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Performance and Emission Test on CI Engine Using Fuel from Waste Plastics

Ravikumar R[1], Kiran K[2], Gurumoorty S Hebbar[3]
[1, 2, 3]Mechanical Engineering, Faculty of Engineering, CHRIST (Deemed to be University), Bangalore, Karnataka, India-560074

***Abstract*—*Day to the day the life of every human being is unimaginable without the think of using energy sources. The rate of Indian economic growth itself difficult without reserving of fossil energy sources like crude oil, natural gas or coal. In this contest, humanity has to think about the different energy sources such that biomass, hydropower, geothermal energy, wind energy, solar energy, nuclear energy, etc. On the other side suitable waste management techniques need to be developed for proper disposal of generated waste such as plastics, kitchen waste, industrial waste, etc. Human produces around 300 million tons of plastic wastes every year, and these wastes end up in the environment destroying marine life and other ecosystems, Due to their non-biodegradable in nature, it is challenging to eliminate the plastic wastes from view. The purpose of this project work is to carry the process of converting the waste plastic into some useful liquid fuel compounds which can give the solution for the shortage of energy sources and waste management strategy. The second phase of this work deals with the evaluation of engine performance and emission characteristics using produced fuel from waste plastics. To convert waste into value-added product efficient polymer process called thermal pyrolysis was used. The physical properties of the obtained fuel and its blends of diesel fuels are determined.*

***Keywords*—** *Waste plastics, energy, thermal pyrolysis, blends.*

I. INTRODUCTION

Plastics, a daily used product plays an important role in our life. It is a unique material because of its toughness, lightweight, chemically resistant, water resistant, resistant to heat and cold, low electrical and thermal conductivity, ease of fabrication, a remarkable range of colours, more flexibility in designs, durability and energy efficiency. Plastic waste management is one of the biggest problems now due to their non- biodegradability nature.

In the current scenario, plastics are managed by plastics recycling technologies. Converting the waste plastic into crude oil will have many benefits. Some of the major disadvantages of plastic wastes are its difficulty in reusability and being a toxic substance can be harmful to animals. These plastic wastes prevent the absorption of water into the soil surface. Hazards caused due to plastic waste can be reduced and we will be able to obtain some amount of oil from it.

II. MATERIALS AND METHODS

Pyrolysis unit is fabricated with parallel flow tube heat exchanger. The effective and efficient polymer energy technology called thermal pyrolysis process is effectively utilized here to convert waste plastics (milk sachets) into liquid fuels. The reactor with shredded waste plastics are filled is placed on a gas burner for the heating purpose. Due to increase in temperature of reactor above 350°C to 400°C the plastic starts to melt at the initial stage and a further increase in reactor temperature results as evaporation of melted plastic. Formed vapours made to pass through the condenser to remove heat and convert vapours into liquid form maintained at atmospheric temperature. The process flow diagram and fabricated pyrolysis unit are shown in Fig 1 & 2. The temperature rise in the reactor is measured and monitored by using the thermocouple with a dial indicator. The pyrolysis process were carried out with many trails with 1 kg of waste plastic sample each. Liquid fuel yield observed and obtained different quantity from each trail like 350 ml to 435 ml. After the end of each process, solid carbon char will obtained as byproduct varied from 50gm to 120gm, remaining mass balance quantity is considered as non-condensable gas which exhaust into atmosphere. The liquid from the pyrolysis process undergone for the purification process.

In this purification process, equal ratio of warm water and obtained plastic fuel in a container stirred thoroughly well and allowed it for five-seven hours to settle at bottom of separation flask. Now water along with some impurities, dust, and carbon residue is collected at the bottom and pure plastic fuel is layered at the top of the flask. The further process carried out to determine the pH value of the plastic fuel which obtained after the purification process is using pH meter. If the pH is less than 7, the fuel is acidic in nature. This is improved by adding 100g of KOH with one litter of water and stirred uniformly by using a stirrer. An equal proportion of plastic liquid fuel and dilution of potassium hydroxide in a container and mixed well allowed it for 2-4 hours to settle down. Now along with dilution of potassium hydroxide, some acids are collected at the bottom and acid-free plastic liquid fuel is collected at top of the container. The properties like viscosities and density of different blends were measured using Redwood viscometer at a temperature of 40°C. The flash and fire points of fuel blends were determined using Abel's Flash and Fire Point Apparatus. The calorific value is determined by bomb calorimeter and was tested at Bangalore testing house. The performance and emission test on the CI engine is conducted under some fixed operating condition such as variable compression ratio, variable load and constant speed. AVL DIGAS 444 D gas analyzer is used to find out emission characteristics like HC, CO, CO_2 and NOx. The performance analysis and emission characteristics are determined at a constant speed with different load.

