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Research Paper

Evaluation of engine performance, emissions, of a twin cylinder diesel engine fuelled with waste plastic oil and diesel blends with a fraction of methanol

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Abstract

A comprehensive study on the methanol and waste plastic oil as an alternative fuel has been carried out. This report deals with the exhaust emission of waste plastic fuel on twin cylinder diesel engine. The objectives of this report are to analyse the fuel consumption and the emission characteristic of a twin cylinder 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 analyse 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 used diesel engine with no load which means no load exerted on it. A four stroke Twin cylinder 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 of fraction methanol in bio-diesel. In this study, the diesel engine was tested using methanol blended with bio-diesel at certain mixing ratios of (WPO: Diesel) 20:80, 40:60 and 60:40 methanol to bio-diesel respectively. By the end of the report, the successful of the project have been started which is Kirloskar engine is able to run with waste plastic oil (WPO) but the engine needs to run by using diesel fuel first, then followed by waste plastic oil and finished with diesel fuel as the last fuel usage before the engine turned off. The performance of the engine using blended fuel compared to the performance of engine with diesel fuel. Experimental results of blended fuel and diesel fuel are also compared.

Keywords: *Alternative Fuel, Waste Plastic Oil (WPO), Diesel, Methanol, Performance, Emissions, Pyrolysis.*

1. Introduction

Compression ignition (CI) engines are widely used for transportation, automotive, agricultural applications and industrial sectors because of their high fuel conversion efficiencies and relatively easy operation. These wide fields of usage lead to increasing requirements of petroleum-derived fuels. The depletion of petroleum reserves and increasing demand also induce a steep rise in fuel prices. On the other hand, their exhaust emissions, such as soot and nitrogen oxide (NOx) are harmful to natural environment and living beings. Much effort is being paid worldwide to reduce the soot, carbon monoxide (CO), hydro-carbon (HC) and NOx emissions from diesel engines. Biodiesel is an alternative for diesel, Plastics are durable and takes a long time degrade because of the molecular bonds in the plastic are so strong and it is resist to natural processes of degradation. In INDIA we still finding the best way to reduce trash and air pollution problems simultaneously. There are examples of pollution from plastic such as burning plastic can release toxic fumes, burning the plastic polyvinyl chloride (PVC) may create dioxin and the manufacturing of plastics often creates large quantities of chemical pollutants.

One of the solutions that can help to solve the problems above is by using Waste Plastic oil (WPO) as an alternative fuel for diesel engine. The production of this fuel is done by pyrolysis process. The result from using waste plastic as a raw material, it will help to reduce the total of waste plastics and will help to solve the problem that occur in INDIA which is how to reduce trash and air pollution problems. The purpose of this work is to compare used waste plastic oil blends with conventional diesel engine. Before this there is a need for survey on various alternate fuels used in diesel engines by various researchers.

C. Wongkhorsub, N. Chindaprasert [2] observed that without engine modification, the tyre pyrolysis offers better engine performance whereas the heating value of the plastic pyrolysis oil is higher. The plastic pyrolysis oil could improve performance by modifying engine. The economic analysis shows that the pyrolysis oil is able to replace diesel in terms of engine performance and energy output if the price of pyrolysis oil is not greater than 85% of diesel oil. P. C. Jikar, M.D.Bawankure, A.G.Rokade [3] Have discussed about the best mixing ratio that produced at lowest exhaust temperature was at 10% of Methanol in 90% of Diesel fuel. The exhaust temperature for diesel fuel was higher compared to any mixing of the blended fuel. The brake specific fuel consumption for the three mixing ratios was not varying significantly but the lowest was for 30% Methanol and 70% Diesel. The specific fuel consumption for diesel fuel was much lower compared to any mixing ratio. It was noticed that brake thermal efficiency was thus improved in almost all operation conditions with the methanol and diesel blended fuels. Pawar Harshal R. and Lawankar Shailendra M. [4] it is concluded that, Engine was able to run with 100% waste plastic oil Engine fuelled with waste plastic oil exhibits higher thermal efficiency up to 75% of the rated power. Brake thermal efficiency of the engine fuelled with waste plastic oil with retarded injection timing is found to be higher.

