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PEFORMANCE AND EMISSION CHARACTERISTICS OF WASTE PLASTIC PYROLYSIS OIL IN D.I SINGLE CYLINDER DIESEL ENGINE

Amaresh M *, Veerabhadra Reddy Basam
* M.Tech Schalor Mechanical Engineering Department, G.Pulla Reddy Engineering College Kurnool
Professor, Department Of Mechanical Engineering, G.Pulla Reddy Engineering College Kurnool

ABSTRACT

Environmental concern and availability of petroleum fuels have caused interests in the search for alternative fuels for internal combustion engines.. There is a need to search for alternative fuels for the automobile applications. Conversion of waste to energy is one of the recent trends in minimizing not only the waste disposal but also could be used as an alternative fuel for internal combustion engines. Waste plastics are indispensable materials in the modern world and application in the industrial field is continually increasing. In this context, waste plastics are currently receiving renewed interest.. In this, waste plastic pyrolysis oil and its blend with diesel has been introduced as an alternative fuel. In the first step the test were conducted on four stroke single cylinder diesel engine by using diesel and base line was generated. Further in the second step experimental investigations were carried out on the same engine with same operating parameters by using plastic pyrolysis oil blended with diesel in different proportions such as 20%, 40%, 60%, 80% and 100% waste plastic pyrolysis oil with diesel fuel (DF) to find out the performance parameters and emissions. It is found that the engine performance with blends improved to a certain extent, without any adverse effect in terms of emissions.

KEYWORDS: Diesel Engine, Plastic Pyrolysis Oil, Performance, Emission Characteristics

INTRODUCTION

Day to day, fuel economy of engines is getting improved and will continue to improve. However, enormous increase in number of vehicles has started dictating the demand for fuel. Gasoline and diesel will become scarce and most costly in future. With increased use and the depletion of fossil fuels, alternative fuel technology will become more common in the coming decades. All these years there have always been some IC engines fuelled with non-gasoline or diesel oil fuels. However, their numbers have been relatively very small. Because of the high cost of petroleum products, some developing countries are trying to use alternate fuels for their vehicles. Another reason motivating the development alternative fuels for the IC engines is the concern over the emission problems of gasoline and diesel engines. Combined with other air-polluting systems, the large number of automobiles is a major contributor to the air quantity problems of the world. Quite a lot of improvement had been made in reducing emission from automobiles engines. If a 35% improvement made over a period of years, it is to be noted that during the same time the number of automobiles in the world increase by 40%, thereby nullifying the improvement. Lot of efforts has gone into for achieving the net improvement in cleaning up automobiles exhaust. However, more improvements are need to bring down the ever-increasing air pollution due to automobile population. Diesel engines are the most efficient prime movers, from the point of view of protecting global environment and concerns for long-term energy security it becomes necessary to develop alternative fuels with properties comparable to petroleum based fuels. Unlike rest of the world, India's demand for diesel fuels is roughly six times that of gasoline hence seeking alternative to mineral diesel is a natural choice. Alternative fuels should be easily available at low cost, be environment friendly and fulfill energy security needs without sacrificing engine's operational performance. Fuels like alcohol, biodiesel, liquid fuel from plastics etc are some of the alternative fuels for the internal combustion engines. Utilization of biomass as alternative fuel for compression ignition engine has a great scope especially in developing and undeveloped countries. Plastics have become an indispensable part in today's world, due to their lightweight, durability, energy efficiency, coupled with a faster rate of production and design flexibility, these plastics are employed in entire gamut of industrial and domestic areas. At the same time, waste plastics have created a very serious environmental challenge because of their huge quantities and their disposal problems. Waste plastics do not biodegrade in landfills, are not easily recycled, and degrade in quality during the recycling process. Instead of biodegradation, plastics waste goes through photo-degradation and turns into plastic dusts which can enter in the food chain and can cause complex health issues to earth habitants, through the thermal treatment on the waste plastic the fuel can be derive3, by adopting the chemical process such as pyrolysis can be used to safely convert waste plastics into hydrocarbon fuels that can be used for transportation. Many researchers have been conducted to convert waste plastics into renewable energy sources.

