance and emission characteristics of Diesel engine. The best blend of pyrolysis oil-Diesel is found. DBM is added as oxygen additives to the best achieved blend to improve the performance and emission characteristics of Pyrolysis oil-Diesel blend and the readings are taken for the analysis.

IV. 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.1 A stationary, 5 hp direct injection diesel engine is used to conduct experiments. Its specifications are given in Table 2. Concentrations of CO, HC, CO2 and NOx 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.

Fig. 1: Engine setup

Table Ii Engine Specification

Parameter	Details
Engine	Single Cylinder High Speed Diesel Engine
Cooling	Water cooled
Bore × Stroke	80 mm × 110 mm
Compression ration	16:01
Maximum Power	5 hp or 3.7 kw
Rated speed	1500 rpm
Capacity	IV.

V. RESULT ANALYSIS

A. Fuel Consumption

Fig. 2 shows the variation of fuel consumption with brake power with various blends of Diesel, Pyrolysis oil and DBM

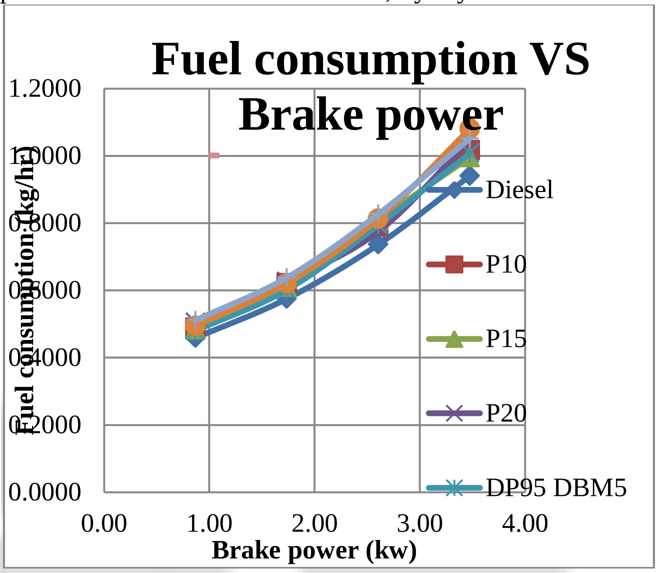

Fig. : Variation of Fuel Consumption with Brake Power.

The above figure shows that the fuel consumption increases with increase in break power because variation in fuel consumption found with brake power. Pyrolysis oil from tyre waste is added as a blended fuel in proportion of 10%,

15% and 20%.With the increase in the concentration of pyrolysis oil into the Diesel, There is an increase in fuel consumption is found with increase in brake power. The fuel consumption also found increased at all load condition compared to Diesel fuel. The less fuel consumption is found in P15 blend compared to P10 and P20.The reason may be a proper mixture. If DBM is added with the concentration of 5 %, 10% and 15% to P15 blend then fuel consumption in DP95 DBM5 blend is less compared to 10% and 15% DBM blend but found higher compared to Diesel Fuel. Because DBM is a good oxygenated additive so the combustion process will be better.

B. Specific Fuel Consumption

Fig.3 shows the variation of specific fuel consumption with brake power

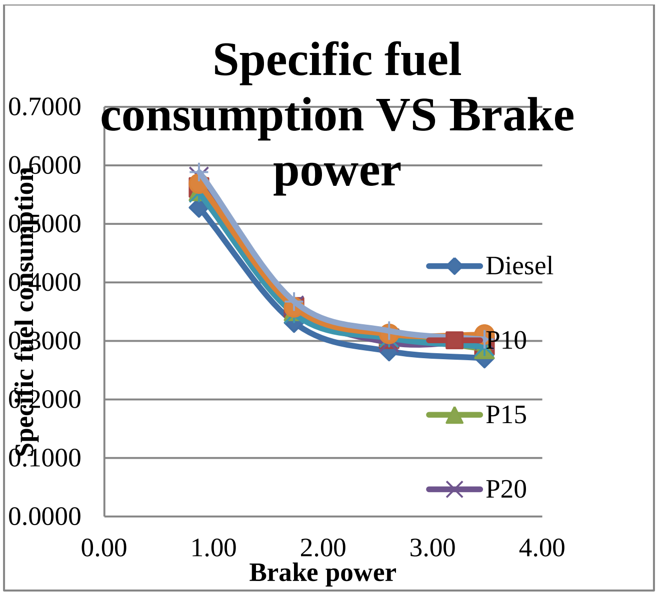

Fig. 3: Variation of Specific Fuel Consumption with Brake Power.

