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EXTRACTION, SEPARATION AND RHEOLOGICAL PROPERTIES OF CRUDE OIL FROM WASTE LDPE PLASTICS

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ABSTRACT

The readily available fuel has been an ever increasing global demand for energy in recent years. The demand, especially for liquid fuels is very high and the limited resources of fuel production have created bottlenecks leading to an energy crisis. Thiscrisis has led to exploring erstwhile resources for fuel production, one of which is plastic, being a non-degradable source, plastics disposed in the open environment as wastes pose a menace to the environment. Most of these waste plastics ends up at landfills. It can instead be used as a source for making fuel. This work describes a challenge to use the waste LDPE plastic to synthesize potential fuel called 'Pyrolysis Oil', since the process used in order to obtain the crude oil is Pyrolysis and separated with different grades. The obtained different graded oil from waste LDPE plastics is tested and analysed so as to validate its use as a blended fuel.

This manuscript deals with the extracting of pyrolysis oil from the waste polymers by fabricating a heating system to carry out pyrolysis at elevated temperatures.

KEYWORDS: *Waste Plastic, Pyrolysis, Pyrolysis Oil, Reactor*

Article History

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INTRODUCTION

Management of plastic waste is a big issue in India. According to Central Pollution Control Board (CPCB) 2018, In India 40,000 tons of plastic waste is generated daily and approximately only 60% of collected plastic waste is re- cycled. Plenty of Plastic waste is dumped on earth and enormous amounts are disposed into the water bodies. These plastic wastes could instead be used for producing fuel. Pyrolysis of waste plastic could provide a better way to dispose the waste plastic which causes environmental pollution.

Pyrolysis Process is a thermo-chemical putrefaction of organic material at elevated temperatures in the inert atmosphere, i.e. absence of oxygen. Pyrolysis of organic substances produce gas and liquid products which are termed as bio-fuels and leave a solid residue richer in carbon content called char.

The task thus selected with an objective of using this non degradable waste plastic as a source to extract crude oil to fuel, which after investigation can be used as an alternative source of energy.

The invention of plastic begins with a distillation process in an oil refinery. The distillation process which involves the separation of heavy crude oil into lighter groups this process is called fractionation. Each fractionation is a mixture of hydrocarbon chains (chemical compounds made up of carbon and hydrogen), which differ in terms of the size and structure of their molecules, retiring of these fractions callednaphtha, is the crucial element for the production of plastics. Plastics are also produced from natural gas.

LDPE (Low-density polyethylene) is a thermoplastic made from the monomer ethylene. LDPE waste materials remained the primary grade of polyethylene, which was produced in the year1933 by company Imperial Chemical Industries use a high pressure process via free radical polymerization. Its manufacture employs the same method today. The EPA estimates approximately 5.7% of LDPE is recycled. In spite of competition from more modern polymers, LDPE continues to be an important plastic grade. In the year 2013worldwide LDPE market reached a volume of about US$33 billion.

METHODOLOGY

Pyrolysis is generally defined as the controlled heating of a material in the absence of oxygen. In plastics Pyrolysis, the macromolecular structures of polymers are busted down into smaller molecules or oligomers and sometimes monomer units. Further ruin of these subsequent molecules depends on the number of different environmental conditions including temperature, residence time, presence of catalysts and other process conditions. The Pyrolysis reaction can be carried out with or without the presence of catalyst consequently, the reaction will be thermal and catalytic Pyrolysis. In view of the fact that majority of plastics used are polyolefin, so extensive research has been done on this polymer which is summarized as below. The Thermal Pyrolysis of Polyolefin stays the non-catalytic, orwarm air Pyrolysis of polyolefin is a high vitality, an endothermic process requiring temperatures of at least 350– 500 °C. Figure 1 Block diagram of pyrolysis process shows the fractionalization of the crude oil from the waste LDPE plastic material and figure 2 shows the flow chart of pyrolysis which helps further to write the program for data collection and acquisition for further study and development computer code in research

