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Feasibility Study of Conversion of selected Plastic in to Synthetic Fuel (Synthetic Diesel) – A Review

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Abstract

Plastic has become an important part of our daily life. Due to its wide applications e.g. strength, durability, lighter weight and flexibility, consumption and production of plastic has been rising very rapidly. But plastics are non biodegradable in nature hence its disposal has become a major problem because it cannot be dispose off directly into the environment. So, researchers are working on new technologies to treat the plastic waste. One of very common process is pyrolysis. Batch reactor is used in pyrolysis process in which temperature ranges between 350 to 500^{0}C in atmospheric pressure. The aim of the study is to convert the mixed plastic waste into crude oil which can be use as hydrocarbons fuel. In the present paper waste plastic pyrolysis oil and its blend with diesel has been introduced as an alternative fuel. Waste plastic oil (W.P.O.) was tested as a fuel in a D.I. diesel engine and it is observed that the engine could operate with 100% waste plastic oil and can be used as fuel in diesel engines.

Keywords: Pyrolysis, Alternative fuel, mixed waste plastics, oil/waxes, waste plastic oil and Diesel engine.

Introduction

Generation of plastic waste in the world is increasing continuously due to Industrial growth and changed in consumption and production patterns. Rapid urbanization and economic development have been resultant as increment in plastic consumption in Asia pacific and other developing regions. Due to higher population growth rate waste plastic and its management has become a major problem. Cities having low economic growth are also participating as larger producer of waste plastic in the form of plastic packaging material, poly shopping bags, P.E.T. bottles and other house hold items containing major percentage of plastic material. So it is necessary to find the alternative ways for the disposal of mixed waste plastic. After so many research and studies it has been found that properties of crude oil derived from waste plastic are similar to the existing hydrocarbons and can be use in diesel engines or for energy production.

Plastics are synthetic organic material and mainly produced by polymerization. Molecular mass of plastic is high and it is possible that to improve the quality and performance and to reduce the cost plastic may contain other substances. Polymers of Plastic are much softened and can be extruded into required shapes. Plastics are synthetic polymers that can be shaped by heat or pressure. There are two main types of plastics, which are Thermoplastic and Thermoses. Approximately 85 to 90% of plastic from our daily life can be recycled or use for the production of synthetic fuel. In order to decrease the volume of non degradable plastic waste material and preserving valuable petroleum resources Pyrolysis is one of the best methods. It is also help full in environmental protection. Because of higher conversion rate of fuel from plastic waste pyrolysis process is in favored.

Pyrolysis System involved, Thermal processing in complete absence of oxygen (at low temperature). Pyrolysis also referred to as destructive distillation or carbonization. It is the process of thermal decomposition of organic matter at high temperature (about 350 to 500^{0}C) in an inert atmosphere or vacuum, producing a mixture of combustible Carbon monoxide, Methane, Hydrogen, Ethane gases, pyroligenous liquid, chemical and Charcoal. Thermal treatment involves conversion of waste in to gaseous, liquid and solid conversion products with concurrent or subsequence release of heat energy. To improve the quality of crude oil from waste plastic pyrolysis so many studies have been carried out by researchers. Objective of this study is to introduce a suitable catalyst into the process to yield the efficiency of product. These catalysts are mainly used in petrochemical industries. The experimental setup on laboratory scale for the pyrolysis is mostly flow reactor; which consist of 'liquid phase contact' and 'vapor phase contact'. In liquid phase catalyst reacted with melted plastic and acted as partially degraded oligomers; in vapor phase catalyst reacted with hydrocarbon vapors which are thermally degraded.

Composition and properties of Crude oil from waste plastic:
Crude oil from waste plastic has made by mixed organic compounds. When compared with diesel plastic oils sulphur content and calorific value is low. W.P.O. contents about 70-75% liquid hydrocarbons which included petrol, diesel and kerosene, small amount of residue coke and L.P.G. Table 1 is showing the Properties of W.P.O. and Diesel.

