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WASTE PLASTIC FUEL REPRESENTS A GOOD ALTERNATIVE FUEL FOR DIESEL ENGINE

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ABSTRACT

Plastic waste component of the urban solid waste is quite problematic. As it is non-biodegradable it can stay in the environment for a longer time causing severe environmental degradation. Recycling of plastics is seen as one method for reducing environmental and resource depletion. Pyrolysis is one of the most versatile process which convert plastic materials into smaller molecules usually liquids or gases which are suitable for use of new petrochemical product and have proven to useful in production of fuel. Pyrolysis involves the degradation of the polymeric materials by heating in the absence of oxygen. This study investigated the characteristics of pyrolysis liquid fuel produced from polypropylene plastic waste for different temperatures. Pyrolysis was carried out on 400 grams of polypropylene plastic waste at the operating temperature of 230°C, 280°C , 330°C , 380°C , 430°C , 480°C for one hour. The liquid products were found to have carbon chain length in the range of C8-C9 , similar with gasoline. The maximum density, volume and calorific value of the oil obtained were 0.82 gm/cc, 85 ml and 1650 Cal/gm respectively. Depletion of non-renewable source of energy such as fossil fuel at this stage demands the improvements of the chemical recycling technique. Based on the properties of the plastic fuel and diesel fuel all the properties are nearly same , so the waste plastic fuel represents a good alternative fuel for diesel engine.

Key words :- Degradation , Polymeric , Incineration , Pyrolysis , Recycling.

INTRODUCTION

Plastic is undoubtedly to reign among the variety of materials for its varied applications. Consumption of plastic in India would increase by 20 percent in the last FY-2017-18 to reach 178 Lakh Tonne in both organized and unorganized sector [1] . Modern lifestyle of the human being and an urgent need for the comfort , plastic production and consumption are increasing day by day. Plastics have grown into a major industry that affects all of our lives which provide packaging materials to textile and new technology such as TV , cars , computers. Plastics have replaced traditional material like cloth paper for packing and carry bags because of the low cost. As the urbanization is increased growth , consumption of plastic and plastic waste are also increased. The plastic waste is now considered as an environmental hazard due to " throw away culture ". This throw away culture results in drainage blockage of water born disease in all cities. Littering reduces

rain water percolating. Soil fertility down due to land filling with plastic bags. In big oceans life of fish and other animals is under risk due to throw away culture of plastics into the sea. Plastic degrade gradually since the molecular bonds containing Carbon , Hydrogen , Nitrogen , Chlorine and other elements that make plastic very durable. The disposal of plastic by land filling and incineration will lead to environmental pollution. Thermoplastics are general purpose plastics used in our daily lives and usually end up as municipal solid waste with 96% of compound being consists of Polyethylene (PE) , Polypropylene (PP) , Polystyrene (PS) , Polyvinylchloride (PVC) . [2]. Therefore alternatives are seen to reduce the impacts of plastic waste. There are number of ways of achieving source reduction. Recycling is one of the best method for reducing environmental and resource depletion. Recycling methods could be classified as follows [3]. Primary Recycling ; Secondary Recycling ; Tertiary Recycling ; Quaternary Recycling.

CHEMICAL RECYCLING TECHNIQUES

Chemical recycling is versatile process which convert plastic materials into smaller molecules usually liquids or gases which are suitable for use of new petrochemical product and plastics. Chemical recycling have proven to useful in production of fuel. Chemical recycling process are similar to those employed in the petrochemical industry e.g. pyrolysis , liquid gas , hydrogenation , viscosity breaking , steam or catalytic cracking and the use of plastic solid waste as reducing agent in furnaces. Chemical recycling non-catalytic thermal cracking , catalytic cracking and steam degradation.

PYROLYSIS

Pyrolysis is the process of thermally degrading long chain polymer molecules into smaller , less complex molecules through heat. The process requires intense heat with shorter duration and in absence of Oxygen [4] . The three major products that are produced during pyrolysis are oil , gas and char which are valuable for industries especially production and refineries . Pyrolysis at high temperature (> 600°C) favor the production of small gas molecules while pyrolysis at low temperature (< 400°C) produce more viscous liquids. Pyrolysis was chosen by many researchers since the process is able to produce high amount of liquid oil up to 80 wt % at moderate temperature around 500°C [5] . Thermal cracking or pyrolysis operating temperature ranges between 400°C and 700°C [6] . The pyrolysis reaction consists of four progressive steps: initiation; Propagation ; Decomposition ; and Termination [7].

