Experimental Study on Performance of Four Stroke Diesel Engine Using Waste Plastic Bio-Diesel Blends

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Abstract— A comprehensive study on the waste plastic oil as an alternative fuel has been carried out. This report deals with the exhaust emission of waste plastic fuel on four stroke diesel engine. The objectives of this report are to analyze the fuel consumption and the emission characteristic of a diesel engine that are using waste plastic oil compared to usage of ordinary diesel that are available in the market. This report describes the setups and the procedures for the experiment which is to analyze the emission characteristics and fuel consumption of diesel engine due to usage of the both fuels. Detail studies about the experimental setup and components have been done before the experiment started. Data that are required for the analysis is observed from the experiments. Calculations and analysis have been done after all the required data needed for the thesis is obtained. The experiment conducted on four stroke diesel engine was adopted to study the brake thermal efficiency, brake specific energy consumption, mechanical efficiency, brake power, volumetric efficiency, indicated thermal efficiency and emissions at full load with the fuel in bio-diesel.

Key words: Bio-Diesel Blends, Four Stroke Diesel Engine

I. Introduction

The present study analyzes the differences in emissions of four different biodiesel blends of three diverse feed stocks. The objective of this research is to find an immediate alternative energy solution, which does not involve a drastic overhaul of the world's engine structure. Obtaining a viable solution is one which can reduce the global green house emissions over the petroleum diesel counterpart, while maintaining a similar output in performance, and efficiency. It should also be noted that this study will look at how these bio-fuels compare in cost to petroleum diesel, and what benefits are provided by recycling used Waste Plastic Oil.

Most of the energy needs of India come from coal, which is 44% of total energy consumption. Resources such as petroleum and biomass contribute 22 percent each, while natural gas at 7%, hydro-electricity at 3%, while nuclear and other renewable contribute just 1% each (U.S. Energy Information Administration). The industry and transport sectors are the largest users of energy and use half of the total energy consumed. The main fuels contributing to this end-use demand growth are coal (in industry), petroleum (in transport), and electricity (in buildings, industry, and agriculture).Use of petroleum will continue to expand on growth in transport sector, particularly road transport. Currently, alone diesel meets an estimated 46 % of transportation fuel demand and gasoline at 24 percent. Further, it is estimated that in next ten years, by the average demand for transport fuels will rise from an estimated 134 billion liters in CY 2015 to 225 billion liters in CY 2026.

II. Material preparation

The technologies for WP recycling are grouped into three main categories: (1) material recycling, (2) chemical recycling, and (3) thermal recycling (or energy recovery). The primary and secondary recycling described above are considered material recycling; tertiary and quaternary recycling have the same meanings as chemical recycling and thermal recycling, respectively. Therefore, pyrolysis of plastics is considered tertiary recycling, which transforms the plastic polymers into their basic monomers or hydrocarbon. The pyrolysis by direct heating was adopted to produce the paraffin and crude oil from the plastic wastes in the 1990s. The pyrolysis process involves the breakdown of large molecules to smaller molecules. Produces hydrocarbons with small molecular mass (e.g. ethane) that can be separated by fractional distillation and used as fuels and chemicals. This process gives on weight basis 75% of liquid hydrocarbon, which is a mixture of petrol, diesel and kerosene, 5 to 10% residual coke and the rest is LPG.

The small-scaled process is featured by facilitation, convenience and low equipment investment. The system consists of feed-supply, pyrolysis reactor, fractionating tower, heating and temperature controller and device for filling the plastics into the pyrolysis reactor. The capacity of this pilot plant is 1000 tones/annum. However, the temperature caused by pyrolysis is higher and all the reactive time is longer than the other methods else. The octane number of gasoline gained is relatively low and the pour point of diesel oil is high. More paraffin is produced in the process of pyrolysis. Although this process is simple and convenient, the converting rate and yield is still lower.