In this paper Pawar Harshal[1] et al. carried out study on pyrolysis process for conversion of waste plastic into fuel in the absence of oxygen. The process concluded that, Engine can run with full efficiency by fuel made from waste plastic**,** Engine fuelled with W.P.O. shows thermal efficiency up to 75% of the rated power and Brake thermal efficiency of the engine with retarded injection timing is found to be higher. Injection timing results the thermal efficiency is 28.2% at full load for standard injection timing and 32.25% for the retarded injection timing of the waste plastic oil, shown in figure 1.

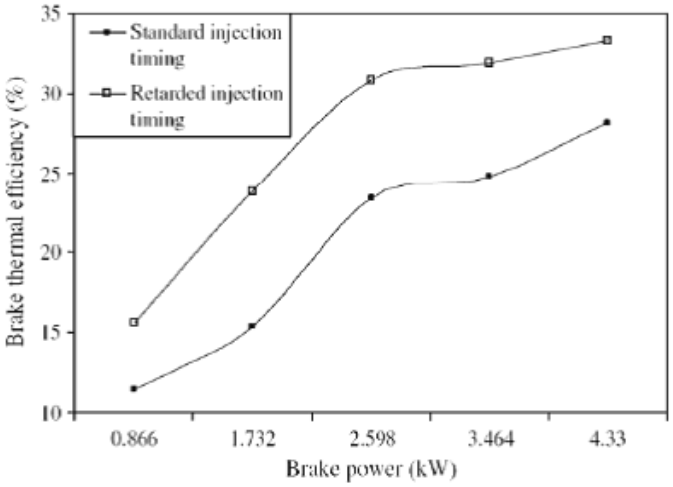

Figure-1
Variation of brake thermal efficiency with brake power

At full load the brake thermal efficiency decreases with increase in E.G.R. (Exhaust gas recirculation) flow rate, shown in figure 2. The exhaust gas temperature for plastic oil is higher than diesel and the NO_x emission in waste plastic oil varies from 8.56 to 14.63 g/ kWh without E.G.R. compared to 10.97–8.2 g/kWh with 20% E.G.R. The NOx emission reduces with increase in E.G.R. percentage.

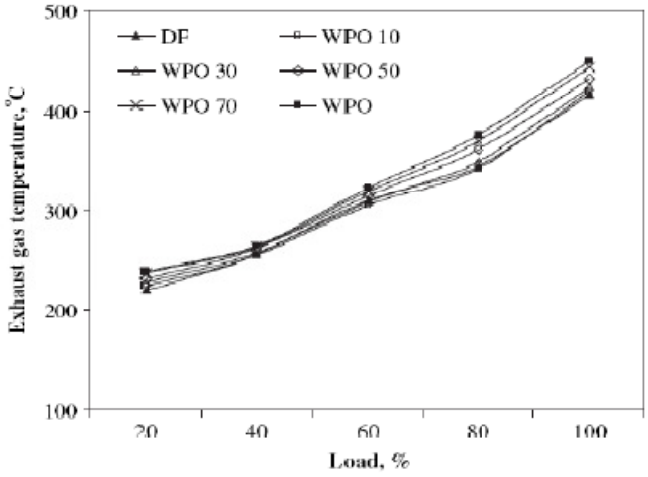

Figure-2
Variation of exhaust gas temperature with load

Table-1
Properties of Waste Plastic Pyrolysis Oil and Diesel

Sr. No	Properties	W.P.O.	Diesel
1	Colour	Yellow	Orange
2	Density(kg/m2)	793	850
3	Ash content (%)	<1.01%wt	0.045
4	Calorific value(kJ/kg)	41,800	42,000
5	Kinematic viscosity @ 40^0C (cst)	2.149	3.05
6	Cetane number	51	55
7	Flash point ^{0}C	40	50
8	Fire point ^{0}C	45	56
9	Carbon residue (%)	0.01%wt	0.20%
10	Sulphur content (%)	<0.002	<0.035
11	Pour point ^{0}C	-4	3-15

In this paper Pouya Mohammadi[2] et al. are investigating the performance parameter for engine**.** The literature consists of calculations and formulation for brake power, brake mean effective pressure, brake specific fuel consumption, brake thermal efficiency and brake fuel conversion efficiency.