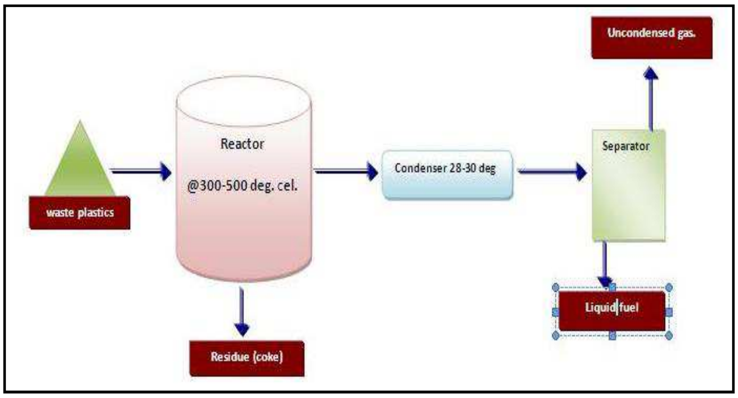

Figure 1: Block Diagram of Pyrolysis Process

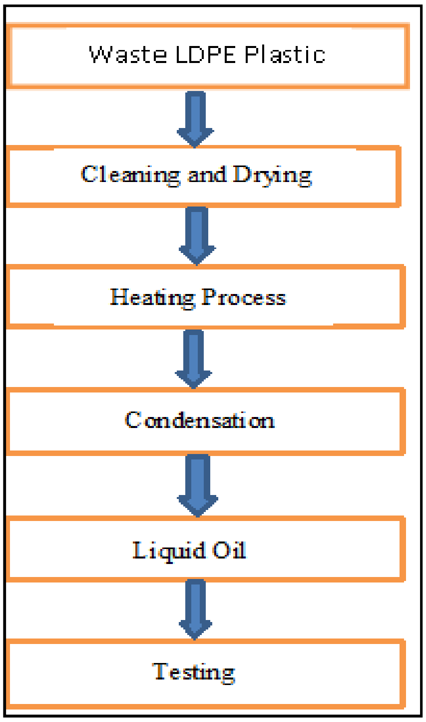

Figure 2: Flow Diagram of Pyrolysis Process

COLLECTION OF WASTE LDPE PLASTICS

The collection of waste LDPE plastics is quite an easy task as compared to other type of waste materials. The LDPE waste plastic materials are abundant and can be obtained in enormous quantities from household, shops, restaurants, parks, automotive parking places, public places, beaches, etc. and this to be cleaned to remove foreign particles deposited on the waste plastic material and which is crushed into small pieces as per our requirement by using semi or automatically operated mechanical machine.

Figure 3: Waste LDPE Plastics

MODELLING AND FABRICATION OF SETUP

The proposed assembly of the experimental setup was modelled in solid works software with certain specifications. The essential different components were determined by the design, layout and was modelled based on the capacity of the heating chamber. The parts have been marked according to the parts directory and assembled then drawn in CAD software which as shown in the figure 3.

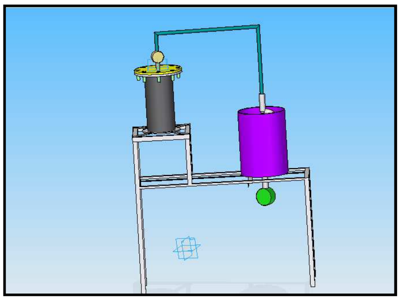

Figure 4: Assembled CAD Model

(A) Reactor (Pyrolyzer)

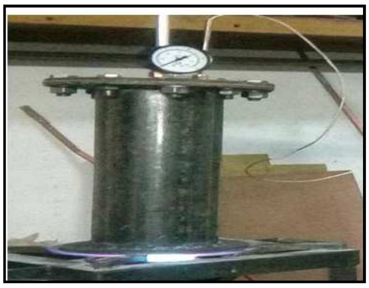

Figure 5: Reactor

The material used for the fabrication of major components is mild steel. Mild steel has a carbon content ranging from 0.15% to 0.30%. It has the properties suitable for fabrication and is available easily. The LPG gas burner was selected for the purpose of attaining the required temperature in the heating chamber.

(B) Cover and Base Plates

Figure 6: Cover and Base Plates

Cover and Base plates are the heads used to close in or cover over the end or top of a reactor, chamber or section of a structure. The cover plate contains 8 holes of M18 and Pressure Gauge is fixed on the cover plate.

