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Performance and Emissions Characteristics of twin cylinder Diesel Engine Fueled with Waste Plastic Oil & Diesel Blends with multi functional diesel fuel Additive

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Abstract: *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 waste plastic oil, which extracted from the waste plastic materials. 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 waste plastic pyrolysis oil blended with diesel and 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 (WPO: DIESEL: DIESEL FUEL ADDITIVE) Such as WPODA10, WPODA20, WPODA30 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 waste plastic pyrolysis oil (WPO) but initially the engine starts with diesel fuel the followed by waste plastic pyrolysis oil (WPO) and finished with diesel fuel as the last fuel usage before the engine turn off. Finally experimental results of blended fuel (waste plastic pyrolysis oil + diesel fuel additive) and diesel fuel are achieved better results.*

Keywords: *Alternative fuel, Diesel, Diesel fuel additive, Emission, Performance, Waste plastic pyrolysis oil (WPO).*

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. Biodiesel is one of the efficient alternate fuel for automotive diesel engines.Hower as the biodiesel is produced from the different vegetable oils and animal fats, there are concern that biodiesel feed stock may compete with food supply in the long term. Hence in environmental current trends says that waste plastic pyrolysis oil is one of the alternate fuel for the automotive diesel engines. The waste plastic oil (WPO) is extracted from the waste plastic materials. It increases the efficiency of the diesel engine performance. The waste plastic oil (WPO) 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 fuel injectors of diesel engines.

II. Preparation Of Waste Plastic Pyrolysis Oil

Waste plastic oil is prepared by the pyrolysis process. Pyrolysis technology is thermal degradation process in the absence of oxygen. Plastic waste is treated in a cylindrical reactor at temperature of 300ºC – 350ºC. The plastic waste is gently cracked by adding catalyst and the gases are condensed in a series of condensers to give a low sulphur content distillate. All this happens continuously to convert the waste plastics into fuel that can be used for generators. The catalyst used in this system will prevent formation of all the dioxins and Furans (Benzene ring). All the gases from this process are treated before it is let out in atmosphere. The flue gas is treated through scrubbers and water/ chemical treatment for neutralization. The non-condensable gas goes through water before it is used for burning. Since the Plastics waste is processed about 300ºC - 350ºC and there is no oxygen in the processing reactor, most of the toxins are burnt. Biodiesel is totally non-toxic, and it does not need any special precautions in storage and handling. The same conditions, which are used for petroleum diesel, are sufficient.

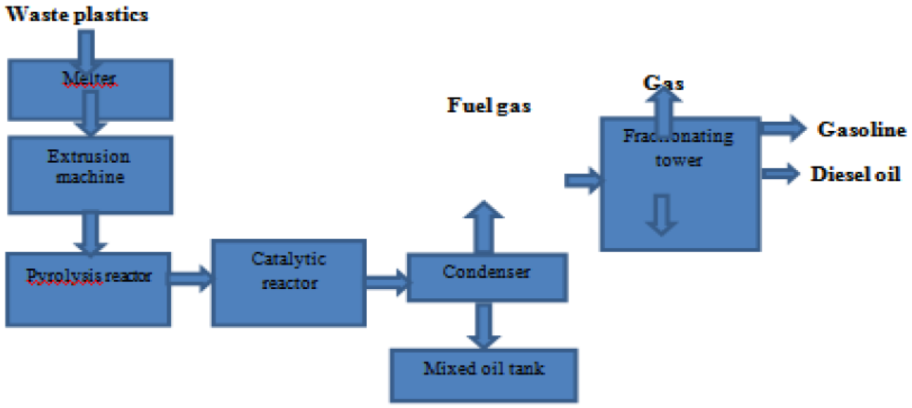

Figure: 1 Process flow of waste plastic pyrolysis oil

Properties of waste plastic oil, and diesel

The properties of various fuels were found in laboratory. Different properties are shown in Table 1.

Sl. No	Properties	WPO	Diesel
1	Density(kg/m2)	820	920
2	Calorific value (MJ/kg)	41.80	42.50
3	Kinematic viscosity@40C (cst)	2.149	3.05
4	Cetane number	51	52
5	Flash point°C	40	50
6	Fire point°C	45	56
7	Specify gravity	0.79	0.82
8	Sulphur content (%)	<0.002	<0.035

Table 1: Properties of WPO and Diesel

Details of Waste plastic pyrolysis oil and additive

Waste plastic oil is supplied by Nac industries Pvt Ltd, Tamil Nadu, 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 2: Properties of diesel 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 II. 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 waste plastic pyrolysis oil is taken to be 41.80 MJ/kg. The specific gravity for diesel and waste plastic pyrolysis oil is 0.82 and 0.79 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 analyser and the smoke opacity was determined using Diesel tune smoke meter.

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 3: Twin cylinder diesel engine specification.