Waste to Energy

Waste to energy is a potential method to produce useful energy by any of the methods such as direct combustion, pyrolysis, gasification, fermentation etc.Plastics are just long hydrocarbon chains. Energy from waste particle can be obtained by a catalyst or liquefying in the absence of oxygen by a tubular continuous reactor. The structure is reformed by rearranging the chains between carbon and hydrogen atoms with the help of catalysts to have a high fuel value. Plastic oil has a low heating value and sulphur content than that of diesel. The will be blend of plastic oil and diesel can be used directly without any modification in the diesel engine. Many researchers have been conducted to convert waste plastics into renewable energy sources. This is possible because plastics are originally made from crude oil. Crude oil is a very limited natural resource that is used to make transportation fuel, plastics and other products. Crude oil is a non-renewable energy source and since it is a natural resource it will deplete in the near future. Successful methods have been carried out to convert waste plastics into liquid based fuels. These methods include various procedures to convert the waste plastics such as PYROLYSIS, in which the contents of waste plastics are thermally degraded to produce liquid-based fuels and other products without the presence of oxygen.

Materials And Properties

1 Material

The plastic pyrolysis oil used in this study was collected from G.K. Industries, Hyderabad. The diesel was bought from the local filling station.

2 Details of Fuel Properties

The properties of the diesel and plastic pyrolysis oil are compared and tabulated below. These properties are compared with ASTM standards . The properties are tested at G Pulla Reddy Engineering College, Kurnool, A.P.

Table1: Comparative properties of diesel and plastic pyrolysis oil.

Property	**Diesel**	**Plastic Pyrolysis oil**
1.Flash Point °c	50	42
2.Fire Point °C	55	46
3.pour point °C	3 to 15	-4
4.Density@30°C(gm/cc)	0.80	0.83 to 0.88
5.Kinematic viscosity (cst@40°c)	2.52	2.58
6.Calorific value (kj/kg)	45.252	46.584
7.Cetane number	55	51
8. sulphur content %	<0.035	<0.002

EXPERIMENTAL SETUP

The engine tests were conducted on a single cylinder, direct injection water cooled ignition engine to evaluate the performance of 3.5 kW diesel engine at different load conditions are no load, 20%, 40%, 60%, 80% and full load. Fuels used in diesel engine were diesel, plastic pyrolysis oil and its blends. Load was applied in five levels namely 20%, 40%, 60%, 80% and full load. Load, Speed, Efficiencies and Exhaust Emissions of HC, CO, CO_2, O_2 and NO_x were measured at all load conditions. The Engler's Viscometer was used to measure the viscosity of fuels at various temperatures. The exhaust gas analyser was used to measure CO, HC, CO_2, O_2 and NO_x levels. All the tests were conducted by starting the engine with diesel only. After the engine was warmed up, it was then switched to plastic pyrolysis oil blends. Cooling of the engine was accomplished by circulating through the jackets of the engine block and cylinder head. At the end of the test, the engine was run for some time with diesel to flush out the plastic pyrolysis from the fuel line and the injection system. The specifications of the C.I engine are summarized in below table 2.

Fig 1: Diesel engine

Fig 2: Emission Analyser

Table 2: Specifications of Engine

Features	**Description**
Make an model	Kirloskar
Type of Engine	4- Stroke diesel engine
No. of cylinder	Single cooled cylinder
Rated capacity	3.5 KW@1500 rpm
Cylinder diameter	80 mm
Stroke Length	1100 mm
Connecting rod length	18:1
Orfice meter	20 mm
Cooling media	Water cooled

1EPRIMENTAL PROCEDURE

a. First switch on the power supply.
b. Check water supply connections.
c. If separate arrangement is done for storage and supply of fuel blends.
d. The engine is started and warm up for 20 minutes.
e. Select the run option.
f. Every test is conducted and data is stored at different load conditions.
g. Engine is run for 10-25 minutes for one test and the data will be taken.
h. All the tests are conducted in the same sequence at all load conditions.