From the literature survey it is concluded that alternate fuels can be used as substitute for diesel by evaluating its properties and blending them with diesel in small proportions can improve performance parameters and reduce emissions without modifying the engine design.

2. Preparation of waste plastic 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.

3. Properties of waste plastic oil, diesel and methanol

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

Table 1: Properties of WPO, Diesel and Methanol

Sl. No	Properties	WPO	Diesel	CH4O
1	Density(kg/m2)	793	850	796.6
2	Calorific value (kJ/kg)	44,340	46,500	23,800
3	Kinematic viscosity@40C (cst)	2.149	3.05	1.04
4	Cetane number	51	55	4
5	Flash pointºC	40	52	12
6	Fire pointºC	45	56	97.6
7	Specifc gravity	0.791	0.84	0.79
8	Suphur content (%)	<0.002	<0.035	-

4. Experimental setup

The experimental test set up Figure 1 consisted of twin cylinder diesel engine, four stroke, Forced cooling system, crank start. The setup is provided with a resistance load bank, DELTA 1600Lexhaust gas analyser and Diesel smoke meter. Etc., for performance and emissions analysis. Specifications of engine are shown in Table 2.

Fig. 1: Engine Test Rig

Table 2: Engine Specifications

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

5. Experimental procedure

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.

6. Results and discussion

The performance and exhaust emission parameters of the engine with diesel and waste plastic oil (WPO) with a fraction of methanol at different blend ratios are presented and discussed below.

6.1. Specific fuel consumption

At higher temperature the effect of proportion of waste plastic oil – diesel blends with a fraction of methanol on specific fuel consumption (SFC) are shown in figure 2. From that figure it is clear that at different loads the variation of SFC with load at different ratios of blends such as D 100,wpo 20,wpo 40,wpo 60, are almost equal to diesel. The reasons behind this results are lower energy value substitute methanol is added to the bio- diesel blends, thus engine responds to the load by increasing the fuel flow. Thus SFC decreases with the increase in thermal efficiency.

6.2. Brake thermal efficiency

Figure 3, shows the variation of brake thermal efficiency with respect to the proportion of biodiesel (wpo) – methanol blends at different loads. From the plot it is observed that as load increases brake thermal efficiency is also increases for diesel as well as blends of waste plastic oil. At full load condition, the brake thermal efficiencies obtained are 6.75%, 13.08%, 12.02% and 11.05% for the diesel, wpo 20, wpo 40 and wpo 60 respectively. Among the three blends of waste plastic oil the maximum BTE is 13.08% which is obtained from wpo 20. The BTE using wpo 20 is increased by 7.6% as compared to the diesel at full load condition. The increment in Brake thermal efficiency is due to better combustion because of high calorific value and less viscosity of waste plastic oil.

6.3. NOx concentration

Figures 4, shows the variation of NOx level with respect to proportion of biodiesel (wpo) and methanol blends at different loads. NOx tends to increase with load, this increase in NOx is explained by the fact that at low loads, but as the load increases, the temperature also increases which in turn increases the NOx emisssions. Results show that NOx is comparatively higher with WPO 20. It is found that NOx emission increases with increase in load. 100% Diesel and WPO 20 has higher NOx level when compared to blends of biodiesel (wpo) and methanol blends. This is due to addition of methanol to the blends which has the property of emitting less nitrogen oxides when it is burnt. NOx is comparatively decreased when compared to diesel fuelled engine.

6.4. CO concentration

Figures 5, shows the variation CO level with respect to proportion of biodiesel (wpo) and methanol blends at different loads. From the graph it is clear that the CO level decreases as the proportion of waste plastic oil decreases in the blends. This is due to the fact that engine is not optimized to run with diesel oil blends or waste plastic oil, so there is a large possibility of rich fuel-air mixture in the cylinder and the higher specific fuel consumption resulting in a higher CO level. Carbon monoxide occurs in engine exhaust. It is a product of incomplete combustion due to insufficient amount of air in the air fuel mixture or insufficient time in the cycle for the completion of combustion. CO level is comparatively less when compared to diesel.

6.5. HC concentration

Figure 6, shows that the variation of HC level with respect to proportion of waste plastic oil and diesel blends with the fraction of methanol at different loads. HC level is found to be low for waste plastic oil compared to diesel. Unburnt hydrocarbon emissions are the direct result of incomplete combustion. Thus HC level is comparatively reduced with increase in the loads, this is due to diffused combustion, increased temperature and after burning phenomenon.

