PERFORMANCE OF DIESEL ENGINE USING WPO-DIESEL BLENDS: A REVIEW

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ABSTRACT

Environmental issue and availability of fossil fuels have caused interest in the search for alternative fuels for internal combustion engine. Many alternate fuels are tried by various researches and found different conclusion. In this review it is found that for diesel engine, Bio Diesel is most important fuel. In this work comparison between different fuel has been carried out and found that WPO is the better fuel which satisfies our two main objectives, to find best alternatives IC engine and reduce plastic waste on earth.

Keywords**:** Biodiesel; WPO; IC Engine.

INTRODUCTION

The demand for energy, fossil fuel cost and its availability have been increasing un- predictably in the last four decades, as a result of increasing in population. The continuous degradation of the environment is probably due to increased pollutants in the air, water, soil, climate, temperature, and light. The main source of hazardous emissions is originated from the combustion of fossil fuels [17]. By U.S. energy information admistration (EIA report 2016), The demand for oil in India is expected to grow at an average rate of 3.6% over the next 5 year, which will be higher than the average growth rate of around 2% in the world. Import dependence of oil in India, which is presently about 70 %, is likely to increase further during the next 10 year. India was the fourth-largest consumer of crude oil and petroleum products in the world in 2014, after the United States, China, and Japan. The country depends heavily on imported crude oil, mostly from the Middle East. The generation of the electricity is the single largest use of the fuels in the world. More than 60% power generated comes from fossil fuels. International crude price is rising, thus increasing the Petrol and diesel price day by day and growth in population of vehicles increasing greatly. Which may cause greater amount of exhaust emissions, e.g. global warming, acid rain etc. Hence, the research on potential alternative fuels has been growing to meet the energy demand [from EIA report].

In other hand, economic growth and changing consumption and production patterns are resulting into rapid increase in generation of waste plastics in the world. Due to increase in generation, waste plastics are becoming a major stream in solid waste. The explosive growth in the production and everyday use of plastics over the past decades has made plastic waste disposal a serious environmental challenge. In 2015 global plastic production reached 322 million tones, a dramatic increase compared to the 279 million tones produces in 2011. The plastics demand in the European Union was 58 million tones, of which 29.7% was recycled, 39.5% was recovered in the form of energy (mainly incineration) and 30.8% was sent to landfill. However, plastics contain a significant amount of energy due to the crude oil that is used in their production. Moreover, most of the plastics are not biodegradable, therefore by sending them to landfill not only pollute the environment, but also throw away a significant amount of energy that could be used to generate electricity and heat [1]. The consumption of plastic in both household and industrial sectors is enormous and the demand is ever increasing. It has successfully replaced the position of metals and ceramics because of their desired qualities and prolonged life. The plastic consumption of the world has skyrocketed from 5 million tons in 1950s to a staggering 100 million tones today [4]. In recent years, despite many environmentally friendly ways being developed in order to recycle the waste plastics, millions of tones are dumped everyday instead of being recycled [3].

To overcome both of the issues stated above, the alternative fuel i.e. Plastic Pyrolysis Oil can be used in CI Engine. As the CI Engine generally available are designed to work effectively with Diesel Fuel only, to use Plastic Pyrolysis Oil in the CI Engine, one need to blend it with Diesel Fuel [14].

There are two main categories of recycling: mechanical and chemical. Mechanical recycling can be applied mainly to single polymer plastic waste, while chemical recycling can be performed on more complex and contaminated plastic waste. Chemical recycling, or feedstock recycling, aims to chemically degrade plastic waste into its monomers or other chemicals (such as alternative fuels). Chemical recycling can be achieved by conventional refinery processes such as gasification, pyrolysis, hydrocracking and catalytic cracking [1]. The pyrolysis process is one of the most promising technologies in the conversion of waste plastics into high quality oil. pyrolysis, plastic polymers are thermally degraded by heating them in the absence of oxygen.

Pyrolysis/Thermal Degradation

Pyrolysis is a procedure of thermal degradation of material without oxygen. Plastic is sustained into a cylindrical chamber. The pyrolytic gasses are condensed in a specially designed condenser framework, to yield a hydrocarbon distillate involving straight and stretched chain aliphatic, cyclic aliphatic, and fragrant hydrocarbons, and fluid is isolated utilizing fragmentary refining to deliver the fluid fuel product.

