EXTRACTION OF PLASTIC OIL AND EXPERIMENTAL EVALUATION OF DIESEL ENGINE WITH BLENDS OF DIESEL AND PLASTIC PYROLYSIS OIL

Santosh S Ghorpade[1], Rudragouda R Patil[2], V Santosh Kumar[3], V R Harish[4]
[1,2,4]Assistant Professor, Mechanical Department, Jayamukhi Institute of Technology & Sciences
[3]Assistant Professor, Mechanical Department, Holy Mary Institute of Technology & Sciences

ABSTRACT

Environmental degradation and depletion of oil reserves are matters of great concern around the globe. In this context, pyrolysis of waste plastic solid is currently receiving renewed interest. Waste plastic pyrolysis oil is suitable for compression ignition engines and more attention is focused in India because of its potential to generate large-scale employment and relatively low environmental degradation.

In the present work the oil is extracted from the waste plastic by pyrolysis process and the performance and emission characteristics of a single cylinder, constant speed and direct injection diesel engine using waste plastic pyrolysis oil blends as an alternate fuel were evaluated and th results are compared with the standard diesel fuel operation. After blending plastic waste oil with diesel in 10%, 20%, and 30% of waste oil the tests on brake thermal efficiency, mechanical efficiency, total fuel consumption, brake mean effective pressure and exhaust emissions are conducted.

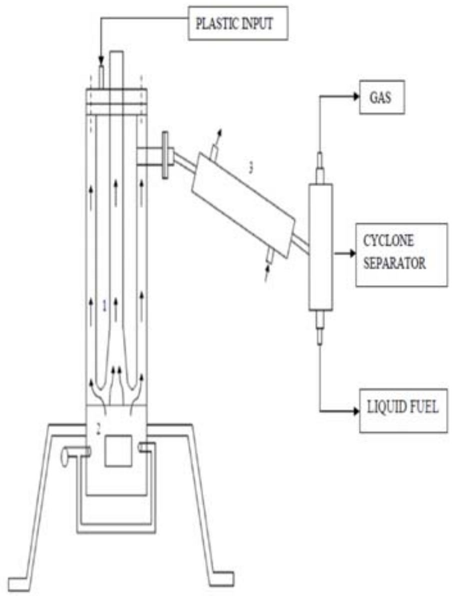
Plastic product manufactured in the 1860, but we are widely used in the past 30 years. Plastic are light, non-biodegradable, durable, modifiable and hygienic. Plastic are made of long chain molecule called polymers. Polymers are made naturally occurring substance such as (crude oil or petroleum) and it is transmuted into other element with absolutely different properties. These polymers can be made into granules, powders and liquids and that becoming raw resources for plastic products.

1. INTRODUCTION

Plastics products are necessary part in today's world. Due to their light weight, durability, energy efficiency, coupled with a faster rate of manufacturing the plastic products. Plastics are produced from petroleum derivates and they composed of hydrocarbons but also contain additives such as antioxidants, colorants and other stabilizers. Disposal of plastics wastes posses a great hazard to the environment and effective method has not yet been implemented. Plastics are non-biodegradablepolymers mostly containing car bon, hydrogen, and few other elements like nitrogen by non-biodegradable in nature, the plastic waste major contributes are municipal non organic solid waste and waste-plastic should be recycled or scientific method of municipal solid wastes disposal. According to survey conducted on the year 12000 approximately 6000 tonnes of plastic wastes were generated per day in India, and in that only 60% of it was recycled, the remaining of 40% plastic wastes remains in cities. Today about 130 Million tonnes of plastics wastes produced per year all over the world, out of which 75 Million tonnes of wastes produced from petroleum.

1.1. Pyrolysis process

Pyrolysis process is carried with and without catalysts using natural zeolite and alumina catalyst. It was found that, time required for completion of the pyrolysis process was 3.5 hrs without catalyst and 2.5 hrs with catalysts. Upon comparison between fuels obtained with and without catalysts.



1. Reactor, 2. Combustion chamber,
3. Condenser

Fig.1.1. Experimental setup of pyrolysis process

Fig.1.1 shows, the experimental setup of pyrolysis process. The apparatus was designed to operate at high temperatures and atmospheric pressure. The heart of the experimental apparatus was a vertical tubular reactor. A feeder was attached to the reactor's upper side and through this controlled amount of plastic is to be added before or during operation. At the bottom of the reactor furnace is attached for the purpose of heating the reactor. Biomass and charcoal with blower is used as a heating source to heat the reactor. Due to increasing the reactor temperature the plastic starts to evaporate and these vapors leaving the reactor and passed into a condenser, (maintained at atmospheric temperature). The cyclone separator is provided at the end of condenser to separate the gaseous fuel and plastic liquid fuel compounds. The gas is reused to heat the pyrolysis unit and another end of cyclone separator is connected to a beaker in which the liquid hydrocarbon product (plastic oil) was collected. Temperatures and pressure were monitored continuously by using thermocouples and pressure gauge connected to it.