MATERIAL AND METHODS

Milk plastic bags and edible oil plastic bags waste (Polyethylene) were collected from the Mahanagarpalica Latur city area , cleaned and dried. The dried plastic wastes were cut into small size pieces (about 5 mm size).

FLOW DIAGRAM OF CONVERSION OF PLASTIC WASTE INTO LIQUID FUEL

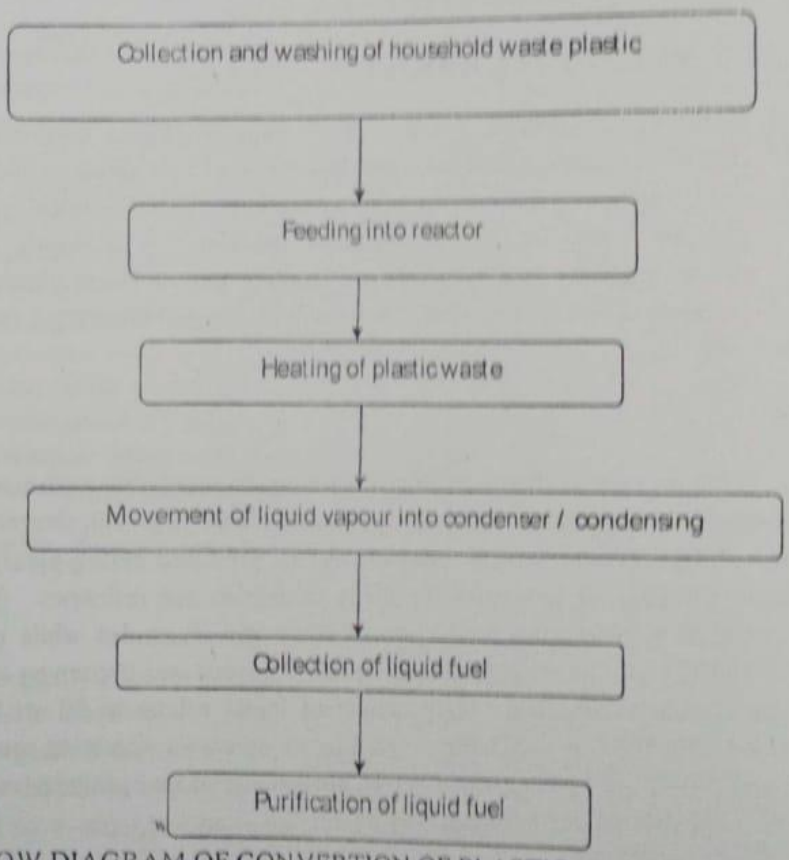

FIGURE-1. FLOW DIAGRAM OF CONVERTION OF PLASTIC WASTE IN TO LIQUID FUEL

EXPERIMENTAL SET UP

The degradation experiment of waste plastic were carried out in a stainless steel bath reactor with 400 ml volume which was equipped with temperature measurement system. 400 gm of

waste plastic milk bags and edible oil bags sample was loaded into the reactor in each pyrolysis reaction. The condensable liquid products were collected through the condenser and the volume was measured. After pyrolysis the char left was weighed and the gases product was calculated. The pyrolysis reactions were carried out at temperature variations of 230°C, 280°C , 330°C , 380°C , 430°C , 480°C for one hour using 10°C / min heating rate.