#	Properties	WPO	Diesel
1	Density	0.8355	0.840
2	Ash content %	0.00023	0.045
3	Gross calorific value(kJ/jg)	44,340	46,500
4	Kinematic viscosity.	2.52	2.0
5	Cetane number	51	55
6	Flash point	42	50
7	Fire point	45	56
8	Carbone residues %	82.49	26
9	Sulphur content %	0.030	0.045
10	Distillation temperature *C at 58%	344	328
11	Distillation temperature *C at 95%	362	340

Table 1: Property of Blends

#	Properties	PO10	PO20	PO30
1	Density	0.83955	0.8391	0.83865
2	Calorific Value	44484.08	44468.14	44452.18

Table 2: Properties of WPO and Diesel Fuel

III. EXPERIMENTAL SETUP

Experiments were initially carried out on the engine using diesel as fuel in order to provide base line data. The various blends of waste plastic oil were prepared and made to run on the engine. The blends were prepared on the proportions of (D: WPO) -80:20, 60:40 and 40:60 with a fraction of methanol (5%, 10%, 15%) added to the biodiesel on volume basis. Finally waste plastic oil (WPO) was directly used to run the engine. The engine was started using neat diesel and allowed to run for at least 30 minutes before taking observations. After engine conditions stabilized and reached to steady state, the base line data were taken. Load was varied using the alternator load bank and the same was recorded. Gaseous emissions, fuel consumption were also recorded from the respective sensor. In case of different methanol and biodiesel blends, the engine was started on diesel and when engine became sufficiently heated; the supply of diesel was substituted by different methanol and biodiesel blends for which a two way valve was used. All the data at different loads and blends were recorded only when engine reached to steady state.

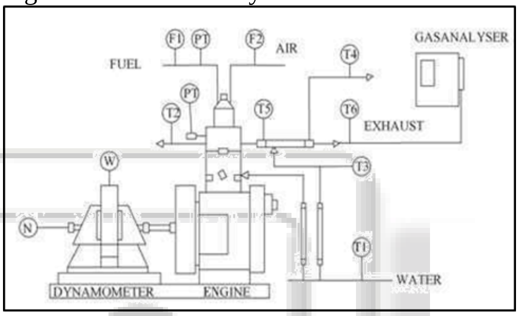

Fig. 1: Schematic diagram of experimental setup

Schematic diagram of experimental setup is shown in figure 4. The experimental setup comprises of single cylinder, four stroke, Multi-fuel, research engine. This engine is connected to eddy-current type dynamometer for loading. The mode of operation in this engine can be changed from diesel to Petrol or from Petrol to Diesel as required with some needed changes. In both operation modes the compression ratio can be changed without stopping the engine and no other changes needed for the geometry of combustion chamber by specially designed tilting cylinder block arrangement. Different other instruments are provided to interface are airflow meter, fuel flow meter, temperatures and load measurement devices. For cooling water and calorimeter water flow measurement Rota meter is provided. For auto start of engine a battery, starter and battery charger is provided. Analysis software Engine-soft is provided for on line performance evaluation and lab view based Engine Performance. For oxygen enrichment, the oxygen cylinder is connected to the engine inlet manifold. The test engine used in this experiment is as shown in figure 2.

Fig. 2: Experimental setup of C I engine

The specifications of the single cylinder four stroke C I engine used in this experiment is as shown in table 3.

Engine manufacturer	Apex Innovations (Research Engine test set up)
Software	Engine soft Engine performance analysis software
Engine type	Single cylinder four stroke multi fuel research engine
No. of cylinder	1
Type of cooling	Water cooled
Rated power	3.5 kW @ 1500 rpm
Cylinder diameter	87.5 mm
Orifice diameter	20 mm
Stroke length	110 mm
Connecting rod length	234 mm
Dynamometer	Type: eddy current, water cooled, with loading unit

Table 3: Engine setup specifications

Also, the level of pollutants in the exhaust of the diesel engine is being measured with the help of Exhaust gas analyzer. The Exhaust gas analyzer used is as shown in figure 3. Its measure proportion of exhaust from diesel engine in ppm. Exhaust gas analyzer is used in various governments authorized test centers. Here, we used a five gas analyzer for measuring of CO, CO_2, NO_X, and HC Emissions.

