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Experimental Investigation on Compression Ignition Engine with Waste Plastic Oil and its blends with Ethanol

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Abstract

Environmental concern and availability of petroleum fuels have caused interests in the search for alternate fuels for internal combustion engines. In this research work, waste plastics are currently receiving renewed interest. As an alternative, non-biodegradable, and renewable fuel, waste plastic oil is receiving increasing attention. The Present investigation was to study the effect of waste plastic oil and its blends with ethanol in 5%, 10%, 15% and 20%,as WpoE5, WpoE10, WpoE15 and WpoE20,on four stroke, single cylinder, direct injection diesel engine. The results indicated that, upto 10% ethanol adding in the waste plastic oil shows higher efficiency than waste plastic oil and also the smoke, which is the main factor responsible for the environmental pollution from the diesel engine, was minimising with the addition of ethanol in the waste plastic oil.

Keywords: Diesel, ethanol, performance, smoke, waste plastic oil.

Introduction

Recently, diesel engine has received considerable attention because of its high thermal efficiency and low Emission however, The better fuel economy, low green gas emission, much longer life span, less maintenance and reliability are the properties of a diesel engine results in their wide spreads use in transportation, thermal power generation and many more industrial and agricultural application. Despite many advantages, the diesel engine is inherently dirty and is the most significant contributor of pollutant which contributes to serious health problem Particulate matter emission from diesel contributes to urban and regional haze. HC and NOx emission leads to ozone formation at ground level. With the stringent emission standard and limited petroleum reserve hence, it is necessary to look for alternative fuels which can be produced from materials available within the country. Alternative fuels should be easily available at low cost, be environment friendly and fulfill energy security needs without sacrificing engine's operational performance. Waste to energy is the recent trend in the selection of alternate fuels[1].

Fuels like alcohol, biodiesel, liquid fuel from plastics etc are some of the alternative fuel for diesel engine. 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 hence plastics have become essential materials and their applications in the industrial field are continually increasing. At the same time, waste plastics have created a very serious environmental Challenge because of their huge quantities and their disposal problems[2]. 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 derive[3], 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[4].

Ethanol is also an attractive alternative fuel because it is a renewable bio-based resource and it is oxygenated, thereby providing the potential to reduce. Particulate emissions in compression-ignition engines, it can be made from many kinds of raw materials such as corn, maize, sugar beets, sugar cane, cassava, etc[5 6]. In this study, all the experiments were performed without any modification on the engine. The performance characteristics of a diesel engine system were investigated by using waste plastic Pyrolysis oil blends with ethanol in different proportion.

Pyrolysis process for conversion of waste plastic into fuel: Pyrolysis is the chemical decomposition of organic substances by heating the word is originally coined from the Greek-derived elements pyro "fire" and lysys "decomposition". Pyrolysis is usually the first chemical reaction that occurs in the burning of many solid organic fuels, cloth, like wood, and paper, and also of some kinds of plastic. Anhydrous Pyrolysis process can also be used to produce liquid fuel similar to diesel from plastic waste.

Pyrolysis technology is thermal degradation process in the absence of oxygen. Plastic waste is treated in a cylindrical reactor at temperature of 300ºC – 350 ºC. 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.