EXPERIMENTAL RESULTS

After the performance and emission characteristics of a high speed diesel engine at various loads from no load to full load fuelled with waste plastic pyrolysis oil and its diesel blends are discussed below as per the results obtained

Performance:

1 Specific Fuel Consumption (SFC):

The graph is plotted in between brake specific fuel consumption and load is shown in fig 2.1.1. As the load increases the fuel consumption decreases. At full load condition the BSFC obtained are 0.33 kg/kW-hr, 0.33 kg/kW-hr, 0.20 kg/kW-hr, 0. 19 kg/kW-hr, 0.18 kg/kW-hr and 0.17 kg/kW-hr for fuels of DIESEL, B20, B40, B60, B80, and B 100 respectively. The SFC of B20 oil decreased when compared to the diesel at full load condition.

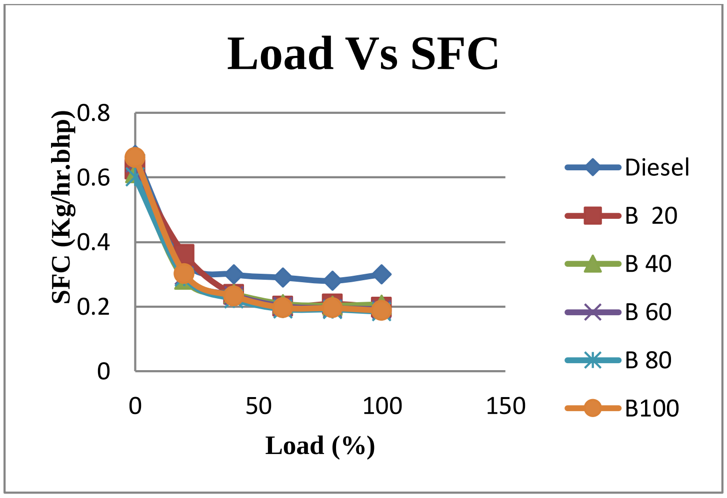

Fig 2.1.1: Variation in specific fuel consumption with change in load

2 Brake Thermal Efficiency (BTE):

The experimental study on a single cylinder four stroke air cooled DI diesel engine with WPP oil. The graph is plotted between brake thermal efficiency and load is shown in fig 2.1.2. As the load increases the brake thermal efficiency increases. At full load condition the brake thermal efficiencies obtained are 19.17%,28.96 %, 27.5%, 29.73%, 30.77% and 30.85 % for fuels of DIESEL, B20, B40, B60, B80, and B 100 respectively. At full load the efficiency of B20 is higher than for diesel. This is due to that at full load the heat release rate is marginally higher for B20 whether compared to diesel fuel.

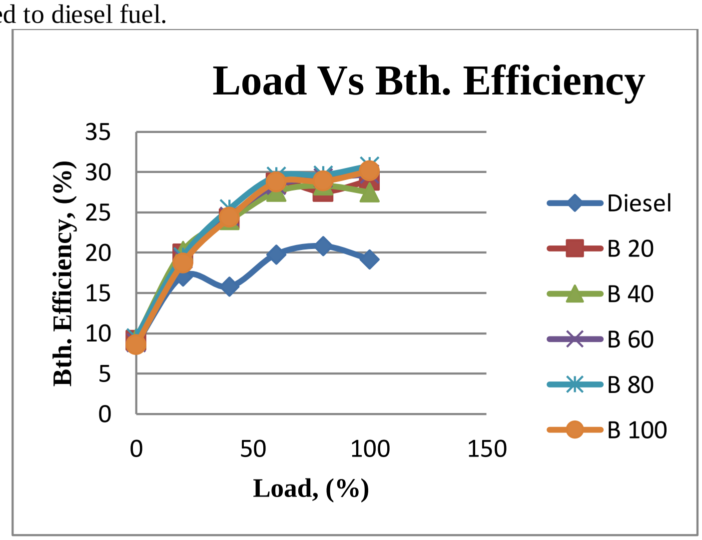

Fig 2.1.2: Variation in brake thermal efficiency with change in load

3 INDICATED THERMAL EFFICIENCY(ITE):

The graph is plotted in between indicated thermal efficiency and load is shown in fig 2.1.3. As the load increases the fuel consumption increases. At full load condition the indicated thermal efficiency obtained are 24.52%, 35.95%, 36.47%, 38.57%, 38.16% and 39.19% for fuels of DIESEL, B20, B40, B60, B80, and B 100 respectively. The indicated thermal efficiency of B20 oil increased when compared to the diesel at full load condition.

