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Investigation of engine performance and Emissions Characteristics of twin cylinder Diesel Engine Fueled with Tyre pyrolysis oil & Diesel Blends with multi functional diesel fuel Additive

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Abstract - In our country the automobile vehicles play major role in transports. In India the wide range of automobiles are increasing day by day. The price of fuels like Diesel, Petrol and Gas are increasing for the vehicle customers. And also the consumption of fuels would lead to serve shortage within coming future decades. India imports fuels like crude oils from the countries with huge quantity for the production of normal fuels. The details of the crude oil imported for India cost approximately Rs726, 386 crores per year. A sustainable energy and environment alternate energy is require to be increasing used instead of normal fuels (diesel, petrol, and gasoline).One of the alternate fuel is tyre pyrolysis oil, which extracted from the used automobile tyres. In this report the initial stage tests are conducted on twin cylinder water cooled diesel engine by using diesel and base line data is produced. Similarly in the second stage experimental process are carried out on twin cylinder water cooled diesel engine with same operating parameters by applying the tyre pyrolysis oil blended with diesel fuel additive. In this study the diesel engine was tested using diesel fuel additive (Total AC2010A) blended with biodiesel at certain mixing ratios of (TPO: DIESEL: DIESEL FUEL ADDITIVE) Such as TPDA10, TPDA20, TPDA30 to find out the performance parameters and emissions. By the finishing of this report, the successful of the project have been started which is kirloskar twin cylinder diesel engine is able to run with tyre pyrolysis oil (TPO) but initially the engine starts with diesel fuel the followed by tyre pyrolysis oil (TPO) and finished with diesel fuel as the last fuel usage before the engine turn off. Finally experimental results of blended fuel (tyre pyrolysis oil + diesel fuel additive) and diesel fuel are achieved better results.

Keywords: **Alternative fuel, Diesel Engine, Diesel fuel additive, Emissions, Tyre pyrolysis oil (TPO), Performance**.

I. INTRODUCTION

In society day by day the non–conventional energy sources are continuously expanding owing to the increasing demands in the use of petroleum products like petrol, diesel and gasoline. Indian government imports the fuels like crude oils from the foreign countries with huge quantity for the production of normal fuels. The details of the crude oil imported for India cost approximately Rs726, 386 corers per year. Hence in environmental current trends says that tyre pyrolysis oil is one of the alternate fuel for the automotive diesel engines. The tyre pyrolysis oil (TPO) is extracted from used tyres. In overall world there is increased in waste tyres, so we can use scrap tyres to produce tyre pyrolysis oil (TPO) and is used as alternate fuel with blending of diesel in diesel engines. It increases the efficiency of the diesel engine performance. The tyre pyrolysis oil (TPO) test is based on the characters of density, carbon residue, ash, viscosity, boiling point, sulphur content and water content. But direct biodiesel is also generating problem for the automotive diesel engines such as cold starting, clogging, slight increments in Nox emissions and high maintenance. Proper running of automotive diesel engines with biodiesel it needs the modification of engines. Now days the modification of engines requires high cost. In this case the engine modification not requires blending of diesel fuel additive in diesel.

Diesel fuel additive helps to improve the engine performance, better combustion, reduces the emissions like Nox, Hc & Co and reduce the knocking .one of the important thing about diesel fuel additive which clean the

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fuel injectors of diesel engines. It also helps the improvement of fuel economy and protection from the corrosion in the fuel tank. S.Murugan et al [1] carried out to evaluate the performance and emission characteristics of a single cylinder direct injection diesel engine fuelled by 10, 30 and 50 percent blends of Tyre pyrolysis oil (TPO) with diesel fuel (DF). Results showed that the brake thermal efficiency of the engine fuelled by TPO-DF blends increased with increase in blend concentration and higher than Diesel. NOx, HC, CO and Smoke emissions were found to be higher at higher loads due to high aromatic content and longer ignition delay. So many investigations have been reported in literature with a wide diversity of fuel improve the fuel economy, engine performance and to reduce exhaust emissions. In this report use of multifunctional diesel fuel additive TOTALAC 2010A on the properties of tyre pyrolysis oil, its blends and its influence on the engine performance and emissions at different loads in twin cylinder diesel engine.