It is observed that in absence of catalyst, process gives about 60-62% yield, with 5 % natural zeolite yield is 65-67 % and with 5 % alumina catalyst it is about 70-71 %. An increase in the yield percentage and calorific value is observed with both the catalysts but higher effect is seen in case of oil obtained with alumina.

Table 1.1 Properties of pyrolysis oil with different fuel blends.

PARAMETERS	PF 0	PF 10	PF 20	PF 30	PF 40	PF 100
Flash point (^{0}C)	58	60	63	65	68	72
Fire point (^{0}C)	57	61	65	69	71	83
Kinematic viscosity at 40^{0}C (mm^2/s)	2.82	4.124	4.582	5.64	5.64	5.88
Density at40^{0}C (kg/m^3)	813	815.7	816.5	818.5	818.95	822.32
Calorific value (MJ/kg)	44.41	42.07	42.8	42.82	42.31	41.222

2. Engine set up

The test engine used is a single cylinder four stroke diesel engine. It produces 3.7 kW of rate power at 1500rpm with a compression ratio of 17.5:1. The engine is cooled using the water. The engine is started by hand cranking. Detailed specification of test engine is listed below in Table 4.2.

Fig 2.1 Engine experimental set up

Fig 2.1 shows the block diagram for engine test rig, computer was used to note down the various parameters from the experiment. The experiments are carried out at the rated speed of 1500 rpm at different load conditions. The eddy current dynamometer is used to vary the load by applying the load. Engine is first operated by the diesel oil for the heating purpose and then the different blends of fuels are used to run the engine. Rate of flow of fuels will be noted by the burette and cylinder pressure is controlled by the control panel. Exhaust gas temperature will be noted by the temperature sensors. Exhaust gas analyzers were switched on and allowed to stability before measurements.

3. RESULTS AND DISCUSSIONS

3.1. Engine performances

Brake specific fuel consumption

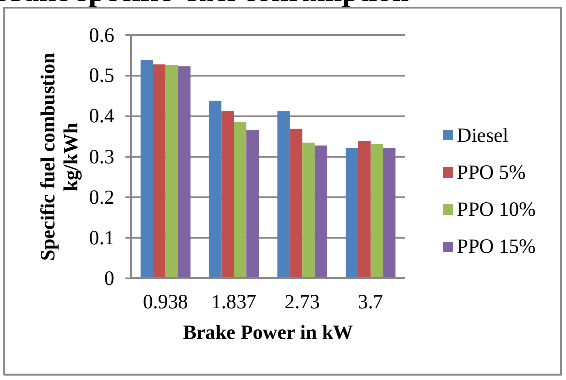


Fig.3.1 Variation of Brake specific fuel combustion with load

Fig. 3.1 shows the variation of BSFC with brake power for various blends of plastic waste oil and diesel with respect to variable loading values and at 250 bar pressure. It can be observed that the specific fuel consumption of different blends is found to be slightly higher than the diesel at full load. It is observed that for 5%, 10% blends the specific fuel consumption is found to be higher than the diesel because of poor combustion, as load increases due to impurities and sulphur content. But for 15% blend BSFC is lower compared to other blends because of optimum blend formation.

Brake thermal efficiency

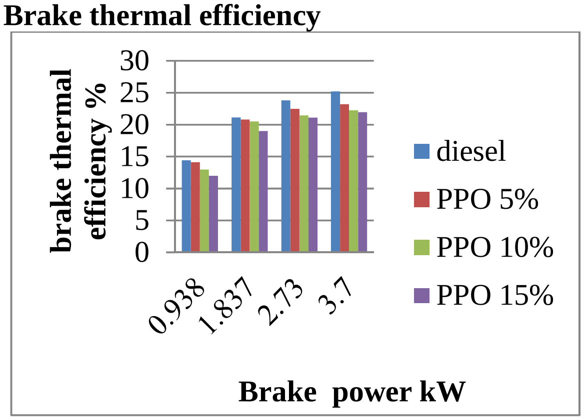


Fig 3.2 Variation of BTE with brake power

Fig 2.2 shows that variation of BTE with BP for different fuel at 250 bar pressure. The graph shows that the BTE decreases when the pressure at 250 bar for 15% PPO as fuel. This may tends to the effective combustion taking place due to the finest fuel particle in the combustion chamber however the further increase in fuel blend results in a drop in BTE.

3.2. Emission testing

Carbon monoxide

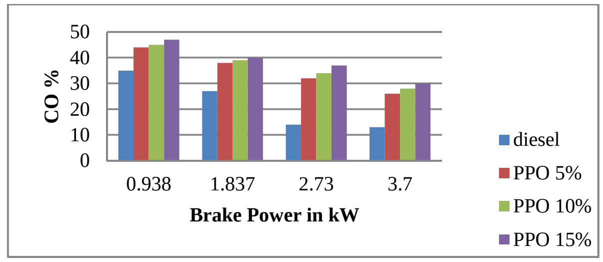


Fig 3.3 Carbon Monoxide with brake power

Fig .3.3 clearly illustrates that as the percentage of blend increases the Carbon monoxide emission decreases. For injection pressure 250bar at 3.7kW brake power the CO content of diesel is 28 and for that of 5% PPO is 26% and it's gradually increases for the 15% blend at the same injection pressure. This is because the Oxygen supply for combustion process is decreases so incomplete combustion takes place.

