EXTRACTION OF OIL FROM WASTE PLASTICS USING CATALYTIC PYROLYSIS METHOD

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ABSTRACT:

This research aims to examine the physical ,chemical properties, and quality of pyrolysis oil extraction from three plastic type; PET,HDPE, and PS. In our experiment, two hundred fifty grams of each plastic type was used in thermal degradation as pyrolysis. From our results, the starting temperature for pyrolysis oil was from 380 to 500 degree census. HDPE was the highest pyrolysis oil compare to other plastic type, in which about 88% of oil v/w was achieved and when compared to oil standard its quality nearest to diesel oil. On the other hand, PS was second most which about 77% oil v/w, but this oil viscosity was very sticky and can not to identify its oil type by laboratory instrument. In contrast, none of the oil extracted from PET only gases and waxes was found under the pyrolysis process. For a summary, HDPE was a potential plastic type for oil extraction and could be alternate for diesel oil in future.

1.INTRODUCTION:

Plastics have become an indispensable part in today’s world, due to their lightweight, durability, and 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.The use of plastics has been associated with significant environmental problems due to their continuous accumulation in landfills, as plastic waste does not degrade or degrades at a very low pace. On average, 50% of the waste plastic generated in Europe is recovered, while the rest is sent to landfills. In 2015, global plastic production reached 322 million tonnes, a dramatic increase compared to the 279 million tonnes produced in 2011.

According to the World Bank, plastic waste accounts for 8–12% of the total municipal solid waste (MSW) worldwide, while it is estimated to increase to 9–13% of the MSW by 2025.The increasing availability of such waste material in local communities, coupled with the high energy density, render waste plastics one of the most promising resources for fuel production. The pyrolysis of plastics and other MSW (end-of-life tires, organic wastes, etc.) for fuel production is practiced by several small-size companies worldwide, especially those of emerging economies, where industries such as cement, glass, and other energy-intensive sectors represent the reference market this type of fuel (diesel-rangehydrocarbons produced via the pyrolysis of plastics and MSW). The pyrolysis of plastics yields on average 45–50% of oil, 35–40% of gases, and 10–20% of tar, depending on the pyrolysis technology.

Waste plastics have created a very serious environmental challenge because of their huge quantities and their disposal problems. Waste plastic pyrolysis in liquid fuel (gasoline, diesel oil, etc.) or chemical raw materials not only can effectively solve the problem of white pollution, but also can alleviate the energy shortage to a certain extent. Recycling of waste plastics is expected to become the most effective way. Waste plastics recycling, regenerating, and utilizing have become a hot spot of research at home and abroad and gradually formed a new industry.The waste to energy technology is investigated to process the potential materials in waste which are plastic, biomass and rubber tire to be oil. Pyrolysis process becomes an option of waste-to-energy technology to deliver bio-fuel to replace fossil fuel.

Waste plastic and waste tire are investigated in this research as they are the available technology. The advantage of the pyrolysis process is its ability to handle un-sort and dirty plastic. The pre-treatment of the material is easy. Tire is needed to be shredded while plastic is needed to be sorted and dried. Pyrolysis is also no toxic or environmental harmful emission unlike incineration. Economic growth and changing consumption and production patterns are resulting into rapid increase in generation of waste plastics in the world. For more than 50 years the global production of plastic has continued to rise.Some 299 million tons of plastics were produced in 2013, representing a 4 percent increase over 2012. Recovery and recycling, however, remain insufficient, and millions of tons of plastics end up in landfills and oceans each year.Approximately 10–20 million tons of plastic end up in the oceans each year. A recent study conservatively estimated that 5.25 trillion plastic particles weighing a total of268,940tonns are currently floating in the world's oceans.

2. OBJECTIVE:

The main objectives of this project are,

- The Primary objective of the project is to extract oil from waste plastics using catalytic Pyrolysis Method.
- The Secondary objective is to study the properties of the extracted oil for domestic (or) commercial usage.
- To establish the basis for the development and implementation of waste plastics recycling with the application of environmentally sound technologies (EST) to promote resource conservation and Green House gases (GHG).
- To raise awareness in developing countries like INDIA on plastic waste and its possible reuse for conversion into diesel or fuel, this could be generated and marketed at cheaper rates compared to that of the available diesel or oil in the market.
- To reduce the dependency on gulf countries for fossil fuels, thereby contributing to the Economic growth of the country.