II. PREPARATION OF TYRE PYROLYSIS OIL

In this study, an automobile tyre was cut into a number of pieces and the bead, steel wires and fabrics were removed. Thick rubber at the periphery of the tyre was alone made into small chips. The tyre chips (feed stock) were washed dried and were fed in a mild steel fixed bed reactor unit. The feed stock was externally heated up in the reactor in the absence of oxygen. The pyrolysis reactor designed for the experiment was a cylindrical chamber of inner diameter 110 mm and outer diameter 115 mm and height 300 mm and fully insulated. 2 kW of power was supplied to the reactor for external heating. The temperature of the reactor was controlled by a temperature controller. The process was carried out between 450°C and 650°C. The heating rate was maintained at 5o/min. The residence time of the feed stock in the reactor was 120 minutes. The products of pyrolysis in the form of vapour were sent to a water cooled condenser and the condensed liquid was collected as a fuel.

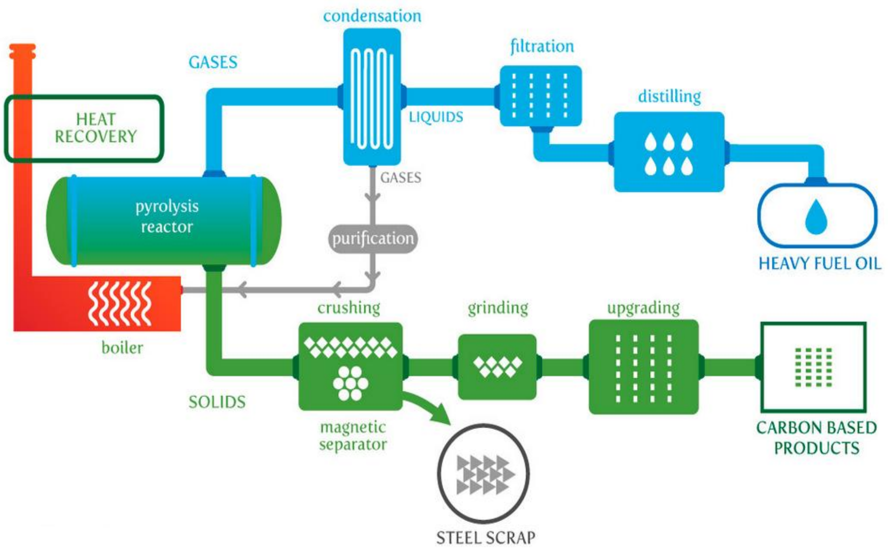

Fig. 1. Tyre pyrolysis oil preparation setup

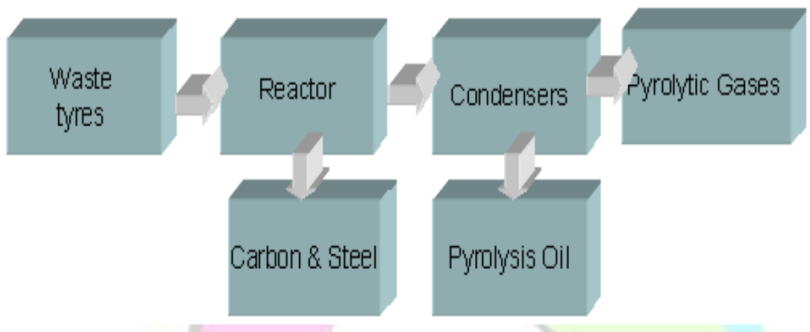

Fig. 2. Sequence of Tyre Pyrolysis oil

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The schematic diagram of the pyrolysis process of waste automobile tyres is given in Figure 1. Three products were obtained in the pyrolysis namely, Tyre Pyrolysis Oil, Pyro gas and Char. 1.9 kg of feed stock was used to produce one kg of Tyre pyrolysis Oil. The yield of the products in the pyrolysis process was: Tyre Pyrolysis Oil (55%), Pyro gas (10%), Char (34%) and moisture (1%) of the input. The heat energy required for the pyrolysis process per kg of TPO produced was around 6 MJ/kg.