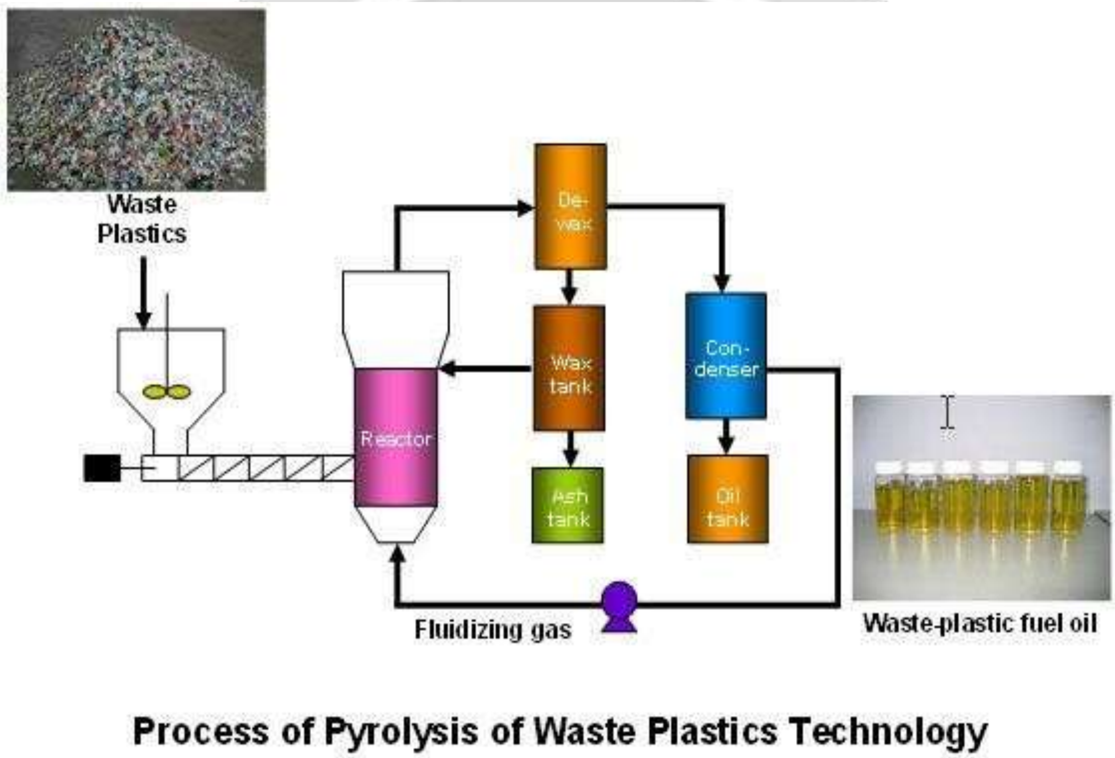

Fig.: Process Of Pyrolysis Of Waste Plastic.

Advantages of Pyrolysis process

(a) Volume of the waste plastic is reduced (<50–90%),

(b) Solid, fluid, and gaseous fuel can be delivered from the waste,

(c) storable/transportable fuel or chemical feed stock is gotten,

(d) Environmental issue is reduced,

(e) Desirable process as energy is obtained from renewable sources like municipal solid waste or sewage slime,

(f) The capital cost is low.

The process flow chart:

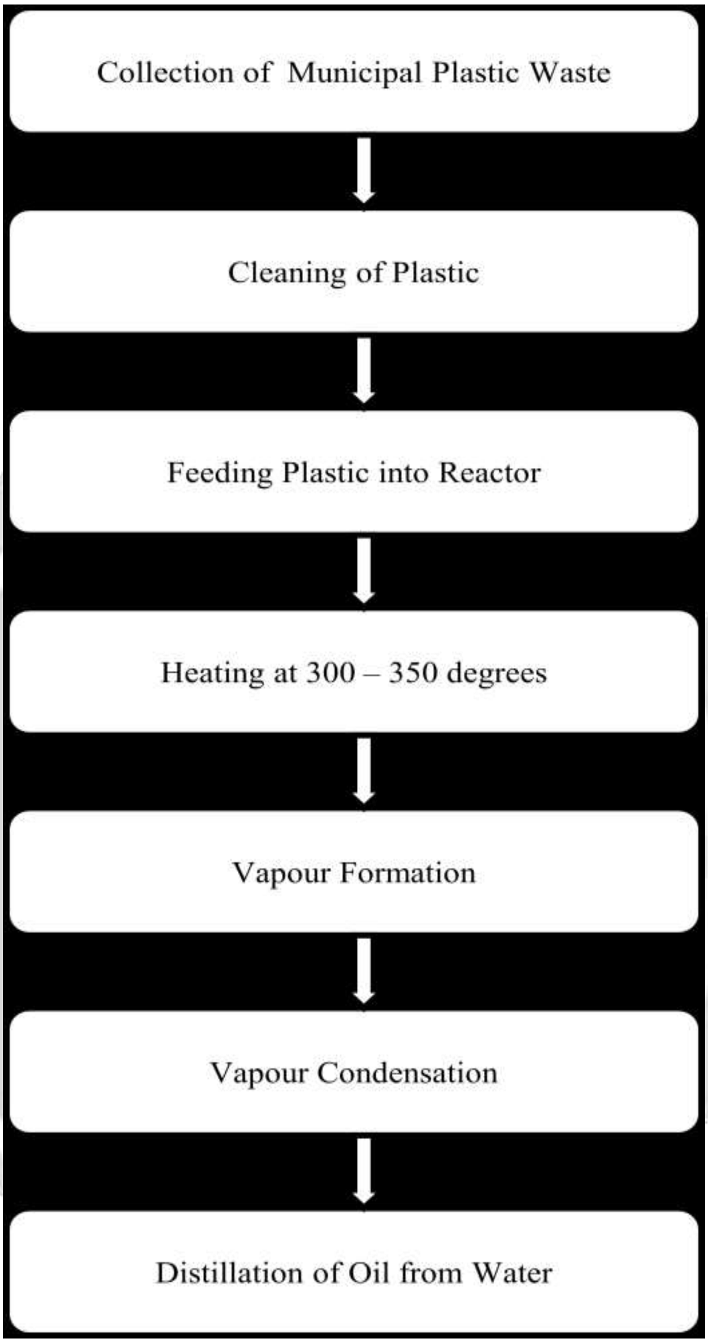

Fig 1: The process flow chart

Property of Waste Plastic Pyrolysis Oil and Diesel

Table 1: Property Of Waste Plastic Pyrolysis Oil And Diesel.

Sr. no.	Property	WPPO	Diesel
1	Density(kg/m3)	793	850
2	Ash content (%)	<1.01%wt	0.045
3	Calorific value(kJ/kg)	41,80	42,000
4	Kinematic viscosity @40C	2.149	3.05
5	Cetane number	51	55
6	Flash point °C	40	50
7	Fire point °C	45	56
8	Carbon residue (%)	0.01%wt	0.20%
9	Sulphur content (%)	<0.02	<0.035
10	Pour point °C	-4	3-15

Produced Plastic Pyrolysis Oil

- Black in color,
- Strong burned rubber smell,
- It can replace diesel and reduce waste plastic disposal problem,
- Higher oxygen content.

Fig 2: Plastic Pyrolysis Oil

LITERATURE SURVEY

Research or innovation regarding any of the subjects can be made possible only through the knowledge of past work related to the same field. So, work carried out by the eminent personalities will always be the steppingstone for the future revelations. Required preparation before carrying research work can be made well by discussing the previous work carried out by the researchers in the various fields which are related to topic.

This chapter presents the detailed literature review on Waste Plastic Waste, Recent problems of available Alternate Biofuel and use of Waste Plastic Oil as a replacement of Diesel in Compression Ignition Engines.

Literature Review on Various Types of Bio-Oils' Blends Used along with Diesel in C.I. Engine

Murugan et al. have invented that the engine is able to run up to 90% DTPO and 10% DF (DTPO 90). Engine failed to run satisfactorily with 100% DTPO. Brake thermal efficiency increases with increase in percentage of DTPO blends but lesser than DF. About 1–2% drop in the thermal efficiency is noticed for DTPO 20 and DTPO 90 operations compared to DF. NO_x is lowered by about 22% and 18% in DTPO 20 and DTPO 90 respectively than that of DF operation. HC emission is higher by about 7% and 11% for DTPO 20 and DTPO 90, respectively at full load than that of DF operation. Smoke is higher for compared to DF. Ignition delay is 1.4–2.5 LCA longer for DTPO–DF blends compared to DF at full load. Cylinder peak pressures are higher by about 2.8bar for DTPO 90 and 3.2 bar lesser for DTPO 20 than that of DF operation. Higher rate of heat release in the initial stages and rate of pressure rise are observed in the DTPO 90 blends compared to DF. **(Murugan, Ramaswamy & Nagarajan, 2008)**