7. 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, WPO 40 and WPO 60) 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.

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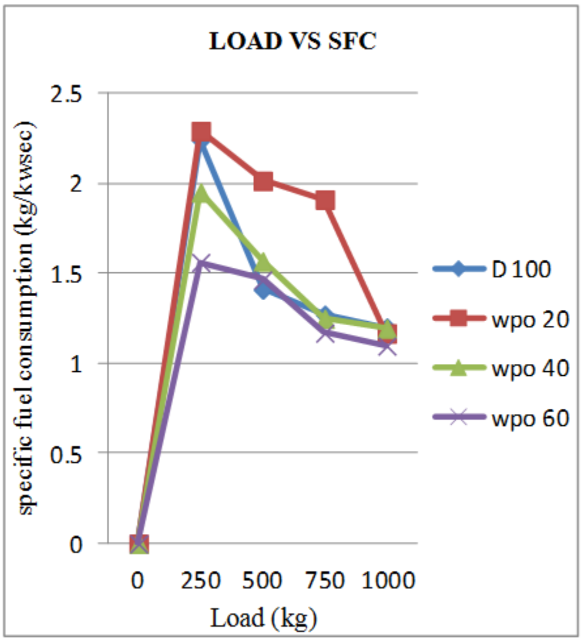

Fig. 2: Variation of Specific Fuel Consumption With Load

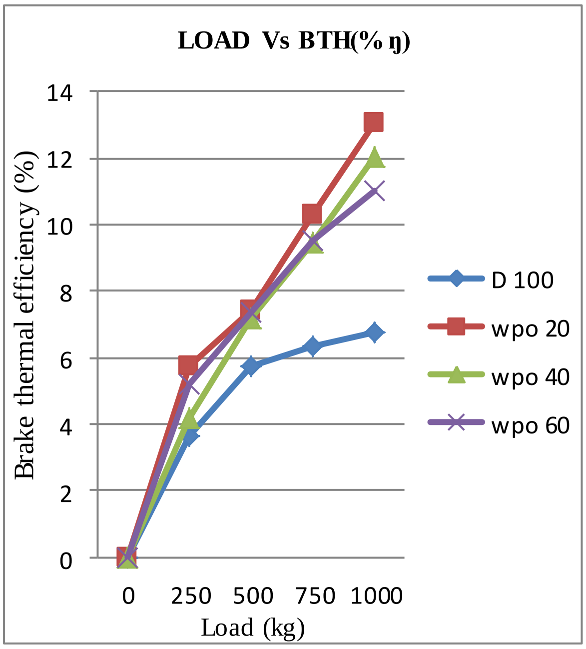

Fig. 3: Variation of Brake Thermal Efficiency With Load