Sr. No	Properties	Diesel	TPO (Tyre pyrolysis oil)
1	Density(kg/m^3)	820	920
2	Gross Calorific value (MJ/kg)	42.50	42.83
3	Kinematic viscosity@ 40C (cst)	3.05	3.2
4	Cetane Number	52	42
5	Cetane index	48	38
6	Flash point ºC	50	43
7	Fire point ºC	56	50
8	Carbon residue (%)	<0.35	0.11
9	Boiling point ºC	180-360	70 - 360
10	Specific gravity	0.84	0.91
11	Sulphur content (%)	<0.035	0.075
12	C%	86	84
13	Ash	Nil	Nil
14	H%	23	22
15	Water content	Nil	Nil

Table I: Physical and chemical properties of diesel fuel and tyre pyrolysis oil

Details of tyre pyrolysis oil and additive

Tyre pyrolysis oil is supplied by Aditya pyro energy Private Ltd, Hyderabad, India. The additive Ac2010a (Butylhydroxytoluene) was supplied by Neo Petcon India Private Limited, IDA, Balanagar, Hyderabad. Properties of Ac2010a fuel additive have given in Table II as collecting from J.kanna Kumar report (2014). The additive contains a new generation detergent superior to any previously available in the market. The detergent assures very high level of injector cleanliness which otherwise inevitably prone to fouling. Injector cleanliness assures excellent fuel atomization, which is absolutely.

Flash point	1270 F (52.70 C) Open cup
Density	1.048 g/cm3,solid
Viscosity Molecular formula	4.60 cSt at 20°C C15H24O

Table II: Properties of fuel additive refer from J.kanna Kumar report

III. EXPERIMENTAL SETUP

A twin cylinder 4stroke water cooled diesel engine developing about 7.5KW at 1500 rpm was used for the examination purposes. The specification of the engine is mentioned in Table III. Several kinds of fuel blends were prepared for the different purpose of engine test. For the testing, the calorific value of diesel is assumed to be 42.50 MJ/kg and the calorific value for tyre pyrolysis oil is taken to be 42.83 MJ/kg. The specific gravity for diesel and tyre pyrolysis oil is 0.82 and 0.92 respectively.

Calculated values for Lower Calorific Value are mentioned in Table I. The fuel flow rate was measured on volumetric basis using a burette and a stopwatch. For measurement of exhaust emissions (NO, HC, CO, CO2) through exhaust gas analyzer and the smoke opacity was determined using Diesel tune smoke meter. All the tests were conducted by starting the engine with diesel only. After the engine was warmed up, it was then

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switched to Tyre pyrolysis blend. At the end of the test, the engine was run for some time with diesel to flush out the tyre pyrolysis from the fuel line and the injection system

Fig. 3. Twin cylinder diesel engine

Engine Make	Kirloskar
Engine Type	Four stroke Twin cylinder diesel engine
No. of cylinders	2
Stroke	110mm
Bore	87.5mm
Method of cooling	Water cooled
Horse power HP	10HP
Type of starting	Crank start
Lubrication	Forced
Compression ratio	17.5:1
Rated speed RPM Max	1800
Air tank type	Square
Orifice diameter	20mm
Load type	Electric load bank
Cubic capacity	0.661 Liters
Digital temperature indicator	0-999 Degree
Digital RPM indicator	0-9999 RPM

Table III: Twin cylinder diesel engine specification

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IV. RESULTS AND DISCUSSION

The performance and exhaust emission characteristics of a high speed twin cylinder diesel engine at various loads from no load to full load fueled with tyre pyrolysis oil and its diesel blends with diesel fuel additive Total AC 2010A are discussed below as per the results obtained.