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Fig. 1. Pyrolysis unit.

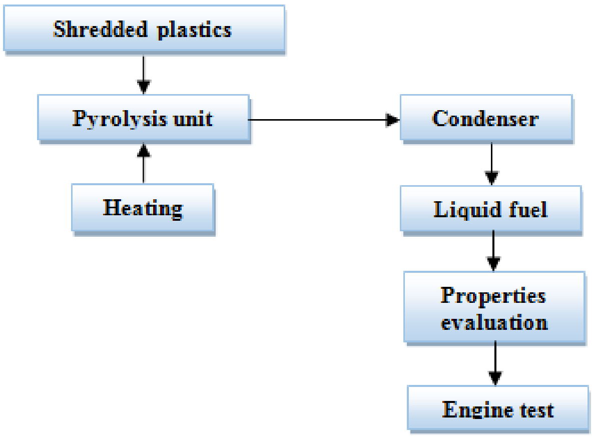


Fig. 2. Pyrolysis process flow chart.

Engine test rig: The produced fuels and its blends with diesel were tested in CI engine with a variable compression ratio, variable load and constant speed operation condition. The specifications of CI engine test rig is tabulated in Table.1. The engine performance and emission test are carried out with two variable compression ratio such as 14:1 and 18:1. Produced plastic fuel is blended with conventional diesel on volume basis namely D95PF05, D90PF10 and D85PF15.

Fig. 3. Engine test rig.

TABLE 1. Engine specification.

Particulars	Details
Engine	Kirloskar
Type	4-Stroke, single cylinder.
Bore	76 mm
Stroke	72.6 mm
Displacement	330 cc
Fuel tank capacity (petrol)	4.5lit
Rated power (kW)	6.02, 1800 RPM
Cooling	Water Cooling
Compression Ratio	6:1 – 12:1
Connecting rod length	190 mm

III. RESULTS AND DISCUSSIONS

TABLE 2. Properties of plastic fuel and its blends.

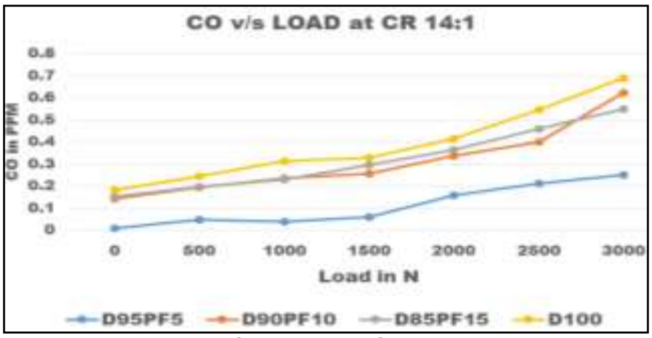
Parameters	PFO	PF05	PF10
Flash point (˚C)	58	61	63
Fire point (˚C)	64	67	68
Kinematic viscosity at 40˚C (mm^2/s)	2.63	4.03	4.37
Density at 40˚C (kg/m^3)	809	812.7	814.3
Calorific value (kJ/kg)	45500	44930	44790

TABLE 3. Properties of plastic fuel and its blends.

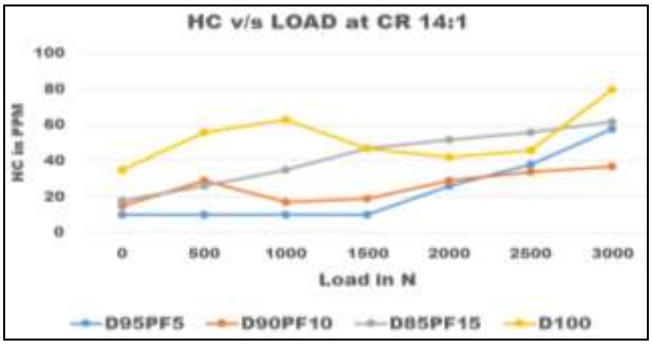
Parameters	PF15	PF100
Flash point (˚C)	66	73
Fire point (˚C)	72	89
Kinematic viscosity at 40˚C (mm^2/s)	4.50	4.55
Density at 40˚C (kg/m^3)	818.8	823.2
Calorific value (kJ/kg)	43580	38832