The specific fuel consumptions decrease with increase engine power. It is increase compared to DF because more fuel is requiring for producing same power produced by Diesel fuel. The SFC of D85 P15 found lower compared to D90 P10 and D80 P20 but found higher compared to Diesel. If DBM is added to Diesel-Pyrolysis oil blend, than the SFC found lower in is added, it is found lower in DP95 DBM5 compared to P15 blend. The specific fuel consumption of DP95 DBM5 also found less compared to DP90 DBM10 and DP85 DBM15 but it is found higher compared to diesel.

C. Brake Thermal Efficiency

Fig.4 shows variation of brake thermal efficiency with brake power.

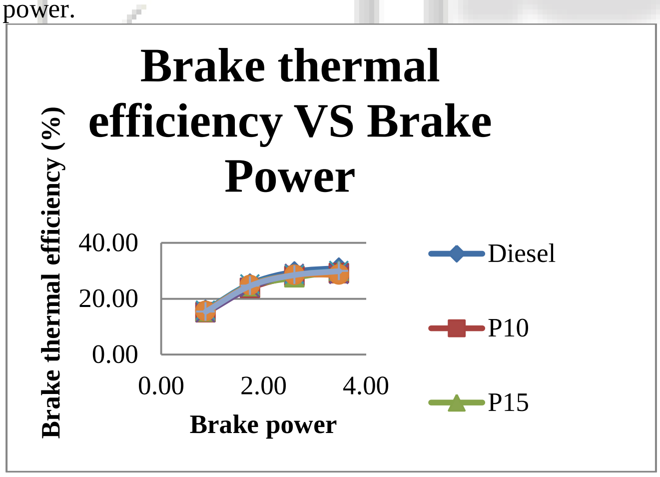

Fig. 4: Variation of Brake Thermal Efficiency with Brake Power.

The brake thermal efficiency increased with increased in the brake power. The brake thermal efficiency found decrease with increase in pyrolysis oil concentration compare to Diesel. The brake thermal efficiency of P15 blend found 15%, 24%, 27% and 29% respectively. The brake thermal efficiency of P15 blend found higher compared to P10 and P20 blend. If 5% DBM is added to the P15 blend then the brake thermal efficiency of DP95 DBM5 found 15%, 25%, 28% and 30% respectively which is better than P10 and P20 and also better than DP90 DBM10 and DP85 DBM15.This may due to the complete combustion process due to the addition of DBM because it's a good oxygenated additives. The brake thermal efficiency of all above discussed blend found lower compared to Diesel.

D. Mechanical Efficiency

Fig.5 shows variation of mechanical efficiency with brake power.

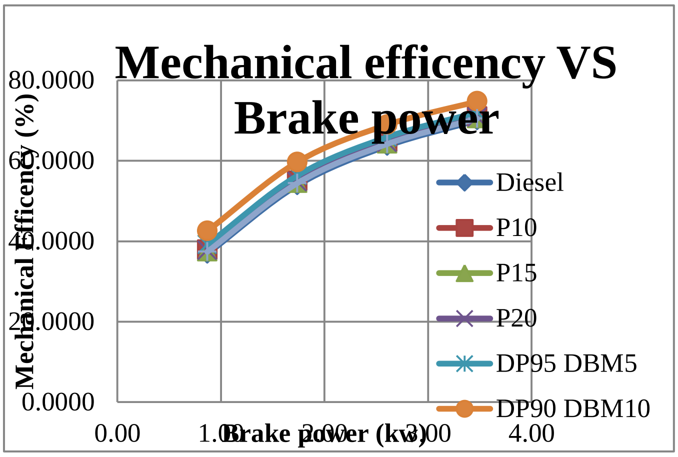

Fig. 5: Variation of Mechanical Efficiency with Brake Power.

The mechanical efficiency of P15 is higher compare to P10 and P20.If DBM is added, the mechanical efficiency of DP85 DBM10 found higher than DP95 DBM5 and DP90 DBM15. This may be due to the less friction power. The mechanical efficiency of DP90 DBM10 blend also found higher compared to Diesel fuel.

E. Exhaust Gas Temperature

Fig.6 shows the exhaust gas temperature variation with brake power. It is observed that the exhaust gas temperature increases with increasing load and increasing concentration of pyrolysis oil in Diesel. The main reason for higher exhaust gas temperature may be Poor volatility and high viscosity. The higher heat release rate of Diesel –pyrolysis oil blends is also the reason because there is an incomplete combustion. The Exhaust gas temperature of Pyrolysis oil-Diesel blend found higher compared to Diesel at all load condition. If 5% DBM is added then there is a slight decrease in exhaust gas temperature is found compared to other DBM added blend. This may be due to the complete combustion in presence of DBM as Oxygenated additives.