(C) Condenser Coil

Figure 7: Condenser Coil

A helical coil heat exchanger consists of a pipe passing through a tank containing water. A standard aluminium pipe of 1\2 inch diameter and 2.8 m length was bent to fabricate a helical coil pipe using hot working.

(D) Condenser

Figure 8: Condenser

The condenser is made up of aluminium material with a number of coils to improve the efficiency of the condensation. After heating the waste plastics in the reactor, the gas is allowed to escape through the outlet, the condenser is dipped into the water containing jar so as to condense the fumes to collect the RAW FUEL drop by drop through the outlet valve at room temperature.

(E) Experimental Assembly of Setup

Assembly of the set-up follows the fabrication and testing of the components required for the process. The supporting stand is placed where the set-up is to be mounted so as to conduct the pyrolysis test. The experiment is performed outdoors for safety. The frame is carefully placed on the stand. The next step involves carefully installing the reactor. Then carefully place the reactor in the center.The ceramic wool and cotton rope is wrapped around the reactor. This ensures minimum heat loss from the reactor in all directions except the top. The cover lid is then used to cover the furnace inside the frame. The lid prevents heat loss. Finally the complete assembly is placing the helical coil heat exchanger assembly on the stand and as shown in figure 5.

Figure 9: Final Setup

PROCEDURE FOR EXTRACTION OF OIL

- Weigh the crushed LDPE plastics and pack into the reactor (required capacity) for the processing.
- Check all the necessary valves, apparatus and connections are fitted correctly and tightly.
- Close the reactor with the top cover plate and tighten the reactor plates with nut and bolts firmly.
- Fill the necessary amount of water in the condenser drum for sufficient cooling of hot flue gases.
- Start the LPG burner and the stop watch to note down the time.
- After a certain period of time the plastics get heated in the absence of oxygen and converted into the vapours by increasing in temperature.
- By observing the pressure value of the pressure gauge the outlet valve is opened.
- Immediately note down the time intervals for coil outlet and temperature at various locations on the experimental setup.
- Note down the pressure and temperature for every 15minutes interval of time.
- After the completion of oil extractions shut off the outlet valve and wait for second trail.
- Repeat above steps for different pressure readings and note down in tabular column.
- After the complete extraction of oil, turn-off the LPG Gas burner and measure the extracted oil using a standard measuring jar.

The extracted crude oil is separated according to the colours and stored in a separate measuring jars and is preserved in a cool place from the temperature. Then this separated oil is propelledfor various oil testing process for finding rheological properties, these properties are tested as per the ASME standards.

Figure10: Extracted Pyrolysis Oil

Figure11:Ash Content

RESULTS AND DISCUSSIONS

The experiments on pyrolysis were conducted by using waste LDPE as the raw material. The plastic was cracked thermally at various temperature ranges of 106ºC, 135ºC, 146ºC, and 184ºC. The products obtained were of different composition and the product yield was different for different temperatures. The liquid product yield varied for all these conditions. The experiment has conducted with waste LDPE plastics of grade 4of 1.5 kg. The yield around 450ml of crude oil and around 490gms of grease has obtained.

For further process we conducted tests on the various parameters are listed below and compared with standard values of petrol, diesel, kerosene, and crude oil.

Table 1

SL NO	Temperature in °C			Pressure gauge kg/cm2	Time in Sec
	T1 °C in Reactor	T2 °C in Condenser	T3 °C in Collecting tank		
01	106	43	33	0.12	900
02	135	54	32	0.28	900
03	146	95	32	0.44	900
04	184	45	31	0.56	900