Figure 2: Twin cylinder diesel engine

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 waste plastic pyrolysis oil and its diesel blends with diesel fuel additive Total AC 2010A are discussed below as per the results obtained.

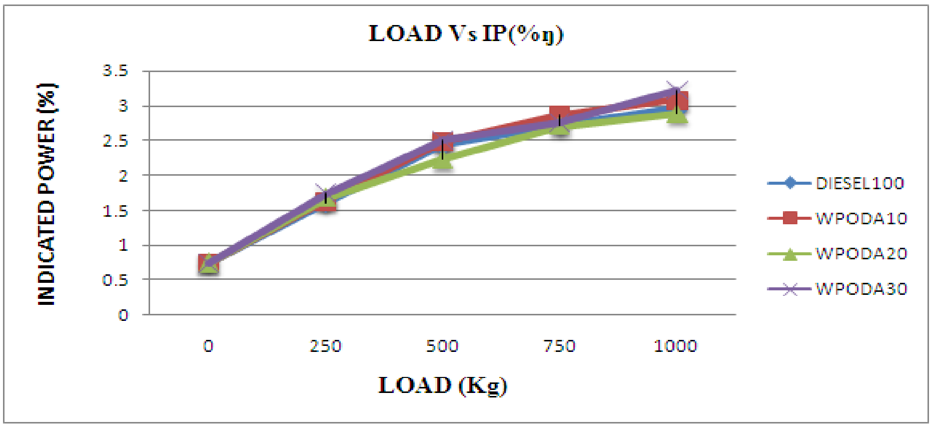

Figure 4: Variation Of Indicated Power (%) VsLOAD (kg)

Indicated Power

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, WPODA10, WPOPDA 20 &WPODA30 respectively. The indicated power of waste plastic pyrolysis oil blend WPODA20 decreased when compared to the diesel at full load condition.

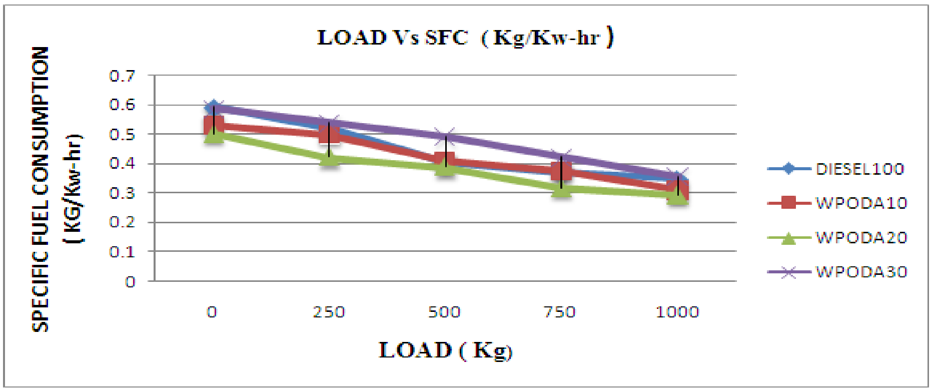

Figure 5: Variation Of SFC ('kg/kw-hr') VS LOAD (kg)

Specific Fuel Consumption

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, WPODA10, WPOPDA 20 &WPODA30 respectively. The SFC of waste plastic pyrolysis oil blend WPODA20 decreased when compared to the diesel at full load condition.

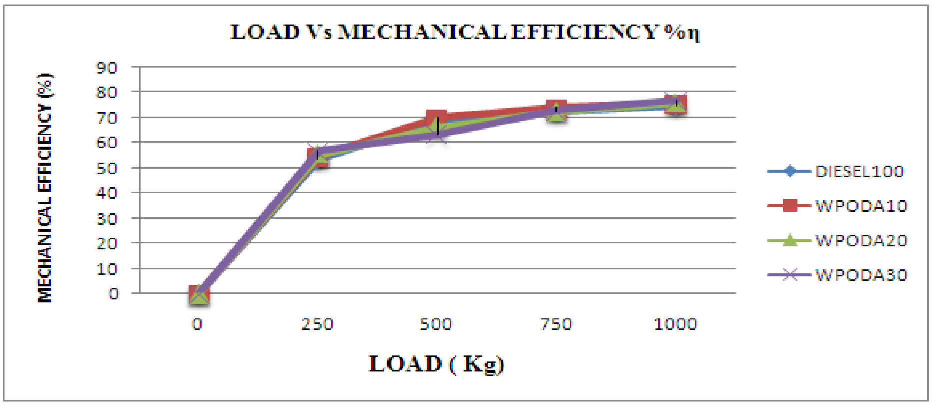

Figure 6: Variation Of Mechanical Efficiency (%) VsLOAD (kg)