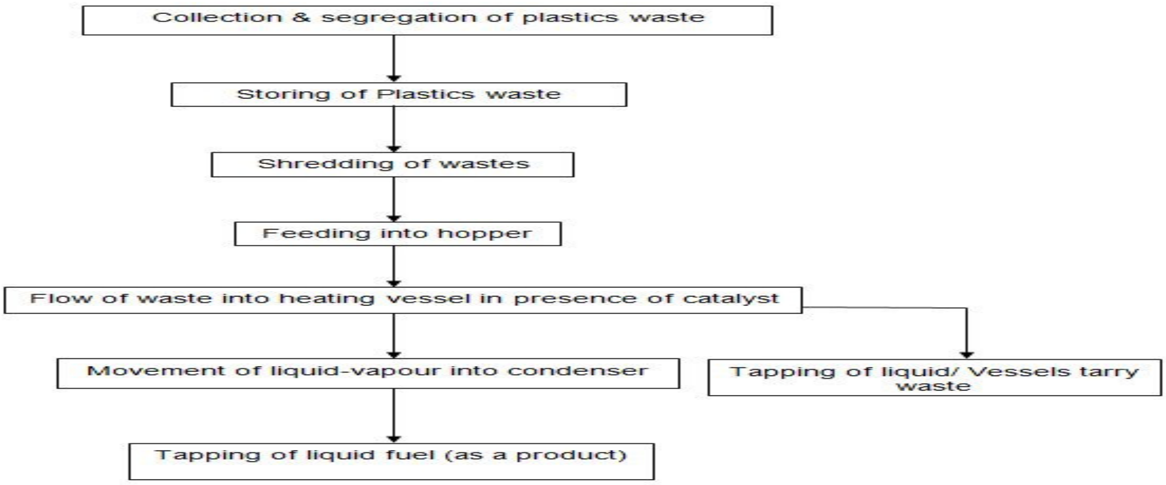

Figure-1
Conversion of Plastics waste into Liquid Fuel

Table-1
Properties of Diesel Waste Plastic Oil and Ethanol

Properties	Diesel	Waste plastic Pyrolysis oil	Ethanol
Density (kg/m^2)	850	795	789
viscosity@40^0	3.4	2.78	1.35
Calorificvalue kj/kg	42,800	41,858	29,700
Cetane number	55	50	7
Flash point	60	50	14
Fire point	82	65	--
Pour point	-4	3-15	--

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 Toxics are burnt. However, the gas can be used in dual fuel diesel-generator set for generation of electricity. The process of oil from waste plastics takes place as shown in (figure 1)

Methodology

The engine used for the experimental study was computerized single cylinder four stroke, air cooled direct injection, compression ignition engine. The engine was started at no load by pressing the exhaust valve with decompression lever and it was released suddenly when the engine was hand cranked at sufficient speed and allowed to stabilize at no load condition. After feed control was adjusted so that engine attains rated speed and was allowed to run (about 5 minutes) till the steady state condition was reached.

All readings, load (kg), fuel consumption (gm), rpm, air flow rate (m^3/sec), temperature of exhaust gas in calorimeter, exhaust gas out from calorimeter, cooling water in calorimeter and temperature of cooling water out from calorimeter were displayed on the computer screen through data acquisition system. The data was logged for no load condition and the calculation table displayed swept volume (m^3/s), actual volume (m^3/s), air/fuel ratio, brake power (kW), brake thermal efficiency (%) and brake specific fuel consumption (kg/kW-min), for no load condition. Load was increased gradually from no load (0kg) to full load condition (15kg). Fuel leakages from the injector were measured with small measuring cylinder but that measurement is omitted in calculation as it is in very small quantity up to full load condition of the engine test. The engine was loaded gradually keeping the speed with in the permissible range and the observations of different parameters were evaluated. Short term performance tests were carried out on the engine with diesel to generate the base line data and subsequently waste plastic oil (neat), 5% ethanol blend with waste plastic oil, ethanol (5%) – waste plastic oil (95%) (WpoE5), ethanol (10) – waste plastic oil (90%) (WpoE10), ethanol (15%) – waste plastic oil (85%) (WpoE15) and ethanol (20%) – waste plastic oil (80%) (WpoE20). were used to evaluate its suitability as a fuel, The load was varied within the interval of 3kg such as, 3 kg, 6 kg, 9 kg, 12 kg and 15 kg. Rope brake type dynamometer was used to load the engine. Load cell measures the value of tension in the rope. All observed data for each load conditions were logged and calculated data was stored.

Results and Discussion

This presents the results obtained from experimental data and these results are thoroughly discussed in subsequent sections.

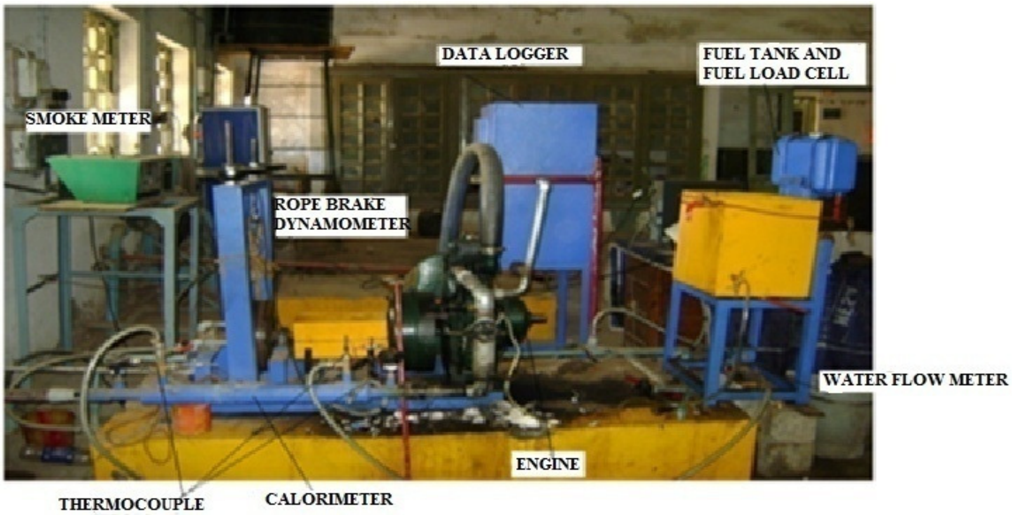

Figure-2
Experimental setup

Table-2
Specifications of Test Engine

Items	Specification
Name of the engine	Kirloskar
General details	Four stroke, Single cylinder, Water cooled, Constant speed, Direct injection
Bore × Stroke	80mm × 110mm
Compression ratio	16:1
Rated output	3.7 kw
Rated speed	1500 rpm