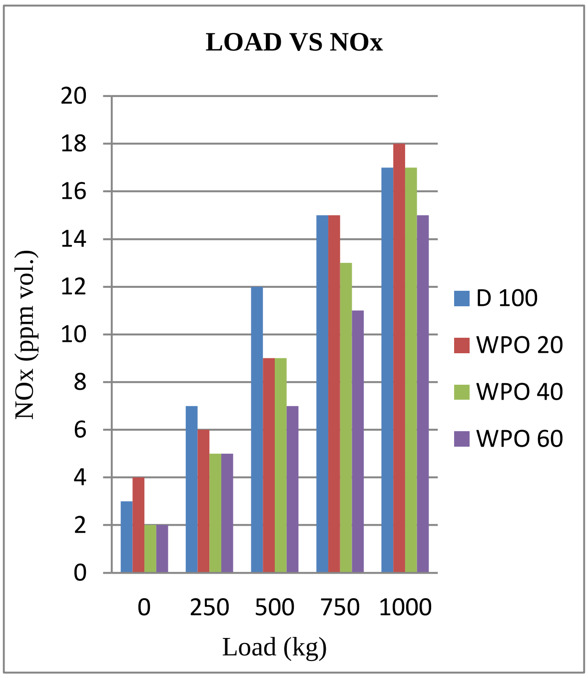

Fig. 4: Variation of oxides of nitrogen with load

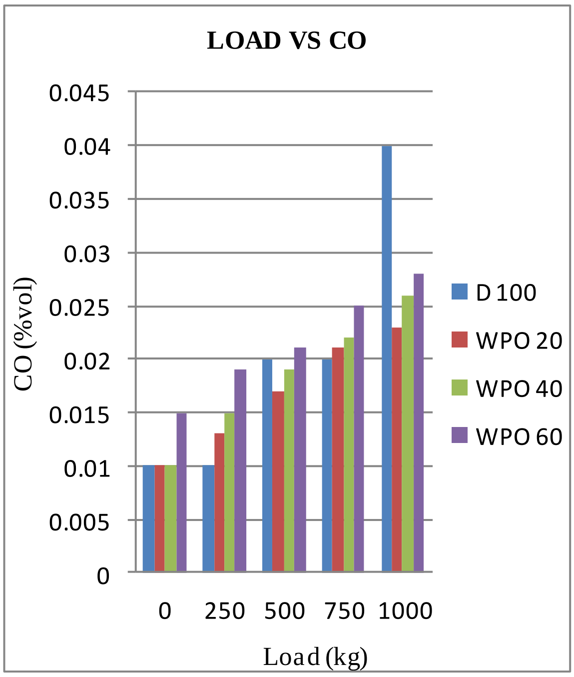

Fig. 5: Variation of carbon monoxide with load

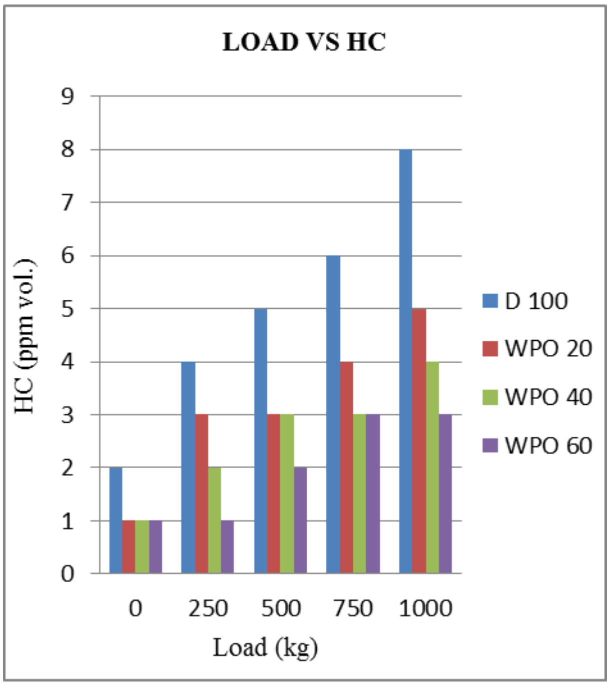

Fig. 6: Variation of Unburnt Hydrocarbons With Load

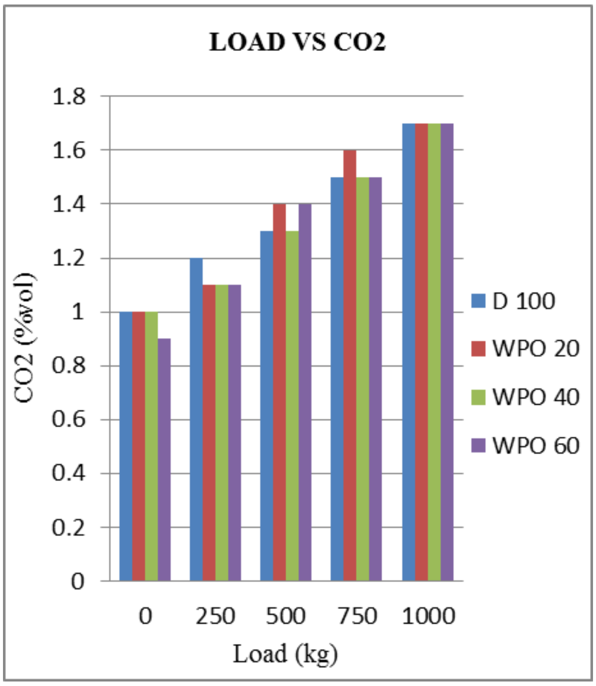

Fig. 7: Variation of Carbon Dioxide With Load

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