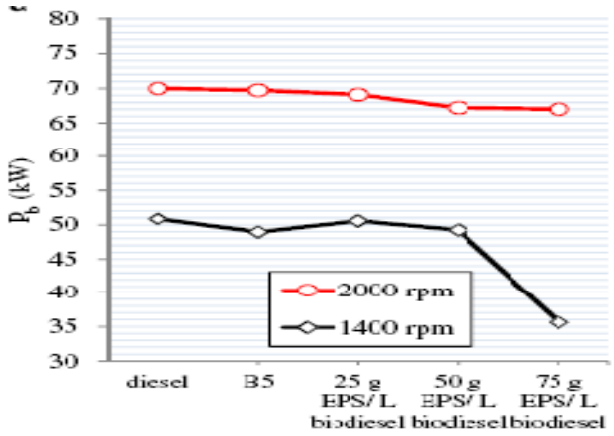

Figure-3
Brake Power Vs speed at max_m load

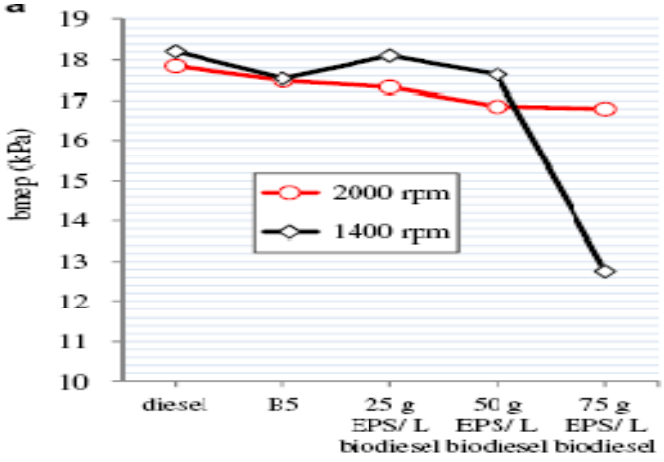

Figure-4
Brake mean effective pressure Vs Speed on max_m load

As speed increases Break power will also increase. At maximum load and speed (2000 rpm) increasing order of break power is 0.36, 1.26, 3.95 and 4.26% which is shown in Figure-3. Figure-4 is showing increase in Brake mean effective pressure that is 2.07, 2.95, 5.60 and 5.89% and decrease in fuel consumption is shown in next Figure- whose percentages are 1.3, 7.4, 8.5 and finally 9.1%.