Fig. 3: Exhaust gas analyzer

IV. PERFORMANCE ANALYSIS

This section consists of comparison of performance parameters for diesel and WPO. Performance parameters which are comparing are specific fuel consumption (SFC), break thermal efficiency (BTHE) and fuel consumption.

A. Load Vs specific fuel consumption (SFC)

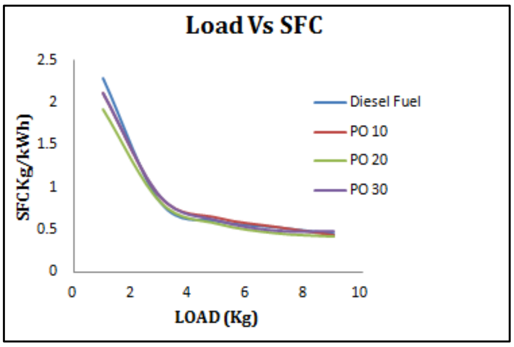

Fig. 4: Load Vs SFC

It is being concluded that the SFC of all blends are slightly lower as compared to Diesel fuel at all varying load. But for PO 20 blends there are much lower as compared to Diesel fuel as shown in above figure. So PO20 D80 is the best blend for the Diesel fuel for minimum fuel consumption.

B. Load Vs BTHE

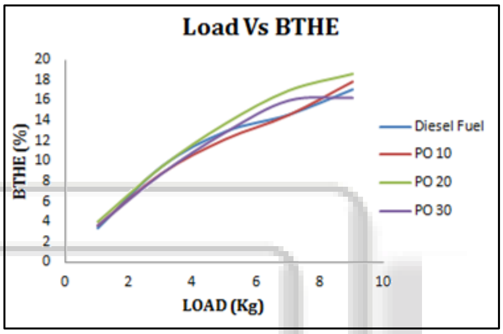

Fig. 5: Load Vs BTHE

It is being concluded that the BTHE for all blends are more than Diesel fuel. And also there are for PO20 D80 blend the BTHE is higher than all blends. So there are concluded that the PO20 D80 is the best waste plastic biodiesel blend that can be used for Diesel engine.

V. EMISSION ANALYSIS

A. Load Vs NOx

It is concluded that the NO_x emission are produced on different load with different biodiesel blends. It can be see that the NO_x emission for diesel fuel are increase with increasing the load and for the PO30 blend there are the produced lowest NO_x emission with increase the load.

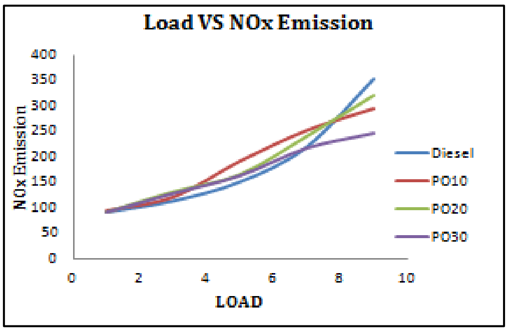

Fig. 6: Load Vs NOx

B. Load Vs HC emission

There are see the HC emission with different varying load for different biodiesel blend. And from this it is concluded that the HC emission are decrease with increase biodiesel blend with diesel fuel. And there are the best blend concluded is PO30. But there are in diesel fuel the lowest HC emission is produced. There is also the HC emission increase with blend ration increase from 10% to 30%.