A. Performance characteristics

1. INDICATED POWER

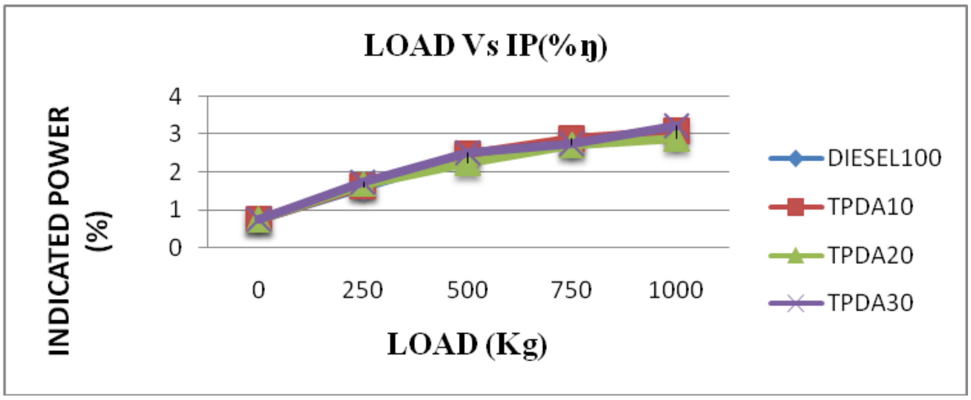

Fig 4: VARIATION OF INDICATED POWER (%) Vs. LOAD (kg)

The variation of indicated power with load is shown in fig 4. At full load condition the indicated power obtained are 2.96Kw, 3.09Kw, 2.89Kw and 3.23Kw for fuels of diesel, TPDA10, TPDA 20 &TPDA30 respectively. The indicated power of tyre oil blend TPDA20 decreased when compared to the diesel at full load condition.

2. SPECIFIC FUEL CONSUMPTION

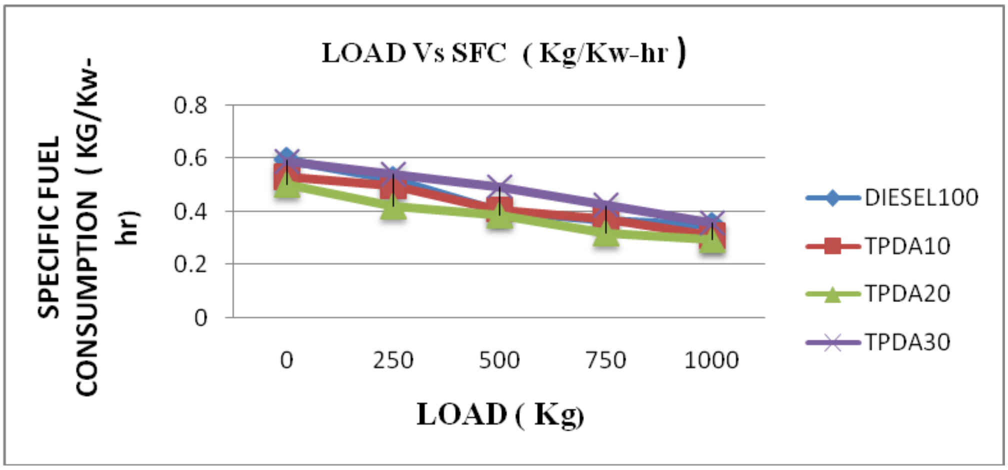

Fig. 5. VARIATION OF SFC ('kg/kw-hr') Vs. LOAD (kg)

The variation of specific fuel consumption with load is shown in fig 5.the plot it is reveals that as the load increases the fuel consumption decreases. At full load condition the SFC obtained are and 0.348kg/kw-hr, 0.310kg/kw-hr, 0.292kg/kw-hr and 0.356kg/kw-hr for fuels of diesel, TPDA10, TPDA20 &TPDA30 respectively. The SFC of tyre pyrolysis oil blend TPDA20 decreased when compared to the diesel at full load condition.