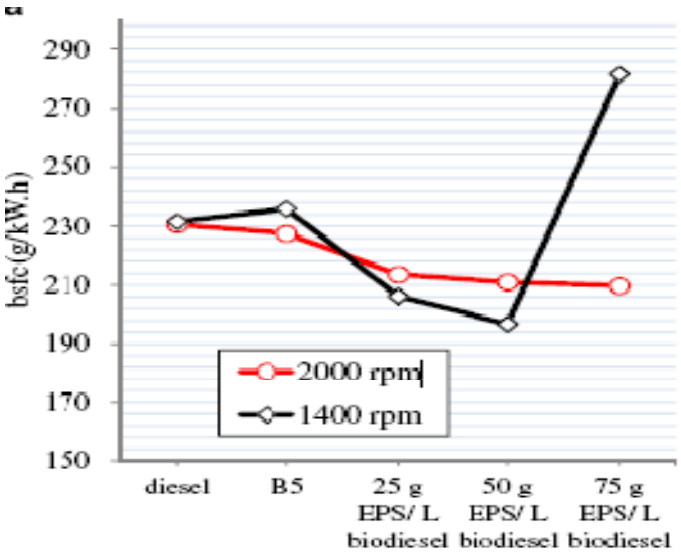

Figure-5
Brake specific fuel consumption Vs speed at max_m load

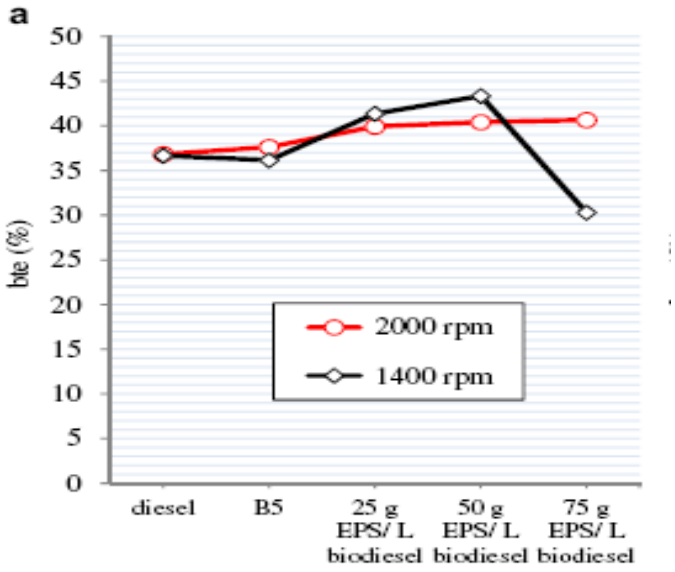

Figure 6
Brake thermal efficiency Vs speed at max_m load

It is clear from Figure-6 that Brake thermal efficiency (B.T.E.) is nearly constant at all levels. On addition of 25 EPS/L of Biodiesel B.T.E. is 8.4, at 50 EPS/L B.T.E. are 9.8 and at 75 EPS/L it enhanced by 10.4% respectively.

In this paper sahu Omprakash[3] et al. studied the fuel oil production from waste plastic. He shows the Structure of polymer material and Effect of temperature on L.D.P.E., Fuel oil etc.

Temperatures effect on Low density Polyethylene (L.D.P.E.)

Temperatures Effect on fuel oil: At different temperatures 1Kg polyethylene was cracked in the reactor and variations in reaction time are noted**.** At different temperatures production of gases is also change. Figure-7 is showing gaseous change and amount of residue left at that temperature. Here, at 180^{0}C gases and residues separation is starts and after 205^{0}C production of gases is 50.5 % and residue is 48.5%. At 210^{0}C gaseous product is about 52% and residue is 46.8%. At last at the temperature 250^{0}C the residue is about 44.9% and gas production is 53%.

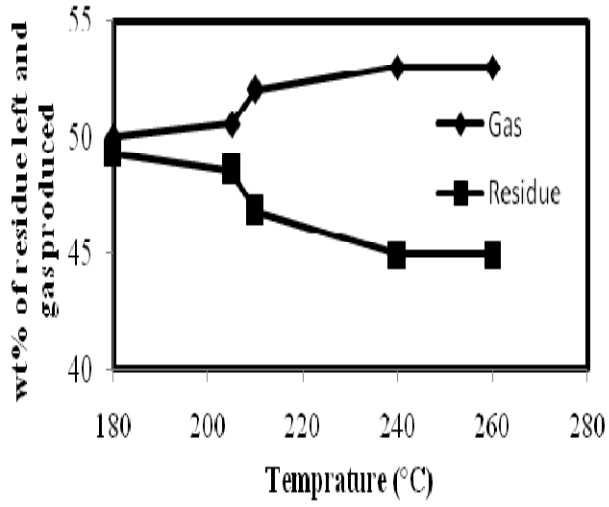

Figure-7
Temperature effect on gas production and residue Left

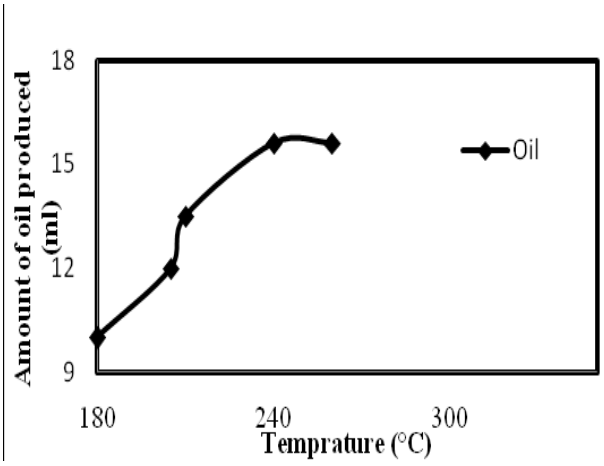

Figure-8
Temperature effect on the oil production

Figure-8 is showing production of crude oil at different temperatures. Oil production is increases with temperature increment and after a certain temperature production of crude oil keeps constant.