Table.1 & 2 showing the different properties of plastic fuels and its blends with diesel. The flashpoint and fire point of raw plastic fuel obtained after purification is showing little higher value than diesel fuel. The value kinematic viscosity of the plastic fuel evident that higher viscous than conventional fuels, the problem of higher viscosity can ventilate through making blends with diesel. Experimental results showing that the calorific value of all blends are at the satisfactory range as per the requirement to achieve higher thermal efficiency, but the raw plastic fuel calorific value is slightly lower than any other. The performance emission test was carried out with the different blends of fuel and diesel to obtain good power output with higher efficiency and minimum exhaust emission.

Emission Characteristics



Graph 1. CO v/s Load at CR 14:1.



Graph 2. HC v/s Load at CR 14:1.

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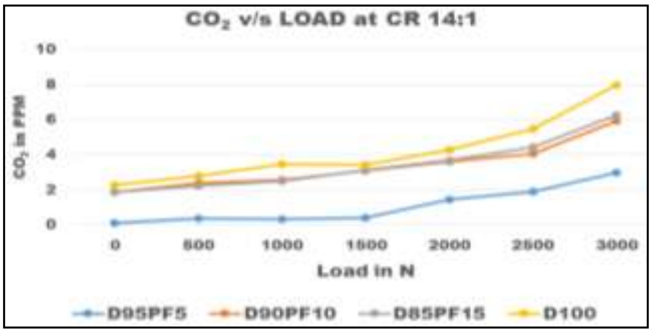
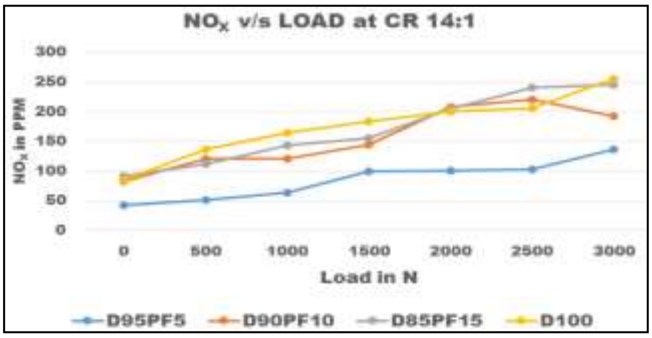
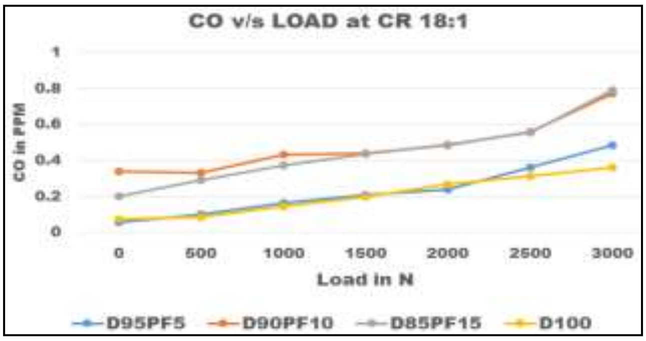


Graph 3. CO_2 v/s Load at CR 14:1.

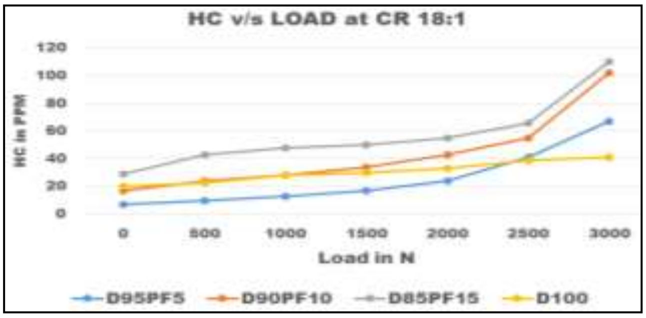


Graph 4. NO_X v/s Load at CR 14:1.