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3. MECHANICAL EFFICIENCY

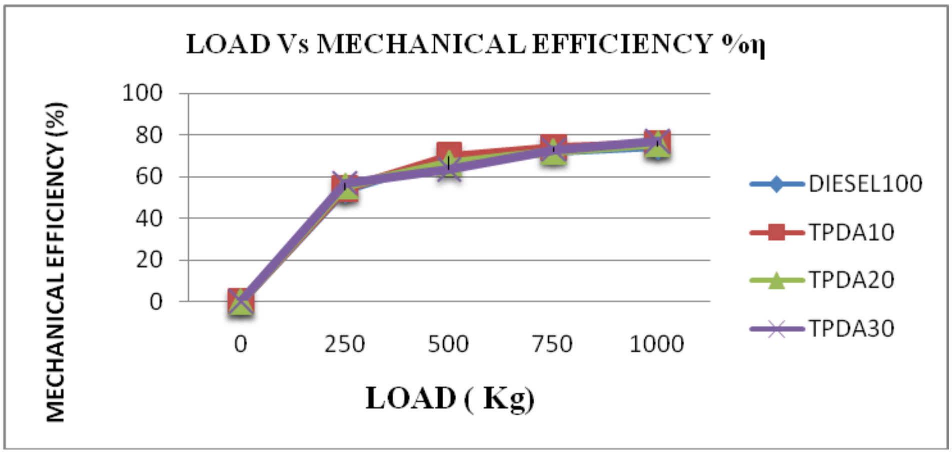

Fig 6: VARIATION OF MECHANICAL EFFICIENCY (%) Vs. LOAD (kg)

The variation of mechanical efficiency with brake power is shown in Fig 6. From the plot it is observed as load increases mechanical efficiency is also increases because of tyre oil is lowest frictional powers compared to diesel. At full load condition the mechanical efficiencies obtained are 74.66%, 75.72%, 75.89% and 76.92% for the fuels: diesel, TPDA10, TPDA20 and TPDA30 respectively. Among the three blends of tyre oil the maximum mechanical efficiency is 76.92% which is obtained for TPDA30. Hence this blend was selected as optimum blend for future investigations.

4. BRAKE THERMAL EFFICIENCY

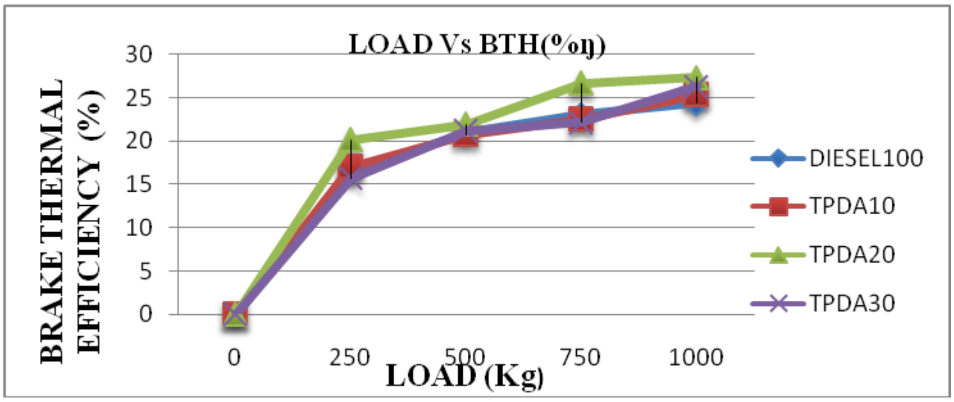

Fig 7: VARIATION OF BRAKE THERMAL EFFICIENCY (%) Vs. LOAD (kg)

The variation of brake thermal efficiency with load is shown in Fig 7. From the plot it is observed that as load increases brake thermal efficiency is also increases for diesel as well as the blends of tyre oil. At full load condition, the brake thermal efficiencies are obtained 24.34%, 25.34, 27.32%, and 26.28% for the fuels diesel, TPDA10, TPDA20 and TPDA30 respectively. Among the three blends of tyre oil the maximum BTE is 27.32% which is obtained for TPDA20. The increment in brake thermal efficiency is due to the better combustion because of high calorific value and less viscosity of the tyre oil.