PYROLYSIS SET UP

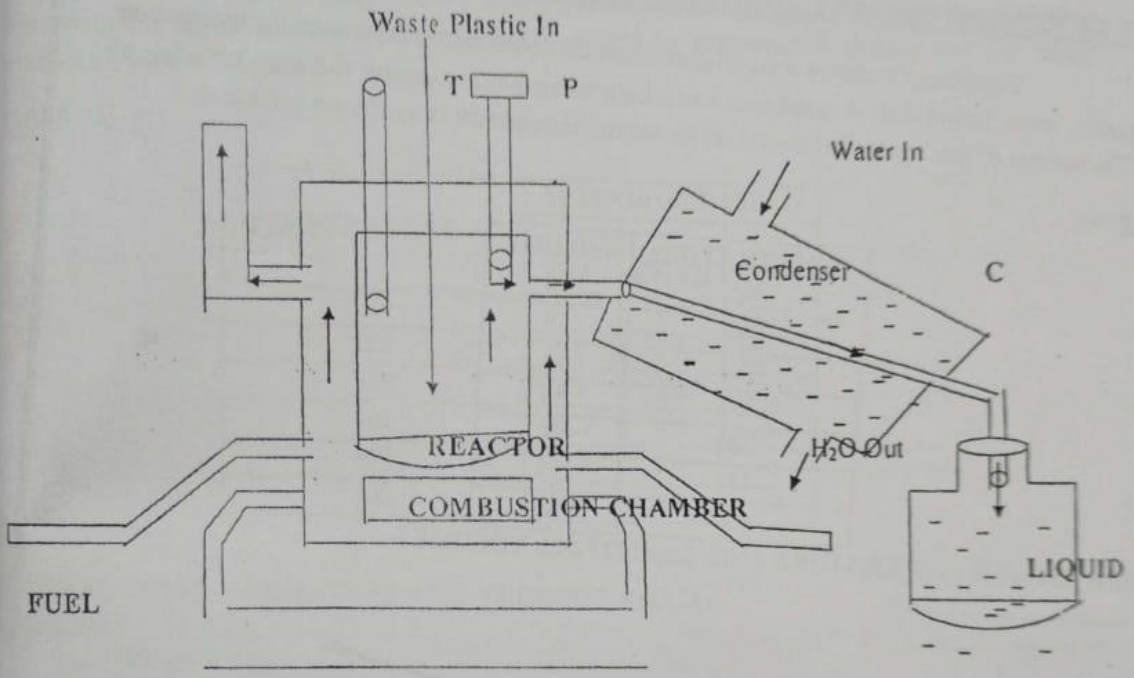

FIGURE- 2 . PYROLYSIS SET UP.

PURIFICATION OF LIQUID OIL

Liquid fuel prepared from the above method is taken in a container and an equal proportion of water is added to the liquid fuel , shake it well and allowed the mixture for about 5 hours to settle down. Water and some crystals are collected at the bottom of the container and pure plastic liquid fuel is collected at the top of the container.

PROPERTIES OF PLASTIC PYROLYSIS OIL :-

Density , Calorific Value , Viscosity , Fire point test are obtained and the effect of temperature on liquid fuel volume , product yields , calorific value are studied.

RESULTS AND DISCUSSIONS

EFFECT OF TEPERATURE ON LIQUID FUEL VOLUME :-

Temperature shows a significant effect on liquid fuel volume . As the temperature is increased , more liquid fuel is produced since high temperature supports the easy breaking of bonds. The volume of the liquid fuel produced for various temperature is as shown in table no.1.

TABLE No. 1.

TEMPERATURE °C	VOLUME ml
230	29
280	38
330	49
380	60
430	71
480	85

GRAPH BETWEEN TEPERATURE AND LIQUID FUEL VOLUME :-

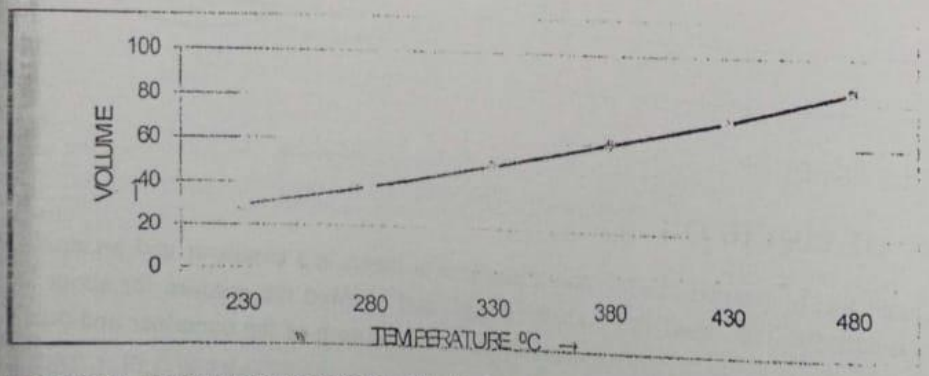

FIGURE-3. EFFECT OF TEPERATURE ON LIQUID FUEL VOLUME.