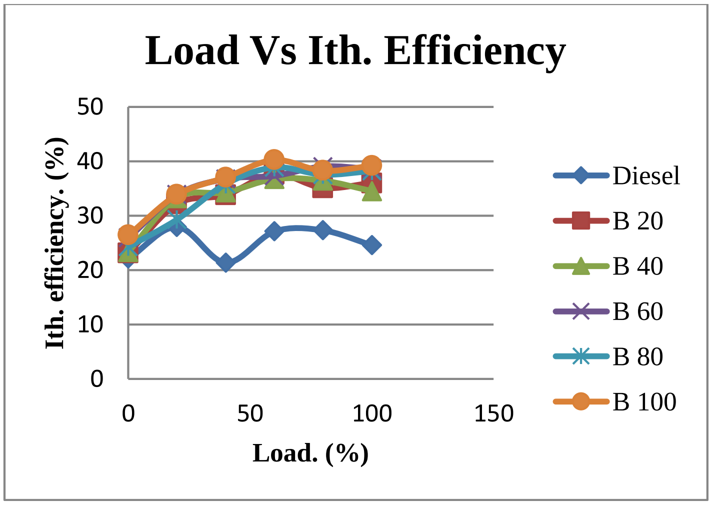

Fig 2.1.3: variation in indicated thermal efficiency with change in load

4 Mechanical Efficiency (η_{mech}):

The graph is plotted in between mechanical efficiency and load is shown in fig 2.1.4. As the load increases the mechanical efficiency increases. At full load condition the mechanical efficiency obtained are 78.02%, 80.56%, 79.97%, 77.07%, 80.62%, and 81.65 for fuels of DIESEL, B20, B40, B60, B80, and B 100 respectively. The mechanical efficiency of B20 oil increased when compared to the diesel at full load.

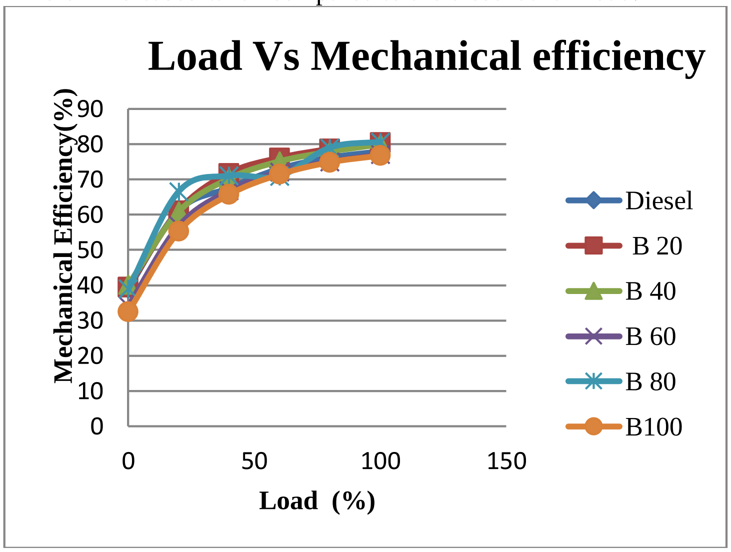

Fig 2.1.4: Variation in mechanical efficiency with channge inload

5 Air-fuel ratio:

he graph is plotted in between mechanical efficiency and load is shown in fig 2.1.6. As the load increases the air fuel atio increases. At full load condition the air fuel ratio obtained are 16.34%, 29.12%, 27.03%, 30.16%, 31.17%, and 31.25% for fuels of DIESEL, B20, B40, B60, B80, and B 100 respectively. The air fuel ratio of B20 oil increased when compared to the diesel at full load.