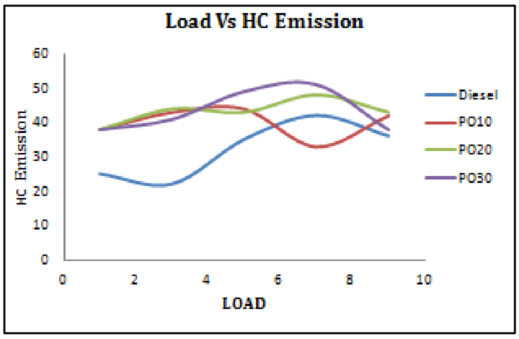

Fig. 7: Load Vs HC

C. Load Vs CO_2 Emission

It is being seen that the CO_2 emission with different varying load for different varying load are indicated. From that it is concluded that for the increase with the bending ratio there are decrease the CO_2 emission. And also see the result there is for PO30 blend to produced minimum CO_2 emission.

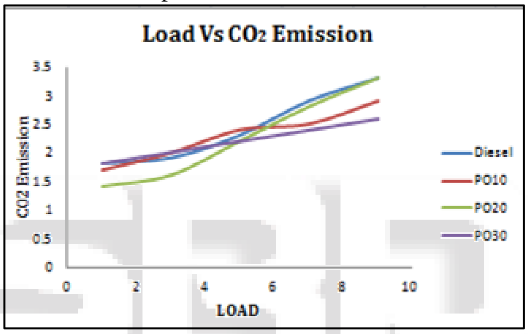

Fig. 8: Load Vs CO_2

D. Load Vs CO Emission

It can be see that the CO emission with all varying load for different blends are so different. And also there are easily seen that the lowest CO emission are produced in PO30 biodiesel blend. So on basis of the above graph it can be concluded that the best biodiesel blend are PO30 for the less CO emission.

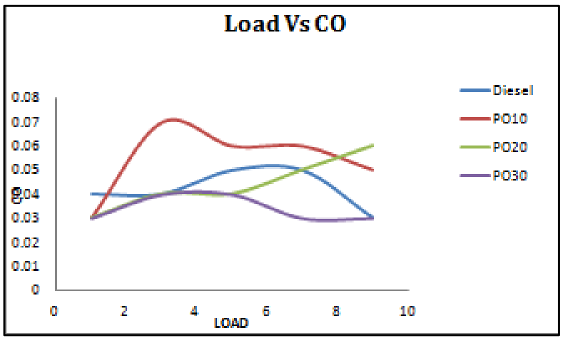

Fig. 9: Load Vs CO

VI. CONCLUSION

Based on the performance and emissions of waste plastic oil, it is concluded that the waste plastic oil represents a good alternative fuel with closer performance and better emission characteristics to that of a diesel. From the above analysis the blend WPO 20 shows better performance compared to the blends (D100, WPO10 and WPO30) in the sense of better performance characteristics like Brake thermal efficiency, Specific fuel consumption and decrease in the emission parameters like NOx, CO, HC. Hence the blend WPO 20 can be used as a substitute for diesel.

- The fuel consumption of all blends is slightly more than the diesel at all varying loads. But PO20 D80 waste plastic biodiesel blend have considerable lesser fuel consumption than all among blends and diesel at lower loading conditions.
- It is being concluded that the specific fuel consumption of PO20 D80 is considerably less than diesel as well as all among waste plastic biodiesel blends at lower loads. And it is nearer to the diesel at all varying loads.
- The Brake thermal efficiency of PO20 D80 plastic biodiesel blend is more among all other blends at all loads but considerably less than the diesel.
- All the blends of WPO biodiesel with diesel have considerable lesser Emission of HC, CO, CO_2, NO_X as compared to diesel.
- HC emission for PO20 blend is slightly more as compared to diesel fuel. For PO10 blend increase the HC emission with increase the load.
- In CO_2 emission there are increase the emission with increase the load for the different biodiesel blends. But there are in PO20 biodiesel blend to reduce the CO_2 emission as compared to all other blends.
- In NO_x emission also there is increase the emission with increase the load but for the PO20 blend there is decrease as compared to other blend (WPO10, WPO30 and D100).
- PO20 D80 can be accepted as a suitable fuel for use in standard diesel engines and further studies can be done with certain additives to improve the emission characteristics.

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