B. Emissions characteristics

1. CARBON MONOXIDE (CO)

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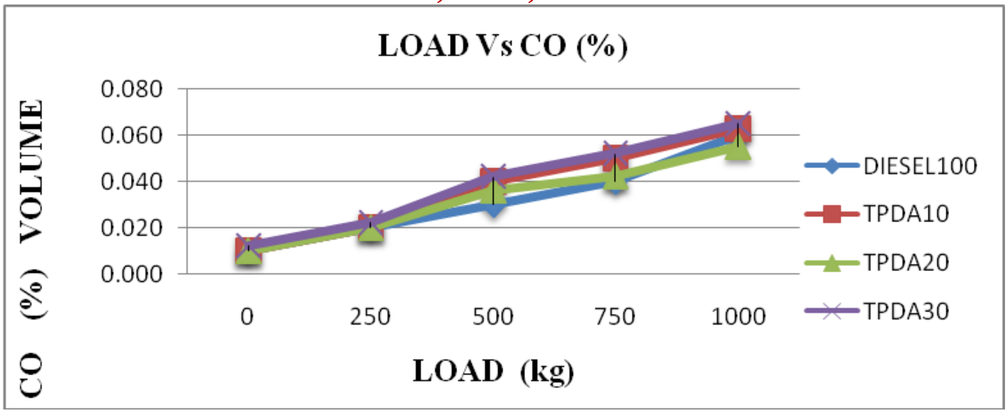

Fig. 8. VARIATION OF CARBON MONOXIDE (%) Vs. LOAD (kg)

The variation of CO emission with load is shown fig 8. The plot it is reveals that as the load increases the CO emission decreases. At full load condition the Co emissions obtained are 0.060%, 0.063, 0.055, and 0.065 for fuels of diesel, TPDA10, TPDA20 and TPDA30 respectively. The Co emission of tyre oil blend TPDA20 decreased when compared to the other diesel at full load condition