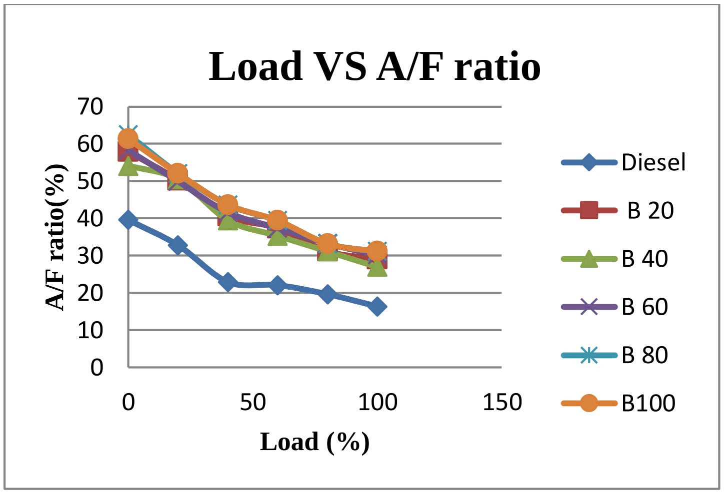

Fig 2.1.5: Variation in mechanical efficiency with change in load

Emissions

1 Carbondioxide(CO_2):

The graph is plotted in between CO_2 emission and load is shown in fig 2.2.1. As the load increases the CO_2 emission decreases. At full load condition the CO_2 emissions obtained are 0.51%, 0.53%, 0.59%, 0.60%, 0.70% and 0.72% for fuels of DIESEL, B20, B40, B60, B80, and B 100 respectively. The CO_2 emission of B20 oil increase when compared to the diesel at full load condition.

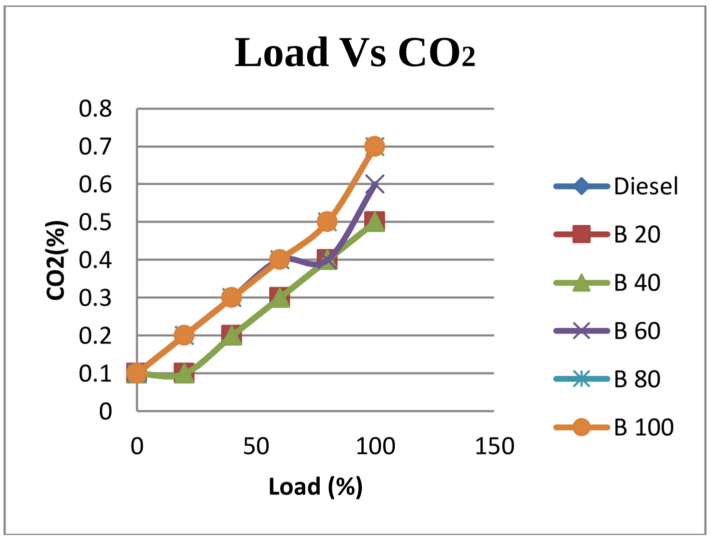

Fig 2.2.1: Variation of carbondioxide with change in load

2 Hydrcarbons(HC):

The graph is plotted in between HC emission and load is shown in fig 2.2.2. As the load increases the HC emission decreases. At full load condition the HC emissions obtained are 16ppm, 19ppm, 20pm, 21ppm.21ppm, and 22ppm for fuels of B20 and B40, B60, B80, B100 and DIESEL respectively. The HC emission of B20 oil increase when compared to the diesel at full load condition.

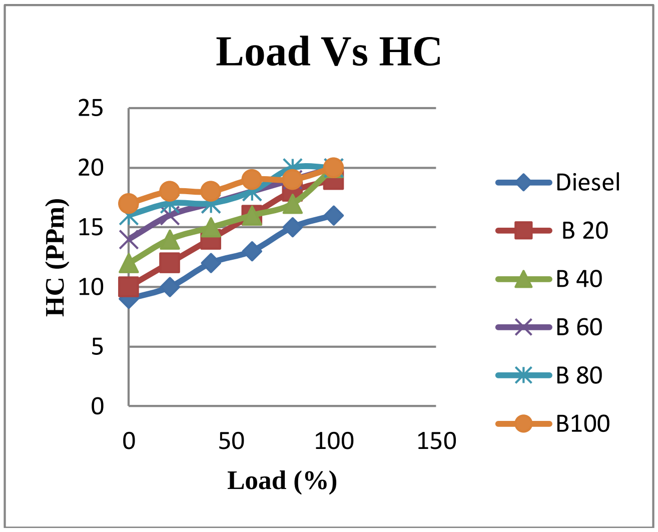

Fig 2.2.2: Variation in unburned hydrocabons with change in load

3 Carbon Monooxide(CO):

The graph is plotted in between CO emission and load is shown in fig 2.2.3. As the load increases the CO emission are increases. At full load condition the CO emissions obtained are 0.061%, 0.062%, 0.062%, 0.051%, 0.064% and 0.065% for fuels of DIESEL, B20, B40, B60, B80, and B 100 respectively.