Mechanical Efficiency

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 waste plastic pyrolysis 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, WPODA10, WPOPDA 20 and WPODA30 respectively. Among the three blends of waste plastic pyrolysis oil the maximum mechanical efficiency is 76.92% which is obtained for WPODA30. Hence this blend was selected as optimum blend for future investigations

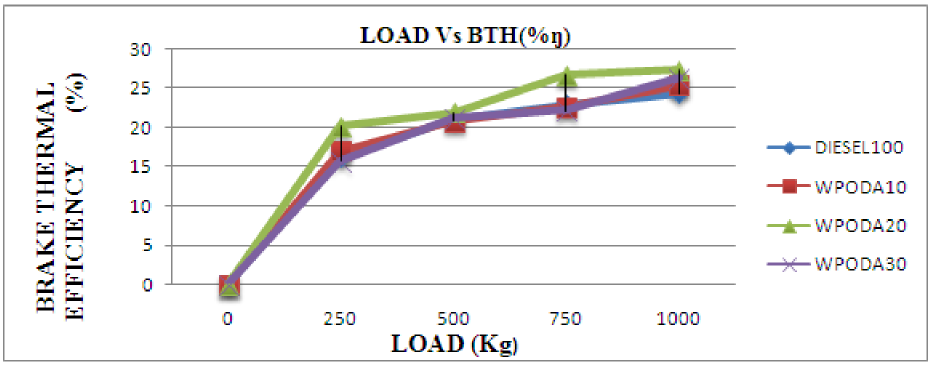

Figure 7: Variation Of Brake Thermal Efficiency (%) VsLOAD (kg)

Brake Thermal Efficiency

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 waste plastic pyrolysis oil. At full load condition, the brake thermal efficiencies are obtained 24.34%, 25.34, 27.32%, and 26.28% for the fuels diesel, WPODA10, WPOPDA 20 and WPODA30 respectively. Among the three blends of waste plastic pyrolysis oil the maximum BTE is 27.32% which is obtained for WPODA20. The increment in brake thermal efficiency is due to the better combustion because of high calorific value and less viscosity of the waste plastic oil.

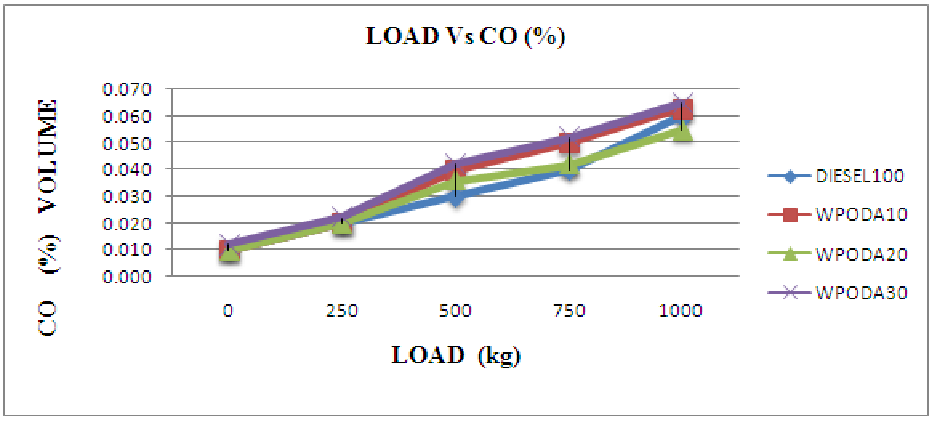

Figure 8: Variation Of Co (%) VsLOAD (kg)

Carbon Monoxide (Co):

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, WPODA10, WPOPDA 20 and WPODA30 respectively. The Co emission of waste plastic oil blend WPODA20 decreased when compared to the other diesel at full load condition

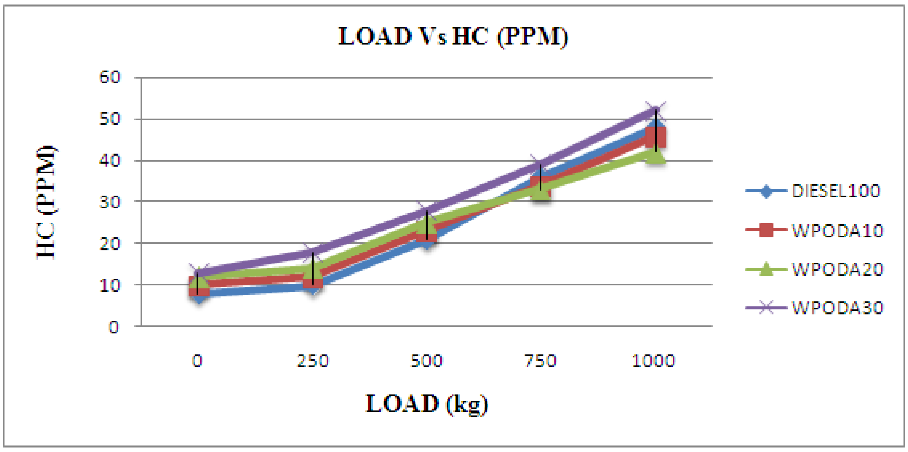

Figure 9: Variation Of Hc (%) VsLOAD (kg)

Unburned Hydrocarbon (HC):

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, WPODA10, WPOPDA 20 &WPODA30 respectively. The Co emission of waste plastic pyrolysis oil blend WPODA20 decreased when compared to the other diesel at full load condition.