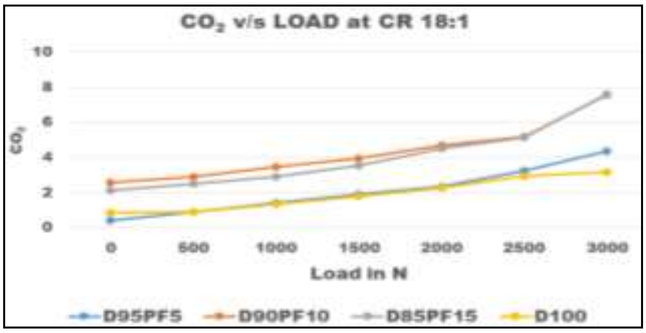
Graph.1, 2, 3 and 4 demonstrating the level of different exhaust emissions obtained from engine test rig at variable load and constant speed at 14:1 compression ratio. The results clearly indicate that the blend D95PF05 gives lesser exhaust emission as compared to remaining blends as well as conventional diesel fuel.



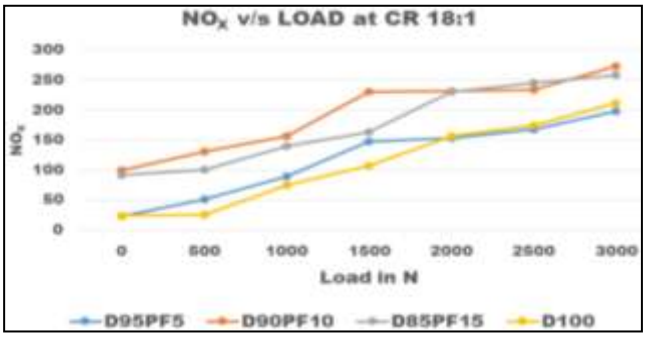
Graph 5. CO v/s Load at CR 18:1.



Graph 6. HC v/s Load at CR 18:1.



Graph 7. CO_2 v/s Load at CR 18:1.

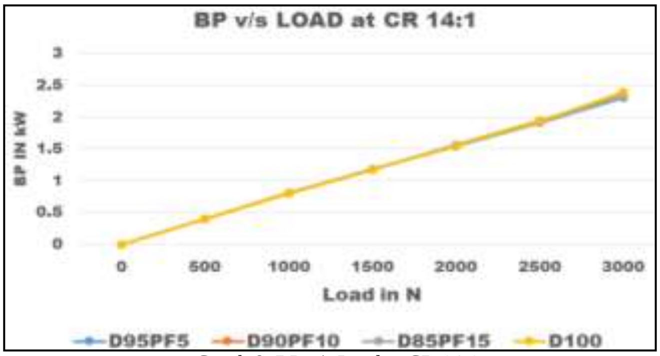


Graph 8. NO_X v/s Load at CR 18:1.

Above graphs 5, 6, 7 and 8 represents the exhaust emissions level for compression ratio 18:1. Results show that the stages of exhaust emission with fuel blend D95PF05 and diesel is always merging each other in certain operating conditions. Increasing load on the engine show the exhaust emission increases dramatically at all operating conditions and different blends of plastic fuel with a diesel. Compared results between the CR 14: 1 & 18:1 indicates the formation of NOx exhaust emission increases with increasing CR and load on the engine due to higher operating temperature.

Performance Parameters

Performance of the CI engine test rig were determined by using a various blend with variable operating conditions. The obtained results of brake power, specific fuel consumption and brake thermal efficiency is demonstrated in below-shown graphics.



Graph 9. BP v/s Load at CR 14:1.

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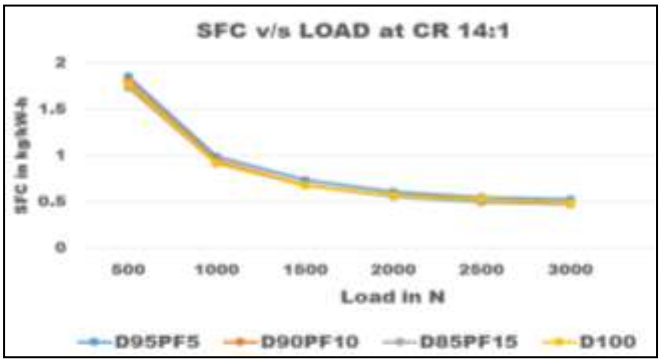
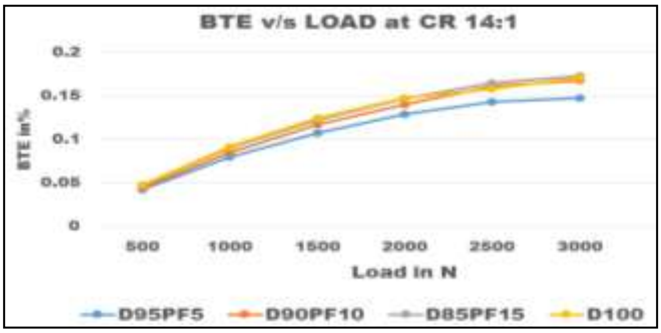
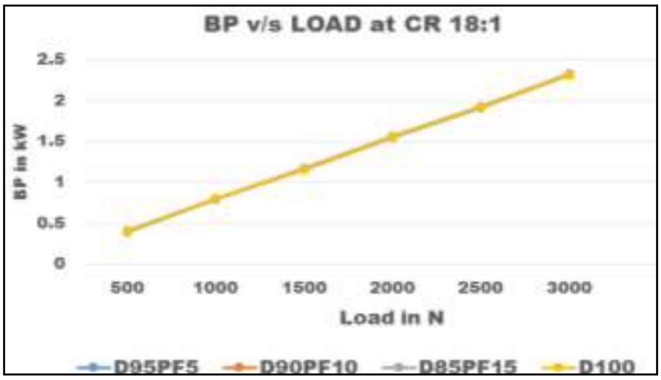