2. UNBURNED HYDROCARBON (HC)

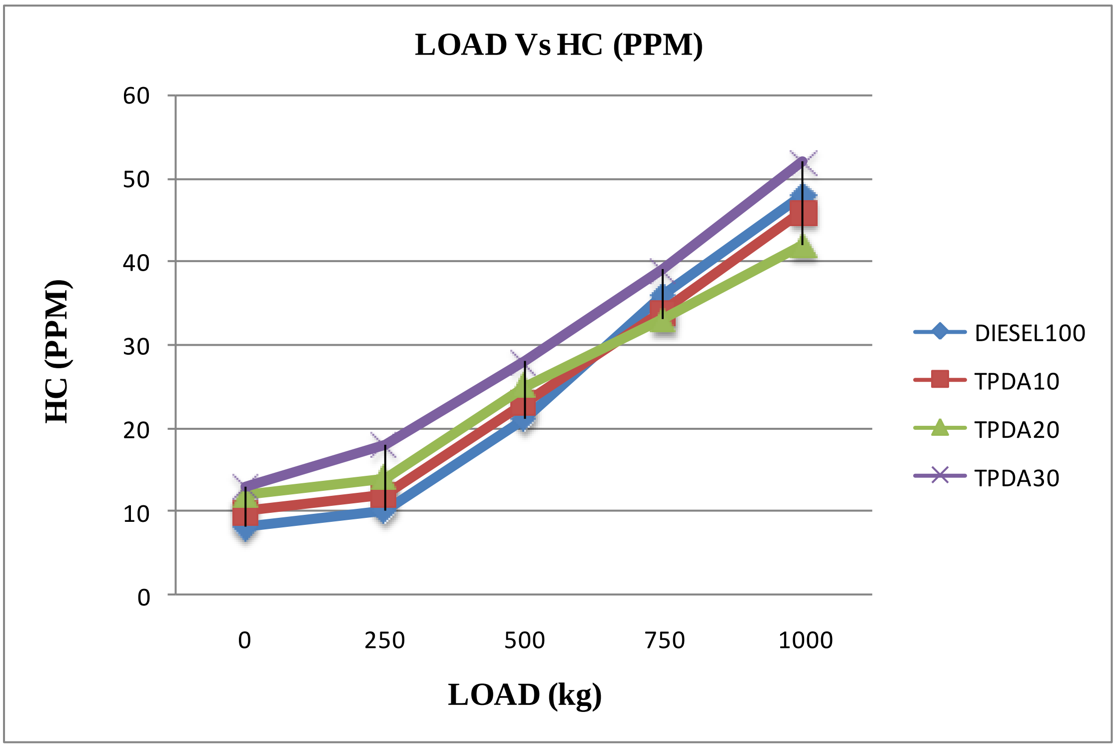

Fig. 9. VARIATION OF UNBURNED HYDROCARBON (%) Vs. LOAD (kg)

The variation of HC emission with load is shown in fig 9. The plot it is reveals that as the load increases the HC emission decreases. At full load condition the Co emissions obtained are 48PPM, 46PPM, 42PPM, and 52PPM for fuels of diesel, TPDA10, TPDA20 and TPDA30 respectively. The Co emission of tyre oil blend TPDA20 decreased when compared to the other diesel at full load condition.

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3. CARBON DIOXIDE (CO_2)

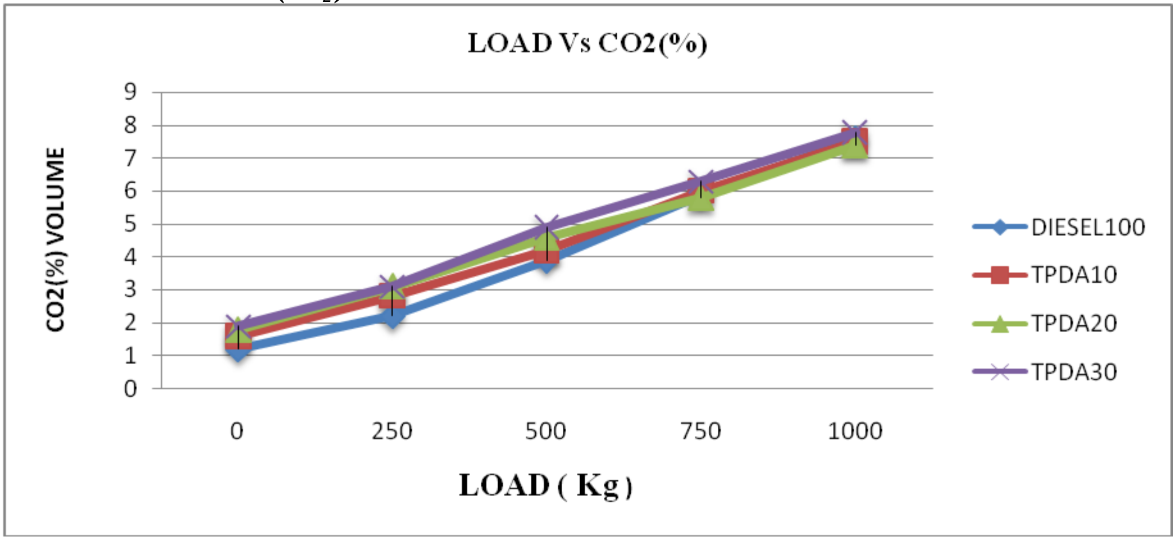

Fig. 10. VARIATION OF CARBON DIOXIDE (%) Vs LOAD (kg)Co_2 Emission (CO_2)

The variation of CO_2emission with load is shown in fig 10. The plot it is reveals that as the load increases the CO_2 emission decreases. At full load condition the CO_2 emissions obtained are 7.6%, 7.5%, 7.4, and 7.8 for fuels of diesel, TPDA10, TPDA20 and TPDA30 respectively. The CO_2 emission of tyre oil blend TPDA20 decreased when compared to the other diesel at full load condition.