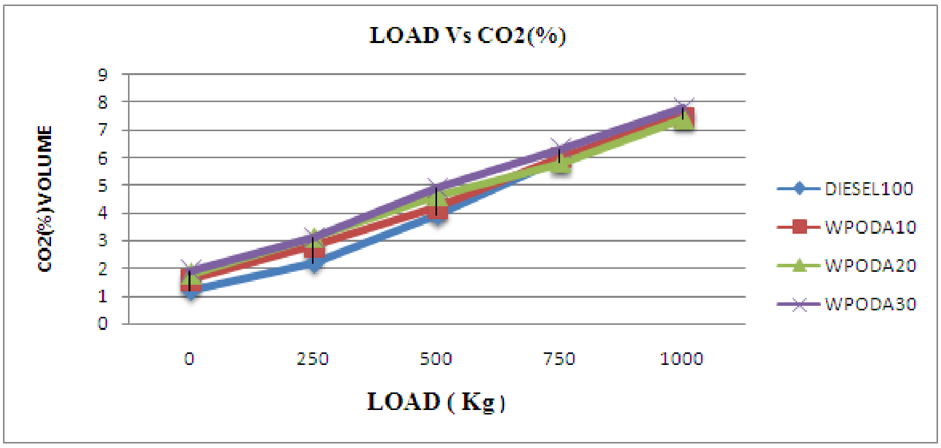

Figure 10: Variation Of CO_2 (%) VsLOAD (kg)

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, WPODA10, WPOPDA 20 and WPODA30 respectively. The CO_2 emission of waste plastic oil blend WPODA20 decreased when compared to the other diesel at full load condition.

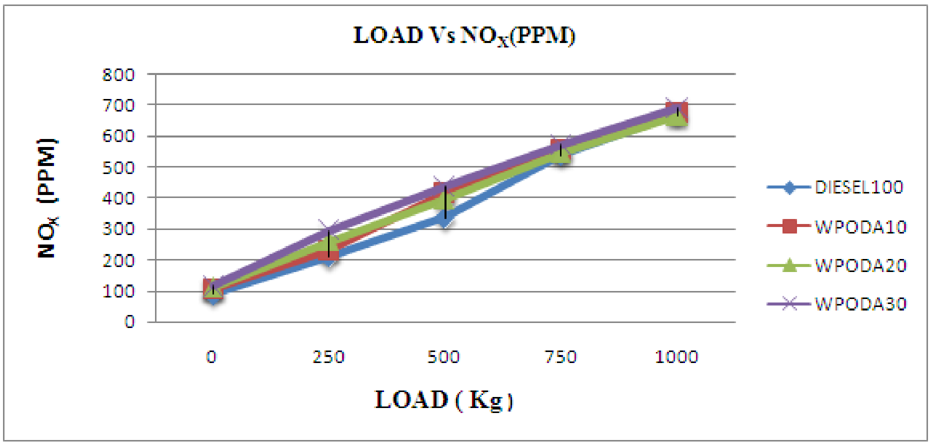

Figure 11: Variation Of NO_X (%) VsLOAD (kg)

Oxides Of Nitrogen (NOx):

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, WPODA10, WPOPDA 20 and WPODA30 respectively. The NO_X emission of waste plastic oil blend WPODA20 decreased when compared to the other diesel at full load condition.

V. Conclusions

The conclusions derived from present experimental investigations to evaluate performance and emission characteristics on twin cylinder diesel engine fueled with diesel WPO 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,CO_2 and HC emissions are decreased significantly with the blends when compared with diesel.
4. From the above analysis the blend WPODA20 shows the better performance compared to other blends WPODA10, WPODA30 and diesel
5. Mechanical efficiency increased with all blends when compared to the conventional diesel fuel.

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
WPODA 10 WASTE PLASTIC PYROLYSIS OIL 10% DIESEL 89%, ADDITIVE 1%
WPODA 20 WASTE PLASTIC PYROLYSIS OIL 20%DIESEL 79%, ADDITIVE 1%
WPODA 30 WASTE PLASTIC PYROLYSIS OIL 30%, DIESEL 69% ADDITIVE 1%
A= Total AC 2010a diesel fuel additive
WPO Waste Plastic Pyrolysis Oil

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Author Profile

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