Yasin et al. studied on fuel properties for biodiesel and its B20-alcohol blend fuels when being compared as an increase in biodiesel concentration is greatly increased the density and viscosity of the biodiesel blend fuel, B20.A small concentration of alcohol, 5% and 10% by volume diluted in B20 blend fuel significantly reduced viscosity and density of the B20 blend fuel. However, as a result, flash point and Cetane number are increased.**(Yasin et al. 2013)**

Imtenan et al. have found comparative evaluation of the improvement of DP20 was done while blended with additives. These additives improved the fuel blend regarding density and viscosity which in turn improved atomization and showed better combustion characteristics through higher engine brake power, lower BSFC and higher BTE than DP20. Among the additives diethyl ether showed highest improvement through its less density and viscosity profile with quite a high calorific value. N-butanol showed quite similar development to diethyl ether but ethanol showed less development because of its lower calorific value. Regarding emission characteristics additives showed quite a good development of CO and NO emission. CO emission decreased for higher oxygen content and NO decreased for lower calorific value and higher latent heat of evaporation of the additives. So ethanol, *n*-butanol and diethyl ether are quite effective regarding emission and performance even when they are used only about 5% as additive.**(Imtenan et al. 2014)**

Mofijur et al. have stated in their research study that Emissions are strongly depended on engine operating conditions and biofuel concentration in the blend. Combined blends of biodiesel-diesel-alcohol reduce NO_X and HC significantly. The peaks of smoke emissions were reduced in a large extent with the increase of percentage of ethanol in blended fuels. Contrary to traditional belief, NO_X and PM emission both reduced due to the use of mixed blends. Addition of ethanol into the biodiesel-diesel blend lowered particle number concentration and particulate mass emission as well. The use of ethanol in the biodiesel-diesel blend showed higher fuel consumption than that of diesel fuel.**(Mofijur, Rasul & Hyde, 2015)**

Kumaravel et al. have observed in their research study blends of pyrolysis oil of waste tyres TF5, TF10, TF25 and TF35 can used in engines without any modifications. CO, HC, SO_2 and smoke emissions were higher than the diesel fuel for TF50, TF75, and TF100.Ignition delay is longer for TPO–DF than DF and peak pressure and rate of pressure rise for TPO–DF blends are higher compared to DF.**(Kumaravel, Murugesan, and Kumaravel 2016)**

Literature Review on Waste Plastic Oil Used as an Alternate Fuel in Diesel Engine

Mani et al. have invented in their research work that the engine could operate with 100% waste plastic oil and can be used as fuel in diesel engines. Oxides of nitrogen (NO_x) were higher by about 25% and carbon monoxide (CO) increased by 5% for waste plastic oil operation compared to diesel fuel (DF) operation. Hydrocarbon was higher by about 15%. Smoke increased by 40% at full load with waste plastic oil compared to DF. Engine fueled with waste plastic oil exhibits higher thermal efficiency up to 80% of the full load and the exhaust gas temperature was higher at all loads compared to DF operation.**(Mani, Subash, and Nagarajan 2009)**

Mani at el. have stated in their research work that WPO exhibits a higher cylinder peak pressure compared to diesel. The heat release rate with WPO is higher compared to DF due to better combustion. With an increase in percentages of WPO, NO_x increases due to the higher heat release rate and combustion temperature. Hydrocarbon is higher for WPO. Smoke for WPO increase by about 35%e40% throughout the load spectrum compared to diesel. Engine with WPO results in better performance than blend of WPO and diesel.**(Mani, Nagarajan, and Sampath 2011)**

Kalargaris et al. have investigated for low viscous oil that the engine was able to operate stably on LDPE700 and EVA blends.LDPE700 has very similar combustion characteristics with diesel, while EVA blends have slightly longer ignition delay period, lower cylinder peak pressures and longer combustion period. The engine's brake thermal efficiency marginally reduced when LDPE700 was used in comparison with diesel and decreased by 1.5–2 % when EVA blends were used. LDPE700 produced lower NO_x, CO and CO_2 emissions than diesel and higher UHC, while EVA blends produced higher NO_x and UHC emissions and lower CO and CO_2 in comparison to diesel. They have shown that for long-term running LDPE700 would be preferable at all engine loads without the addition of diesel or any modification to the engine. EVA900 has good combustion characteristics but for long-term use it should be taken into consideration the high acidity.**(Kalargaris, Tian & Gu, 2017b)**