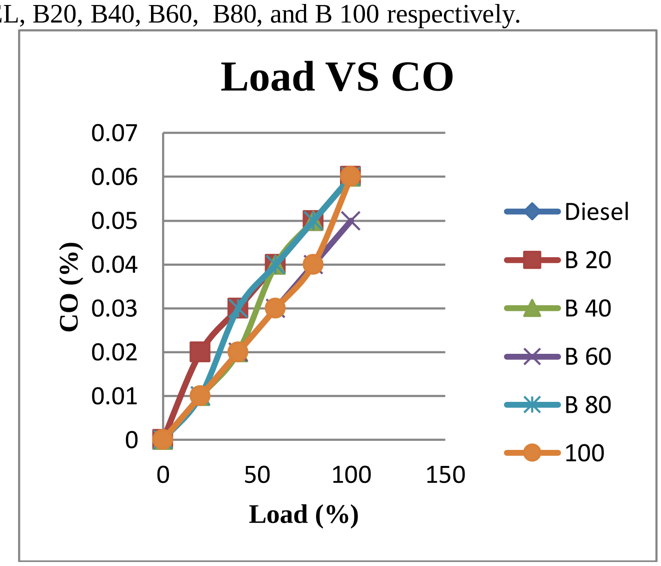

Fig 2.2.3: Variation in carbon monoxide with change in load

4 Oxides of Nitrogen(NOx):

The graph is plotted between NOx emissions and load is shown in 2.2.4. As the load increase NOx emissions are in same range. At full load conditions the NOx emissions are 12ppm, 13ppm, 14ppm, 14ppm, 15ppm, and 16ppm for the fuels of DIESEL, B20, B40, B60, B80, and B 100 respectively. The NOx emission of B20 oil are in acceptable range when compared to diesel at all fulload conditions.

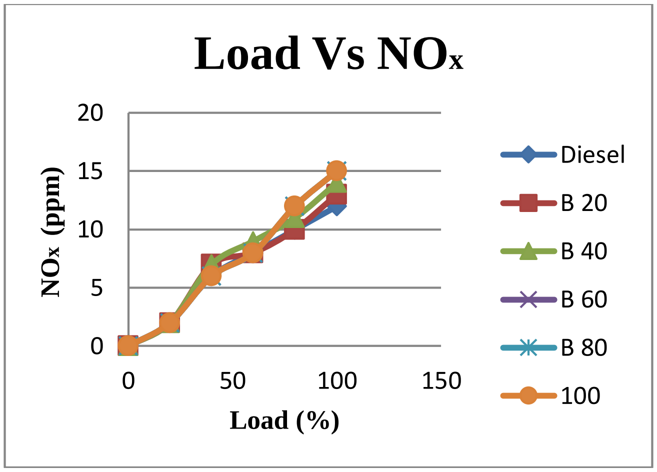

Fig 2.2.4: Variation in oxides of nitrogen with change in load

CONCLUSION

The performance and emission characteristics of four stroke single cylinder diesel engine fuelled with diesel, plastic pyrolysis oil blends are evaluated. It is possible to replace(plastic pyrolysis oil) as an alternate fuel used in the internal combustion engine without any modification. The final conclusion are summarized as follows

- Brake Thermal Efficiency and Indicated thermal efficiency are increased with all blends when compared to the diesel fuel.
- The Brake Specific Fuel Consumption is decreased with the blends when compared to conventional diesel fuel.
- Air fuel ratio is higher in B20 because more air is drawn into it which results in high efficient combustion and greater cooling effect.
- CO emissions are almost similar to diesel.
- CO_2 and HC, emissions are increased in full load condition, and NOx emissions are in acceptable range when compared to diesel fuel.

From the above analysis the B20 showed the better performance compared to other blends of plastic oil and Diesel.

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