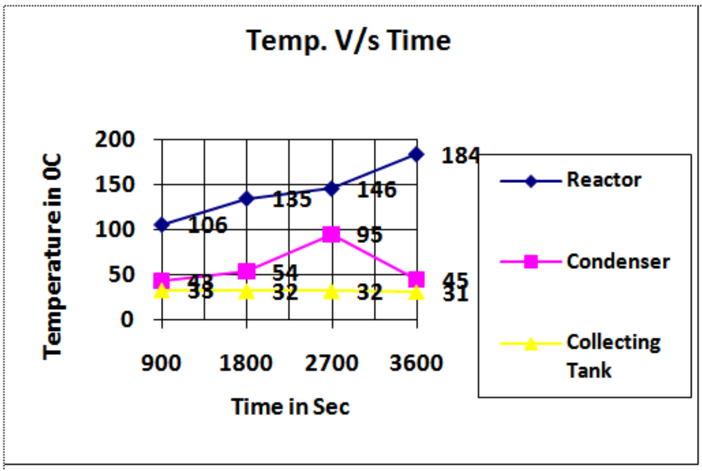

Figure 12: Temperature versus Time

It is observed that for every 15 minutes of heating pressure increases and the temperature also increases in the reactor, condenser from room temperature to 184 ^{0}C, 43 ^{0}C and decreases from 33 ^{0}C to 31^{0}C due condensation.

Flash and Fire Point

The *flash point* determined for pyrolysis oil is in the range of 10°C -12°C.

The *fire point* determined for pyrolysis oil is in the range of 14°C -16°C.

Water Content (Karl Fischer Method)

$$K.F\ Factor = \frac{volume \times 1000}{KF - \text{Re}ading} = \frac{0.064 \times 1000}{12.89} = 4.965$$

$$Water\ (= \frac{KF - \text{Re}ading \times KF - Factor \times 100}{Sampleofweight \times 1000} = \frac{0.26 \times 4.965 \times 100}{0.056 \times 1000} = 2.30\%$$

Sulphur Content: [Advanced Bomb Calorimeter]

$$\text{Sulphur weight percentage} = (P - B)\frac{13.69}{W}$$

P- Gram of $BaSO_4$ obtained from sample

B- Gram of $BaSO_4$ obtained from blank

W-Weight of sample = 0.5934g

Ash filter paper weight =0.0004g

$$\text{Sulphur weight percentage} = \frac{(0.0004 - 0.0009) \times 13.69}{0.5934} = 0.011\%$$

Gross Calorific Value

Sample weight = 0.5074g

$$CV = \frac{Highest.reading \times factor}{sampleweight} = \frac{1.25 \times 3530.5}{0.5074} = 8697.52 Cal/g$$

Properties of Petrol, Diesel, Kerosene and with Crude Oil

Table 2

Sl. No.	Parameter	Units	Pyrolysis oil	Petrol	Diesel	Kerosene		Crude oil
						1-K	1-K	
01	Kinematic viscosity@40°C	cSt	2.36	1.45	2.98	2.71	7.9	
02	Water content	%	2.30	0.0001	0.02	0.035	0.0390	0.36
03	Sulphur content	%	0.01	0.05	0.06	0.04	0.30	2.55
04	Total chromium as Cr	ppm	<0.1(BDL)	0.54	0.86	0.33	0.026	0.1
05	Iron as Fe	ppm	56.60	0.0031	0.155	0.29	0.21	41
06	Lead as Pb	ppm	50.87	0.24	1.01	0.41	0.011	0.24
07	Copper as Cu	ppm	22.31	1.74	1.77	1.98	0.005	1.3
08	Zinc as Zn	ppm	<0.1(BDL)	1.43	2.87	2.63	2.4	30
09	Gross Calorific Value	Cal/g	8697.52	11082.4544	10891.377	9600	8000	10915.257

CONCLUSIONS

Plastic materials present a major hazard to today's society and the environment. Approximately more than 14 million tons of plastic material is dumped into the oceans annually, killing about 1,000,000 species of oceanic lifespan. However man hood has awoken to this hazard and retorted with developments in creating this type of degradable bio-plastic materials, there is still no conclusive effort done to repair the damage already caused. In this concern, extraction of Pyrolysis process was premeditated and here presents an efficient, uncontaminated, and very effective means of removing the debris that we have left behind over the last several decades. By converting plastics to bio-fuel, we solve two issues and more, one of the large plastic areas, and the other of the fuel shortage. This advantage, however, will exist individual as long as the waste plastic materials last, but will positively provide a strong platform for us to build in a sustainable, clean and green future. By taking into account the financial benefits of such a project, it would be a great boon to our economy. So, from the studies conducted we can conclude that the properties of the fuel obtained from plastics are similar to that of diesel and further studies in this field can yield better results.

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