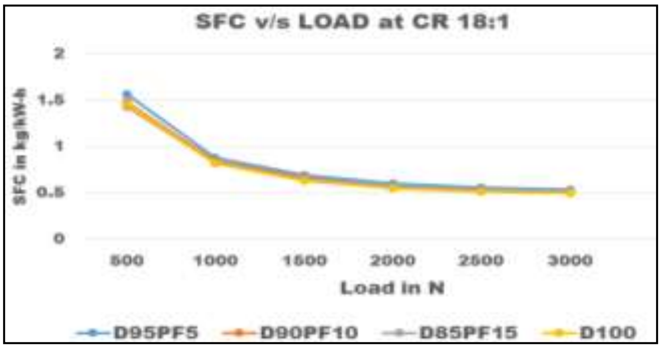
Graph 10. SFC v/s Load at CR 14:1.



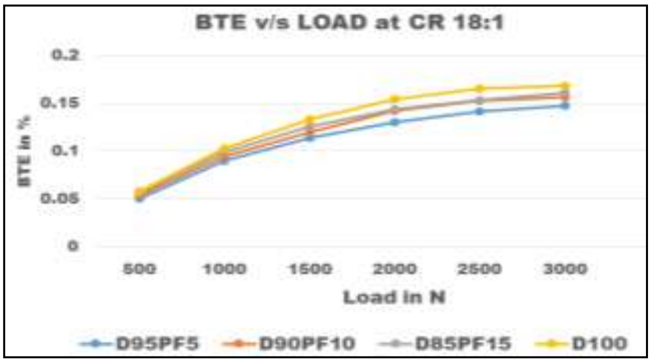
Graph 11. BTE v/s Load at CR 14:1.



Graph 12. BP v/s Load at CR 18:1.



Graph 13. SFC v/s Load at CR 18:1.



Graph 14. BTE v/s Load at CR 18:1.

Graphs no from 9 to 14 illustrates the range of performance parameters at different loading condition with compression ratio 14:1 and 18:1. Number of experimental trails carried out with using different blends. Brake power for the blends at both compression ratio shows almost similar results, and BP for all blends overlap each other even for both compression ratio shown in graphs.9 and 12. Graphs.10 and 13 concludes the level of the specific fuel consumption at low load (500N) with compression ratio 14:1 is slightly higher as compared to 18:1, as load increases engine consumes almost same quantity of fuel with all different blends. It is evident that from graphs.11 and 14 the brake thermal efficiency is bit better with compression ratio 18:1 as compared to 14:1.

IV. CONCLUSION

Adopting polymer technology, efficiently convert weight of waste plastics into useful liquid hydrocarbon fuels without emitting much pollutant. The engine test carried out with plastic liquid fuel blends which are obtained from the waste plastic pyrolysis process. The results shows, almost similar engine performance with different blends as well as diesel fuel. All the emission characteristic shows slightly less for the blend D95PF05 at both the compression ratio. The fuel consumption of the engine was somewhat higher with all blends at low load condition for the compression ratio 14:1 This facilitate to recover valuable product and/or energy from wastes plastics and Perfect solution for waste plastic management. Raw sources are readily & freely available in abundant quantity for the process. Adoption of process can start-up the small scale industry based on the production of biofuel using waste plastics and upon building a small scale industry can create employment.

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