Kalargaris et al. The engine was able to operate steadily on PPO 100 at loads higher than 75%, on PPO 90 for loads higher than 50% and on lower PPO blends for all loads. PPO blends have longer ignition delay, higher cylinder peak pressure and higher heat release rate. The thermal efficiency decreased by 3–4% when PPO blends were used in IC engine. But increasing PPO ratio does not have a significant impact on thermal efficiency. All measured emissions, including NO_X, UHC, CO and CO_2, increase with higher PPO blending ratio. For low to medium blending ratios, the increases of NO_X and CO are mild.**(Kalargaris, Tian, and Gu 2017a)**

Literature Review on Various Performance Parameters of Diesel Engine Modified while Operating on Different Types of Bio-Diesel

Mani et al. have Concluded that the influence of injection timing on the performance, emission and combustion characteristics of a single cylinder, four stroke, direct injection diesel engine has been experimentally investigated using waste plastic oil as a fuel. Tests were performed at four injection timings (23, 20, 17 and 14 bTDC). When compared to the standard injection timing of 23 BTDC the retarded injection timing of 14 bTDC resulted in decreased oxides of nitrogen, carbon monoxide and unburned hydrocarbon while the brake thermal efficiency, carbon dioxide and smoke increased under all the test conditions**.(Mani and Nagarajan 2009)**

Ioannis Kalargaris et al. have investigated that the combustion performance and emission characteristics of a diesel engine gen-set running on oils derived from the pyrolysis of plastics at 700 $^{\circ}$C and 900.. The engine was able to operate stably on PPO700 and PPO900 blends at 75%, 85% and 100% load. PPO900 had a significantly longer ignition delay period, higher peak heat release rate and shorter combustion period compared to PPO700.The engine brake thermal efficiency was 3-4% lower for PPO900 and 2-3% lower for PPO700 in comparison to diesel. All measured emissions (NO_X, UHC, CO and CO_2) were higher for PPO700 and PPO900 compared to diesel, however the highest emissions were produced by PPO900.**(Kalargaris, Tian, and Gu 2017c)**

Kaimal et al. have concluded in their research work that the diesel engine can be operated using 100% plastic oil and Rice bran methyl ester. But the thermal efficiency of the engine is low when run with PO and RME compared to that of diesel. The BSEC of waste plastic oil is less when compared to diesel and RME. The cylinder pressure and peak pressure of engine while using plastic oil and RME are higher than diesel. The peak heat release rate is high for both PO and RME when compared to diesel. The higher heat release of neat plastic oil and RME during the rapid combustion phase. Ignition delay for diesel is less when compared to RME and plastic oil. The lower cetane number and higher viscosity of the oils affects the proper mixing of air and fuel increasing the delay period**(Kaimal and Vijayabalan 2015).**

Nileshkumar et al. have experimented that Efficiencies are increasing and fuel consumption is decreasing with increase in blend proportion. But at the same time there is much hike in exhaust emission after 30 % blend proportion of plastic pyrolysis oil. Results of 20% blend proportion of plastic pyrolysis oil are nearly similar to diesel fuel. But increase in exhaust emission is having major value than increase in performance after 30% blend of plastic pyrolysis oil. So they considered Performance and Exhaust Emissions, 30% Blend of Plastic Pyrolysis Oil is having optimum values than other Blend Proportion of Plastic Pyrolysis Oil and Diesel Fuel.**(Nileshkumar, Patel, and Rathod 2015)**

Concluding Remarks on Literature Review

From the above referred research paper it is concluded that, The performance and emission analysis for various vegetable oil, waste oil and gasses were conducted by numerous specialist to find blended fuel for diesel engine. Dimethyl ether, ethanol can be utilized to enhance performance and to decrease discharge from diesel engine. In recent trend waste to energy is another concept. Pyrolysis oil is a low cost fuel produced using Plastic waste and tire waste. This oil can likewise be utilized as a blended fuel for diesel engine. Engine run with waste plastic pyrolysis oil has more thermal efficiency up to 50% of the rated power for petrol engine and 75% for Diesel engine. Brake thermal efficiency of the engine run with waste plastic oil with retarded injection. timing is observed to be higher.

So inferred that the waste plastic Pyrolysis oil represent to a decent alternative fuel for diesel and in this way should be taken in to consideration in the future for transport reason.

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