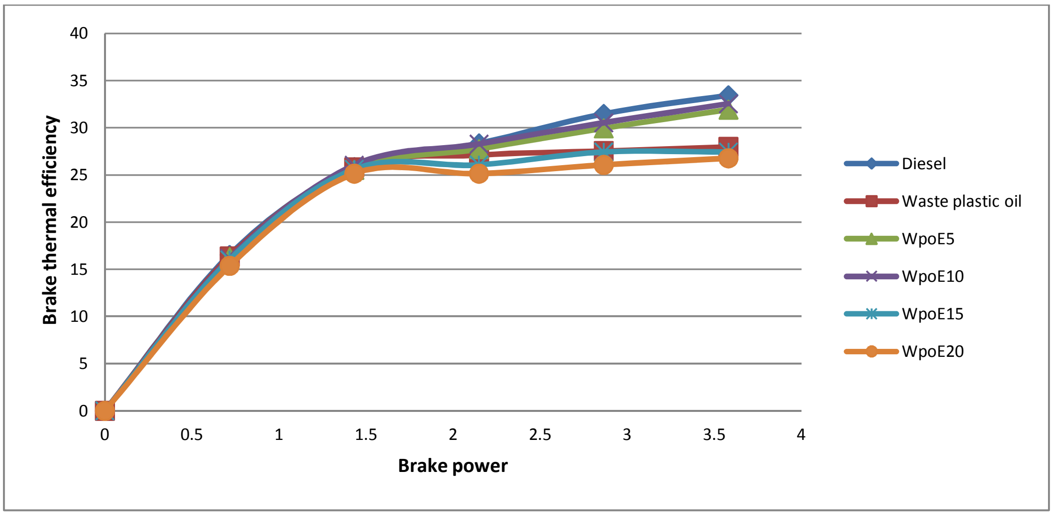

Figure-3
Brake thermal efficiency Vs Brake power

Brake Thermal Efficiency: Figure 3 shows the variation of brake thermal efficiency with brake power of the engine for diesel, waste plastic oil and waste plastic oil – ethanol blends. It can be seen that in beginning with increasing brake power of the engine the brake thermal efficiency of various concentration of blends , waste plastic oil and diesel were increased.The diesel shows the higher efficiency than all other blends and waste plastic oil.it is observed that upto the 10% ethanol in the waste plastic oil shows the higher thermal efficiency than the neat waste plastic oil.

This is due to the oxygen content in the blend improves the combustion of fuel is find but more than 10% ethanol in the waste plastic oil shows the lower thermal efficiency than waste plastic oil this is due to the lower cetane number leads to longer ignition delay and hence incomplete combustion occurs as more fuel burnt in the expnsion strokes and the reduction in the lower heating value of the fuel blends leads to an increase in the volume of fuel injected to maintain the same engine power. Therefore, the WpoE15 and WpoE20 shows lower brake thermal efficiency than all other fuel.

Exhaust Gas Temperature: The exhaust gas temperature of the test fuels with respect to brake power at engine speed of 1500 r/min is shown in figure 4. Exhaust gas temperature for diesel is lower than the neat waste plastic oil and waste plastic oil – ethanol blends. The waste plastic oil has higher heat release rate than diesel thus diesel shows the lower exhaust gas tempreature than waste plastic oil and its blends with ethanol. For complete combustion fuel should be evaporates early as possible as and mixed with air, ethanol has low viscosity. When ethanol added in the waste plastic oil fuel evaporates faster and mixed with the air. It helps the combustion process; WpoE10 shows higher tempreature than all other blends this is due to the complete combustion of fuel it shows 13.62% more EGT than diesel and 3.6% than waste plastic oil.The blend WpoE20 shows lower exhaust gas tempreature than waste plastic oil this is due to the etahnol adding in the waste plastic oil leads to the lower heating value of the blend.