Temperatures effect on High density Polyethylene (H.D.P.E.)

H.D.P.E.: Measured quantity (1Kg) of plastic material is heated into the reactor with temperature variations and Crude oil produced during the process is collected. Residue left during the reaction is also separated at the end of the process. Figure-9 is showing temperatures effect on oil production from High density Polyethylene. In the starting oil production is increases with temperature and after a certain temperature oil production became constant.

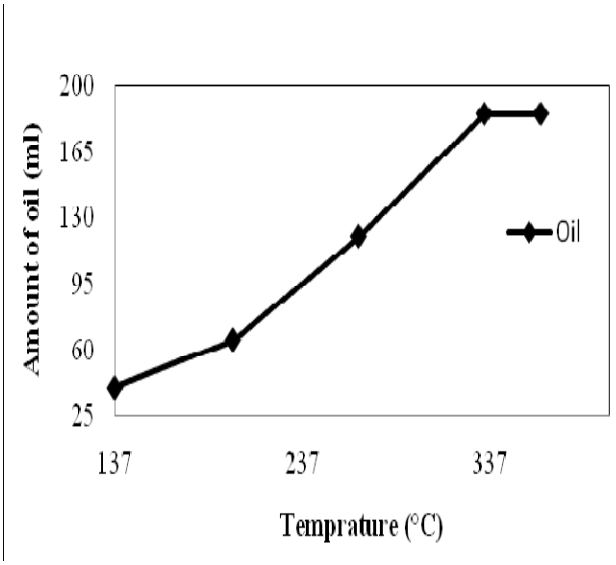

Figure-9
Temperature effect on the Crude oil Production from HDPE

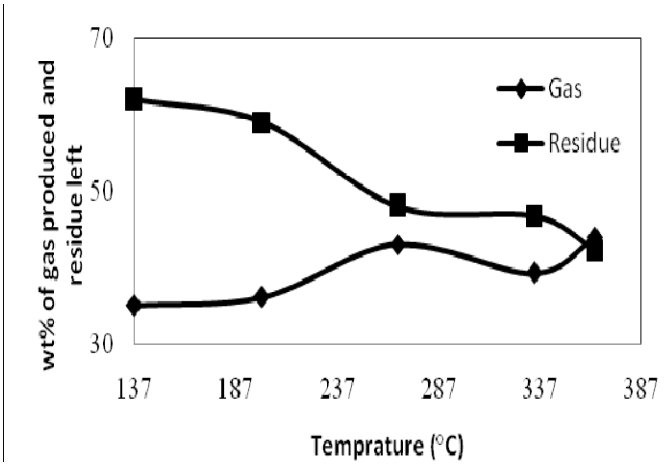

Figure-10
Temperature effect on the distribution of residue and produced gas

Above 135^0C weight percent of produced gas and residue left were approx 32-36% and 60-65%. Rate of plastic cracking is increases at high temperature hence gas production is also increases and the amount of residue left is almost nil.

Conclusion

From the review of all above papers for the performance and emissions of W.P.O**.,** it is concluded that the waste plastic Pyrolysis oil represents a good alternative fuel and therefore must be taken into consideration in the future for transport purpose. This plastic oil has compositions similar to the existing primary hydrocarbons (i.e.-petrol, diesel and gasoline). Possible these oil products can be use directly for energy generation or in a refinery for reprocessing. The study of this papers conclude that prospects for using small or medium scale pyrolysis processes to handle the waste plastics appear good but more investigations are needed. Presences of P.E.T. and P.V.C. in mixed plastic waste are also a matter of concern. Contaminants and additives present in municipal plastic waste have adverse effects on environment and they should be removed before process

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