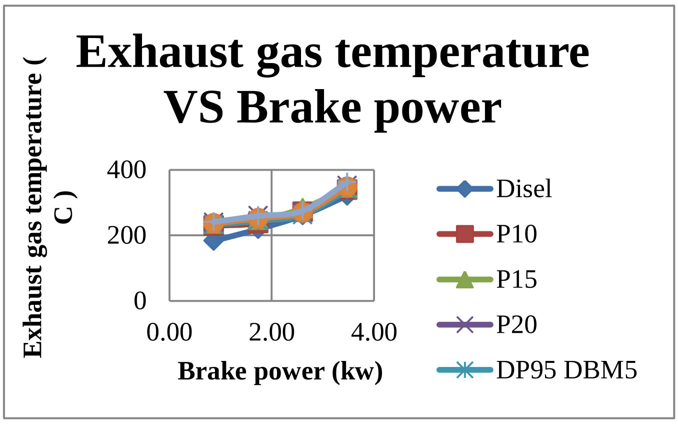

Fig. 6: Variation of Exhaust Gas Temperature with Brake Power.

F. Carbon Monoxide Emission

Fig.7 shows the variation of Carbon Monoxide (CO) with Load.CO emission increase with increase in load. The CO emissions also increase with the increase in the concentration of pyrolysis oil in Diesel compared to Diesel fuel. The reason may be due to the presence of low molecular compound during the combustion process affects the atomization process and which results a rich mixture responsible for a higher CO emission. This may also be due to the higher viscosity, poor mixture preparation and poor volatility. If DBM is added to P15 blend than the CO emission of DP95 DBM5 blend found slightly lower compared to DP90 DBM10 and DP85 DBM15. If there is sufficient oxygen available, CO will continue to convert to CO2 until relatively small concentration of co are left in the exhaust.

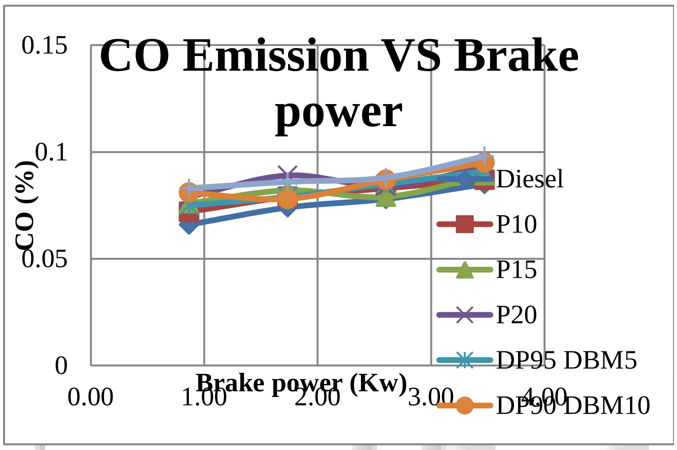

Fig. 7: Variation of Carbon Monoxide Emission with Brake Power.

G. Hc Emission

Fig.8 shows the variation of HC with brake power. It is observed that HC emission increase in all pyrolysis oil-Diesel blends compared to diesel. With increase in the pyrolysis oil concentration in pyrolysis oil-Diesel blend, HC emission increase Compared to Diesel. This may be due to higher viscosity, density, rich fuel mixture and poor volatility. Because tyre pyrolysis oil is aromatics in nature which results in higher unburnt hydrocarbon emissions. If DBM is added to P15 blend, HC emissions slightly decrease. With increase in concentration of ethanol in Diesel-Pyrolysis blend. In DP95 DBM5 blend, emission of HC found lower compare ton DP90 DBM10 and DP85 DBM10. There is a complete combustion due to the addition of DBM.

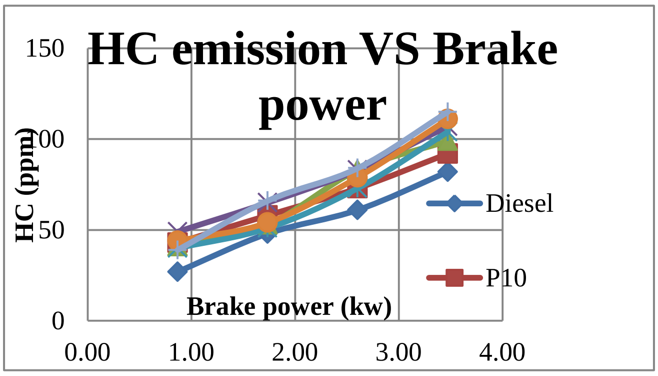

Fig.8 Variation Of Carbon HC (Hydro Carbon) Emission With Brake Power.