4. OXIDES OF NITROGEN (Nox)

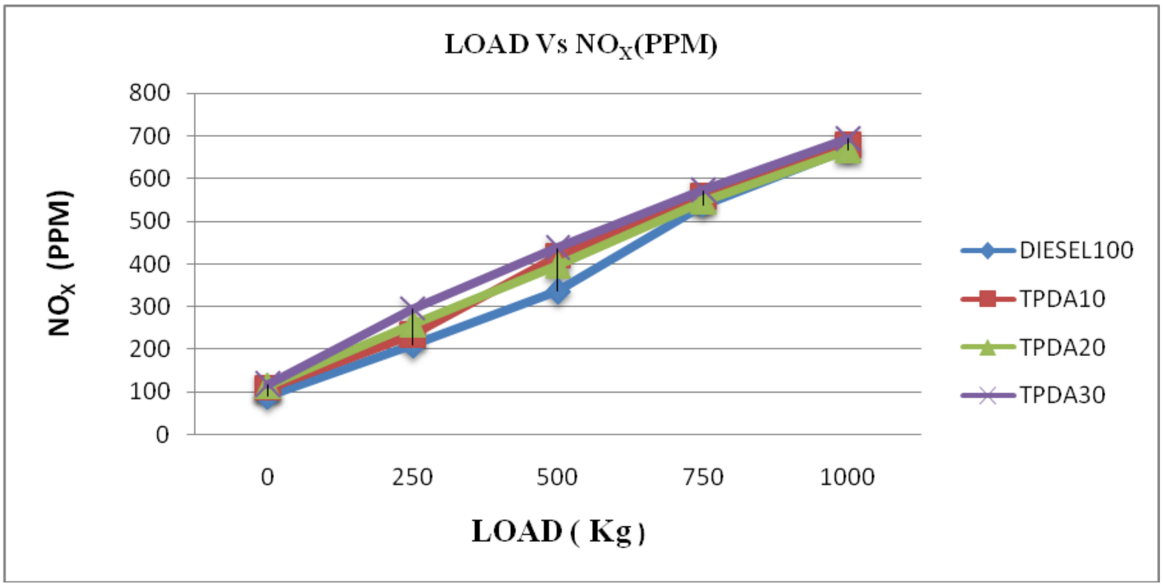

Fig. 11. VARIATION OF OXIDES OF NITROGEN (%) VsLOAD (kg)

The variation of NO_X emission with load is shown fig 11. The plot it is reveals that as the load increases the NO_X emission decreases. At full load condition the NO_X emissions obtained are 670PPM, 680PPM, 668PPM, and 693PPM for fuels of diesel, TPDA10, TPDA20 and TPDA30 respectively. The NO_X emission of tyre oil blend TPDA20 decreased when compared to the other diesel at full load condition.

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V. CONCLUSION

The conclusions derived from present experimental investigations to evaluate performance and emission characteristics on twin cylinder diesel engine fueled with diesel TPO blends and diesel fuel additives are summarized as follows.

1. Brake thermal efficiency increased with all blends when compared to the conventional diesel fuel.
2. The Brake specific fuel consumption is decreased with the blends when compared to diesel.
3. CO, CO2 and HC emissions are decreased significantly with the blends when compared with diesel.
4. From the above analysis the blend TPDA20 shows the better performance compared to other blends TPDA10, TPDA30 and diesel.
5. Mechanical efficiency increased with all blends when compared to the conventional diesel fuel.
6. In future we do the distillation process for tyre pyrolysis oil we can achieve the better results compare to these results.

VI. NOMENCLATURE

B.P Brake Power
I.P Indicated Power
SFC Specific Fuel Consumption
Mechanical Efficiency
Volumetric Efficiency
BTE Brake Thermal Efficiency
CO Carbon Monoxide
HC Unburned Hydro Carbons
NOx Oxides of Nitrogen
Ppm parts per million
D100 DIESEL
TPDA 10 TYRE PYROLYSIS OIL 10% DIESEL 89%, ADDITIVE 1%
TPDA 20 TYRE PYROLYSIS OIL 20%DIESEL 79%, ADDITIVE 1%
TPDA 30 TYRE PYROLYSIS OIL 30%, DIESEL 69% ADDITIVE 1%
A= Total AC 2010a diesel fuel additive
TPO Tyre Pyrolysis Oil

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