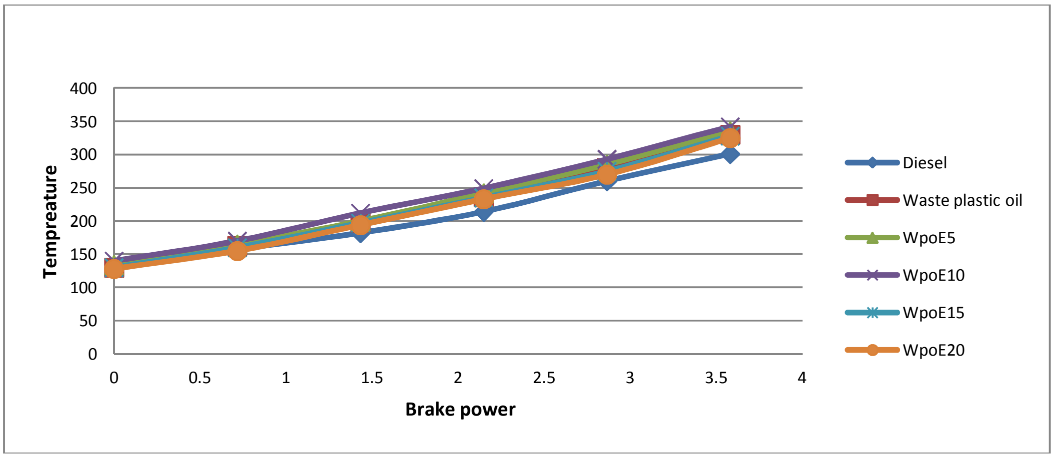

Figure-4
Exhaust gas Vs Brake power

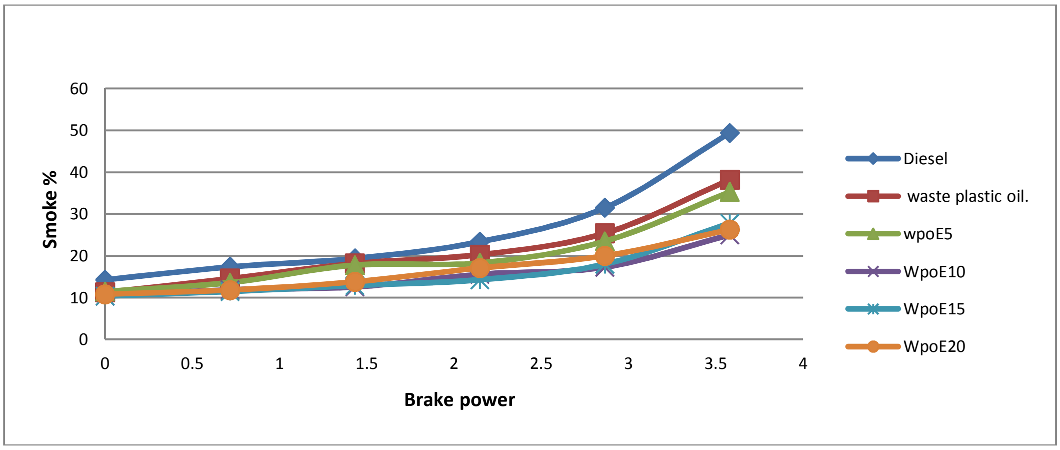

Figure-5
Smoke Vs Brake power

Smoke: The smoke opacity increased with the load for diesel fuel, waste plastic oil and its blends with ethanol. The smoke is formed due to incomplete combustion; The variation of smoke emission in different loads for neat diesel, waste plastic oil and waste plastic oil-ethanol blends is shown in figure 5. Diesel shows the higer smoke than all other fuel further smoke decreased as the ethanol in waste plastic oil increased. Higher combustion tempreature leads to the extended duration of combustion and rapid flame propation are the reason for reduced smoke in waste plastic oil.

Among the blends , WpoE10 shows minimum smoke than other fuels. This is due to the the oxygen content in the fuel increase there would be complete combustion, high combustion temperature and therefore the smoke content in the exhaust is reduced than that of other blend.The blend WpoE20 shows the variation of smoke in between the waste plastic oil and blend WpoE10,this is due to the incomplete combustion of fuel.

Conclusion

The main results obtained on the engine performance by using waste plastic oil and waste plastic oil-ethanol blends are summarized as follows: i. Engine was able to run with 100% waste plastic oil. ii. The brake thermal efficiency of the engine fuelled with WpoE5 and WppoE10 blends were higher than that of waste plastic oil , further all the fuels shows lower brake thrmal efficiency than that of neat diesel. iii. Smoke for the blend WpoE10 is minimum for all loads than that of other blends,waste plastic oil and diesel.

Nomenclture

Wpo	**Waste plastic oil**
WpoE5	95% Waste plastic oil and 5% Ethanol.
WpoE10	90% Waste plastic oil and 10% Ethanol.
WpoE 15	85% Waste plastic oil and 15% Ethanol.
WpoE20	80% Waste plastic oil and 20% Ethanol.

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