H. Carbon Dioxide (Co2) Emission

Fig.9 shows that there is a increase in Carbon dioxide (CO2) with Load. If pyrolysis oil is added, (CO2) emission again increases with the increase in the pyrolysis oil concentration compared to Diesel. If DBM is added than (CO2) emission slightly decreases in DP95 DBM5 blend compared to DP90 DBM10 and DP85 DBM15 blend. Because there is a better combustion occurs due to the addition of DBM.

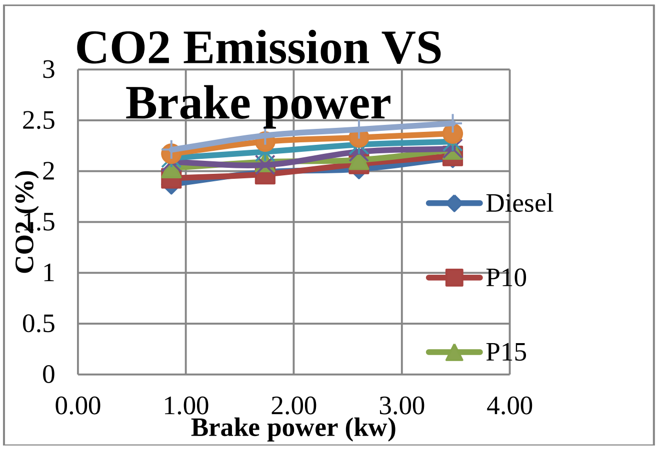

Fig. 9: Variation of Carbon Dioxide (CO2) Emission with Brake Power

I. Nitrogen Oxide (NO_X) 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. It hat fuel with higher aromatic content produces higher NO_X emission. The other reason may be a higher heat release rate due to longer ignition delay. If DBM is added, The NO_X emission slightly decreases in DBM5 blend but it is found higher compared to diesel fuel.

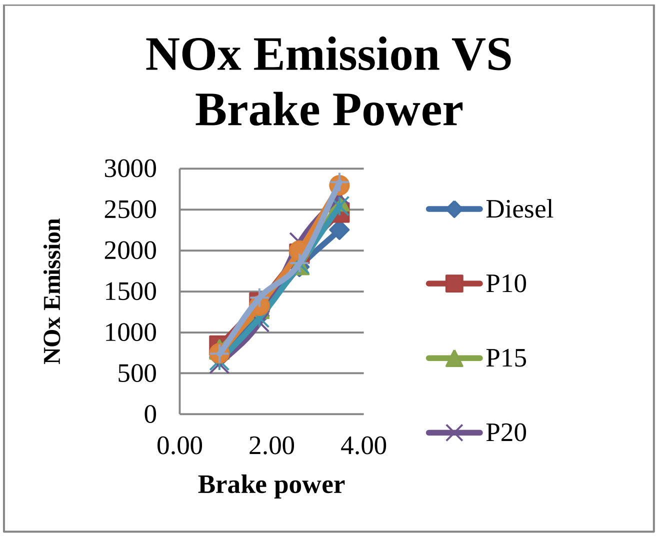

Fig. 10: Variation of Nitrogen oxide Emission with Brake Power

VI. CONCLUSIONS

– It is concluded that the fuel consumption of P15 blend found less compared to P10 and P15 blend.

- The brake thermal efficiency of P15 blend also found higher of P15 blend compared to other pyrolysis oil blend. If DBM is added than DP95 DBM5 blend found higher brake thermal efficiency compared to DBM10 and DBM15 blend.
- The CO and HC emission found higher in Diesel-pyrolysis oil blend compared to diesel.
- CO_2 and NOx emission also found higher in Diesel-pyrolysis oil blend compared to diesel.
- If 5% DBM is added to the Diesel-Pyrolysis oil blend, than CO,HC, CO_2 NOx emission slightly decrease in DP95 DBM5 compared to DP90 DBM10 and DP85 DB15
- It is concluded that pyrolysis oil can be used as an alternative fuel for the Diesel engine without any engine modification. If 5% DBM is added as an oxygenated additive, the performance of P15 blend slightly improves and emission also slightly reduced.

VII. Abbreviations And Acronyms

D	Diesel
P	Tyre pyrolysis oil
DBM	Dibutyl Maleate
P10	Blend of 10% Tyre pyrolysis oil and 90% Diesel
P15	Blend of 15% Tyre pyrolysis oil and 85% Diesel
P20	Blend of 20% Tyre pyrolysis oil and 80% Diesel
DP95 DBM5	5 % DBM blend with 95% Tyre pyrolysis oil-Diesel blend
DP90 DBM10	10 % DBM blend with 90% Tyre pyrolysis oil-Diesel blend
DP85 DBM15	15 % DBM blend with 85% Tyre pyrolysis oil-Diesel blend

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