EFFECT OF TEPERATURE ON PRODUCT YIELDS :-

The products are separated into gas , oil and char residue by pyrolysis of waste plastic about 6 % of 'of waste plastic pyrolysis oil (WPPO) was obtained at 230°C. The oil percentage is

increased constantly to 50.3 % at temperature 480°C. The gases produced through plastic pyrolysis consists principally of Hydrogen (H_2) , Carbon dioxide (CO_2) , Carbon monoxide (CO) , Methane (CH_4) , Ethane (C_2H_4) , and Butadiene (C_4H_6) , with trace amounts of Propane ($CH_3CH_2CH_3$) , and other miscellaneous hydrocarbons. The maximum yield of char is 3.6 % was obtained at the temperature of 230°C and with the further increase in temperature the yield of char decreased. The highest yield of gas 90.4 % was obtained at the temperature of 230°C . With the increasing temperature the gas yield is decreased. At higher pyrolysis temperature the liquid fuel yield increases where as the solid yields (char) decreases. This is due to the fact that at higher temperature the components in the waste plastic would be decomposed sharply and the waste pyrolysis oil yield is increased.

TABLE No. 2.

TEMPERATURE °C	% PRODUCT YIELD		
	OIL	CHAR	GAS
230	6	3.6	90.4
280	9.9	7.8	82.3
330	8.5	5.6	75.9
380	23.7	4.3	72
430	35.6	3.4	61
480	50.3	2.7	47

GRAPH BETWEEN TEPERATURE AND PRODUCT YIELD :-

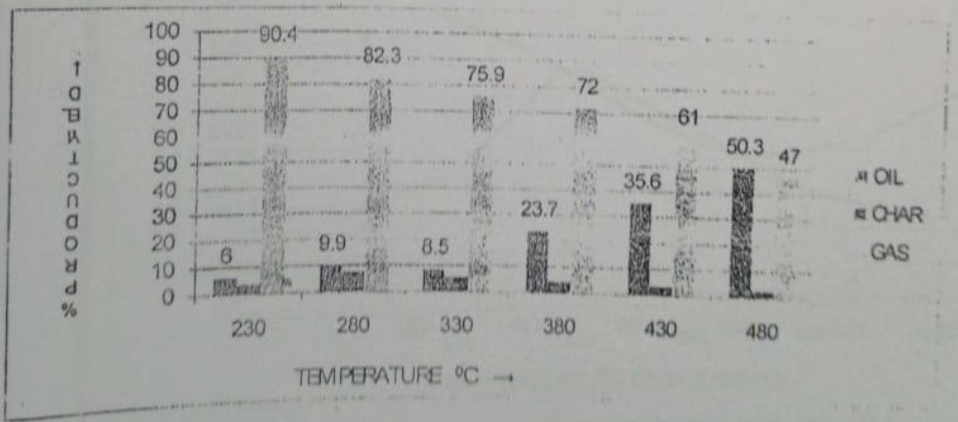

FIGURE-4. EFFECT OF TEPERATURE ON PRODUCT YIELD.

EFFECT OF TEPERATURE ON CALORIFIC VALUE :-

Calorific value is calculated for each pyrolysis temperature by using Bomb Calorimeter. The calorific value of a fuel is the quantity of heat produced by its combustion at constant pressure and under normal conditions. Using the relation below, the calorific value of a liquid fuel is calculated.

Mass of the fuel [m_f] x Calorific value [C_f] = Mass of the water[m_w] x Specific heat[C_v] x Change in temperature [$t_1 - t_2 = T'$].

i.e. $$C_f = \frac{[mw] \times [Cv] \times T'}{[mf]}$$ Cal /gm.