Carbon dioxide

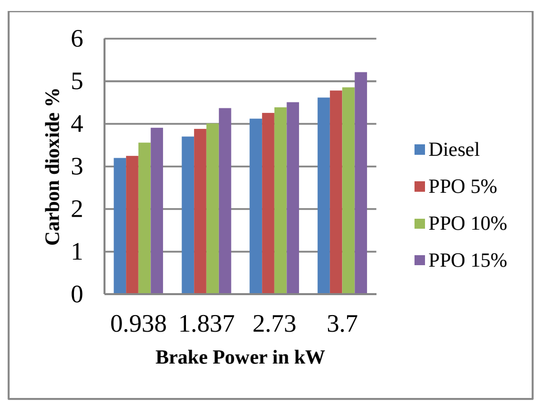


Fig 3.4 Variation of CO_2 with brake power

Fig 3.4 shows the variation of CO_2 emission at 250 bar injection pressure. As the load increases the emission of CO_2 increases this is because of the more carbon particles in the plastic oil. So the CO_2 emission is more as compare to diesel. Increase in CO_2 content doesn't affect much to environment because trees need CO_2 and gives back O_2.

Hydrocarbon

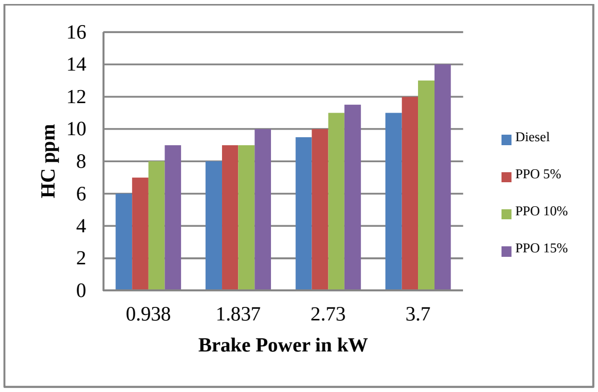


Fig3.5 Variation of HC with brake power

Fig 3.5 indicates the variation of the HC at different brake power for different blends. As the blending percentage increases the HC emission also increases this is because at the higher injection pressure the fuel particles are remains in the injector nozzle sac volume and escapes out after the combustion, which produces the higher HC emission.

Nitrogen oxide

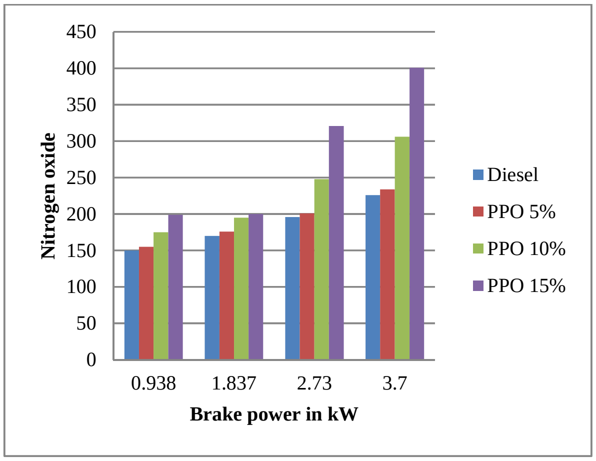


Fig 3.6 Variation of NO_x with brake power

The plastic wastes are mainly made up of polymers. The oil extracted from waste plastic is through pyrolysis process during which the polymers chain breaks, this result in free nitrogen molecules in the oil. Therefore as the percentage of plastic oil in the blend increases, the NO_X emission increases. The NO_x emissions are higher for 15% plastic fuel blends

4. CONCLUSIONS

From the tests conducted with waste plastic oil and diesel blends, the following conclusions are arrived

1. The engine can able to run with 50% of blends. The engine starts to vibrate and emissions are high above this percentage.
2. Without exhaust gas recirculation the NO_x, CO, HC and smoke emissions were found higher than diesel.
3. Low heat rejection operation with plastic oil produced an improvement in brake thermal efficiency when compared with standard engine operation. However, this improvement did not match the standard diesel only engine operation.
4. EGT increased with an increase in brake power for all fuel and engine conditions.

REFERENCES

1. **Achyut K. Panda :** "Waste oils as alternative fuel for diesel engine: A review" :Journal of Petroleum Technology and Alternative Fuels,2013
2. **Pawar Harshal R et al :** "Waste plastic pyrolysis oil alternative fuel for CI engines: a review" : Vol 2, Research journal of Engineering Sciences, 2013.
3. **Jane pratoomyod et al : "**Performance and emission evaluation of blends of diesel fuel with waste plastic oil in a diesel engine" : Vol 2, IJESIT, 2013.
4. **Anup T J and Vilas Watwe :** "Waste plastic pyrolysis oil as alternative for SI and CI engines" : Vol 3, IJIRSET, 2014.
5. **Mochamad Syamsiro :** "fuel oil production from municipal plastic waste in sequential pyrolysis and catalytic reforming reactors":Energy procedia, Elsevier, 2014.