TABLE NO. 3

TEMPERATURE °C	CALORIFIC VALUE Cal/gm
230	1250
280	910
330	800
380	1040
430	1400
480	1650

GRAPH BETWEEN TEMPERATUR AND CALORIFIC VALUE:-

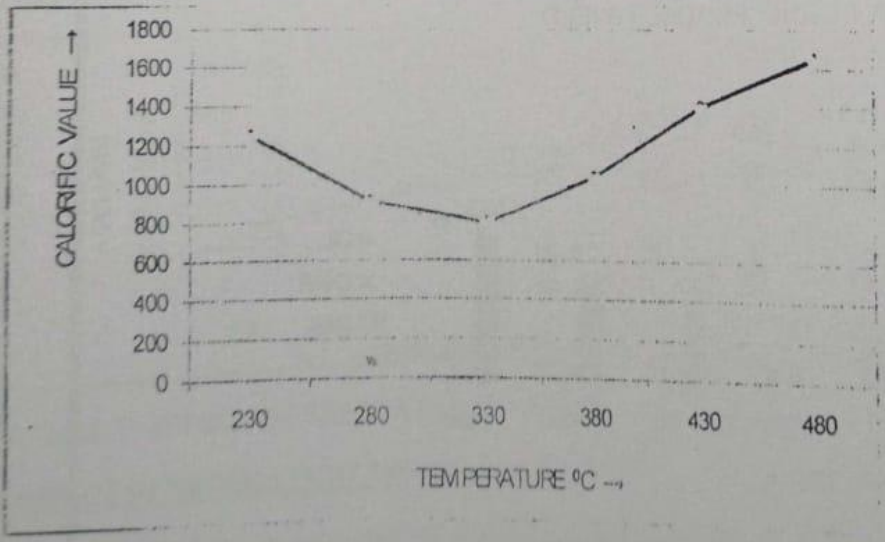

FIGURE- 5. EFFECT OF TEPERATURE ON CALORIFIC VALUE.

The calorific value calculated for the plastic oil is reduced up to the temperature 330°C and then it increases with the increase in temperature. The maximum value of the calorific value obtained is 1650 cal/gm for the highest temperature of 480°C.

EFFECT OF TEPERATURE ON LIQUID FUEL DENSITY :-

The density of the plastic fuel produced is measured by pycnometer and calculated by using the relation

$$\rho_f = \frac{(m(p+f)-mp)}{(m(p+w)-mp)} \times \rho_w$$

Where,

ρ_f = Density of the liquid fuel to be calculated.
ρ_w = Density of the water.
$m(p+f)$ = Mass of the pycnometer plus mass of the liquid fuel.
mp = Mass of the empty pycnometer.
$m(p+w)$ = Mass of the pycnometer plus mass of the water.

TABLE NO. 4

TEMPERATURE °C	DENSITY gm/cc
230	0.71
280	0.74
330	0.82
380	0.77
430	0.72
480	0.7

GRAPH BETWEEN TEMPERATUR AND DENSITY:-

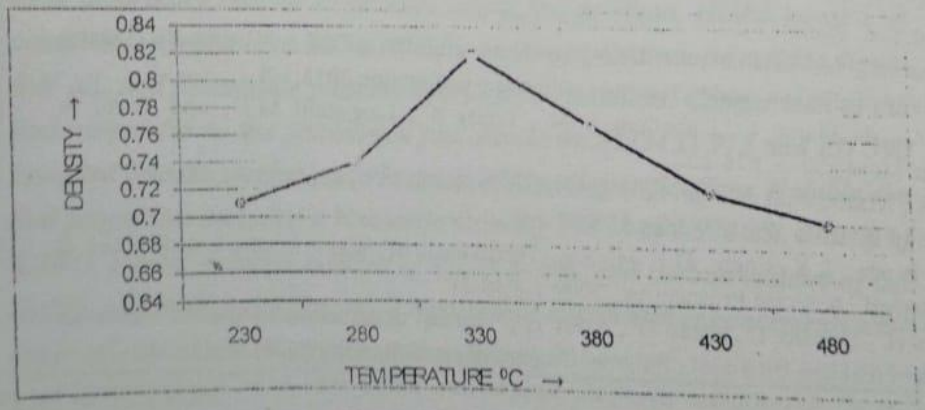

FIGURE- 6. EFFECT OF TEPERATURE ON LIQUID FUEL DENSITY.

The density of the liquid fuel produced is in the range of 0.7-- 0.82 gm/cc. The density is inclined up to the temperature 330°C and then it decreases for further increase in temperature.

CONCLUSION

Thermal pyrolysis of waste plastic milk bags and edible oil bags were performed in a bath reactor at a temperature variation of 230°C, 280°C , 330°C , 380°C , 430°C , and 480°C for one hour. The maximum liquid fuel yield is 50.3% at temperature of 430°C. The pyrolysis process showed an inverse ratio between solid yields (char) and liquid products (oil).

Thermal pyrolysis method is superior in all respect (ecological and economical). By adopting this technology, efficiently convert weight of waste plastic in 75% of useful liquid hydrocarbon fuels. It would take care of hazardous plastic waste and reduce the import of crude oil. Depletion of non-renewable source of energy such as fossil fuel at this stage demands the improvements of this techniques. Based on the properties of the plastic fuel and diesel fuel all the properties are nearly same , hence concluded that waste plastic fuel represents a good alternative fuel for diesel engine.

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