3. LITERATURE REVIEW:

Plastics materials are very frequent in daily life and provide a fundamental contribution to our society. The typical distribution of household plastics as a part of the overall solid waste stream is: polyolefins 66.9%, polystyrene 13.3%, PVC 10.3%, PET 5.3% and others 4.2%. Waste plastic ends its lifetime as municipal solid waste on the landfill. Over the world plastic waste has continuously grown in the last decades. Disposal of waste plastics causes serious environmental problems. Thus, plastic waste recycling has been a focus of many researchers in the past few decades. Pyrolysis appears to be promising technic of conversion of solid wastes plastic (SWP) to more usable materials such as gas fuel and/or fuel oil or to high value feedstock for the chemical industry.

Different types of reactors has been used for pyrolysis of waste plastic like, batch or autoclaves semi-batch, screw conveyors or fluidized beds and fixed beds, shaft kilns or rotary kilns. Most studies are carried out in beds or batch processes where all products are collected as a single sample, and subsequently analyzed. Often focus of the studies is effect of experimental conditions (reaction temperature and time) on product yield and composition, but others are focused on characterization of obtained products.

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4. COMPONENTS AND SELECTION OF MATERIAL:

4.1 COMPONENTS:

The below mentioned components are used in the pyrolysis method.

1. Catalytic reactor.
2. Condenser.
3. Pyrolysis reactor.
4. Supply hose.

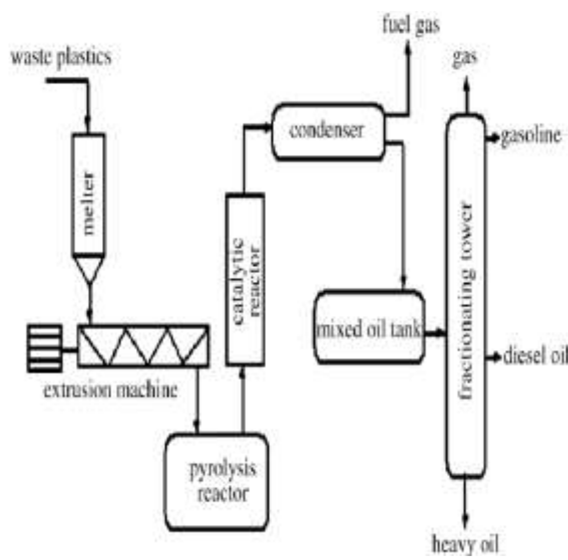

Figure 1 Components of Pyrolysis

4.2 SELECTION OF COMPONENTS:

The proper selection of material is a main objective for safety. The choice of material engineering purpose depends upon the following factors.

1. Availability of material.
2. The cost of material.
3. Physical and chemical properties of material.
4. Mechanical properties of material.
5. Suitability of material for the working condition.

Selection of material depends upon factors of safety, which runs depend upon the following factors.

1. Reliability of properties.
2. The certainty as to exact mode of failure.
3. The extent of localized.
4. The extent of simplifying assumption.

5.TYPES OF PLASTICS:

Figure 2 Types of Plastics

5.1 POLYETHYLENE REPTHELENE:

GENERAL PROPERTIES:

1. High heat resistance.
2. Tough.
3. Hard.
4. Solvent resistant.

5.2 HIGH DENSITY POLYETHYLENE:

GENERAL PROPERTIES:

1. Chemical resistance.
2. Hard to semi-flexible and strong.
3. Soft waxy surface.
4. Permeable to gas.

6. DISPOSAL METHOD OF WASTE PLASTICS & THEIR ADVANTAGES AND DISADVANTAGES:

1. Ocean dumping.
2. Sanitary landfills.
3. Incineration.

6.1 OCEAN DUMPING:

ADVANTAGES:

1. Convenient.
2. Inexpensive.
3. Source of nutrients.

DISADVANTAGES:

1. Ocean overburdened.
2. Killing of plankton.
3. Desalination.

6.2 SANITARY LAND FILLS:

ADVANTAGES:

1. Volume can increase with little addition of people.
2. Filled landfills can be reused for other community.

DISADVANTAGES:

1. Completed landfill area can settle.
2. Require proper planning, design and operation.

6.3 INCINERATION:

ADVANTAGES:

1. Require minimum land.
2. Can be operated in any weather.

DISADVANTAGES:

1. Expensive to build and operate.

2. High energy requirement.

7. CHARACTERISTICS OF PLASTICS AND OIL PRODUCTS:

Before looking at the process options for the conversion of plastic into oil products, it is worth considering the characteristics of these two materials, to identify where similarities exist, and the basic methods of conversion. The principal similarities are that they are made mostly of carbon and hydrogen, and that they are made of molecules that are formed in "chains" of carbon atoms.

8. METHODOLOGY:

8.1 PROCESS:

1. Identification of waste plastics.
2. Subjecting the waste plastic for pyrolysis process.
3. Condensation of the gas to obtain raw fuel.
4. Conversion of raw fuel into its pure form (diesel, etc.) by the process of distillation.

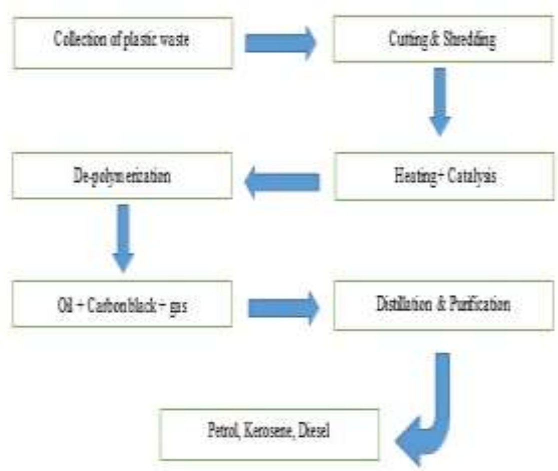

Fig 3 Process Flowchart

8.2 COLLECTION AND IDENTIFICATION OF WASTE PLASTIC:

The collection of waste plastic is quite an easy task as compared to other waste. The plastic wastes are abundant and can be obtained in large quantities from the households, roadsides, hospitals, hotels etc.

Fig 4 Identifying of Plastics

8.3 WASTE PLASTIC PYROLYZED OIL:

This plastic are usually termed as,

1. POLYETHYLENE (PE)
2. POLYPROPYLENE (PP)
3. HIGH DENSITY POLYETHYLENE (HDPE)
4. LOW DENSITY POLYETHYLENE (LDPE)

Usually they are manufactured in the form of plastic bags, saline bottles, plastic tools, chairs and other components which we usually come across in our day to day life. These plastics could be collected or usually purchased at Rs.10 to 15/kg after being shredded and washed properly.

8.4 SUBJECTING THE WASTE PLASTIC FOR PYROLYSIS PROCESS:

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 broken down into smaller molecules or oligomers and sometimes monomer units. Further degradation of these subsequent molecules depends on a number of different conditions including (and not limited to) temperature, residence time, presence of catalysts and other process conditions. The Pyrolysis reaction can be carried out with or without the presence of catalyst. Accordingly, the reaction will be thermal and catalytic Pyrolysis.

The pyrolysis is a simple process in which the organic matter is subjected to higher temperature about 300ºC to 500ºC in order to promote thermal cracking of the organic matter so as to obtain the end products in the form of – liquid, char and gas in absence of oxygen.

9. MAIN DEVICES USED IN THIS PROCESS:

1. CONDENSER:

It cools the entire heated vapour coming out of the reactor. It has an inlet and an outlet for cold water to run through its outer area. This is used for cooling of the vapour. The gaseous hydrocarbons at a temperature of about 350°C are condensed to about 30°C – 35°C.

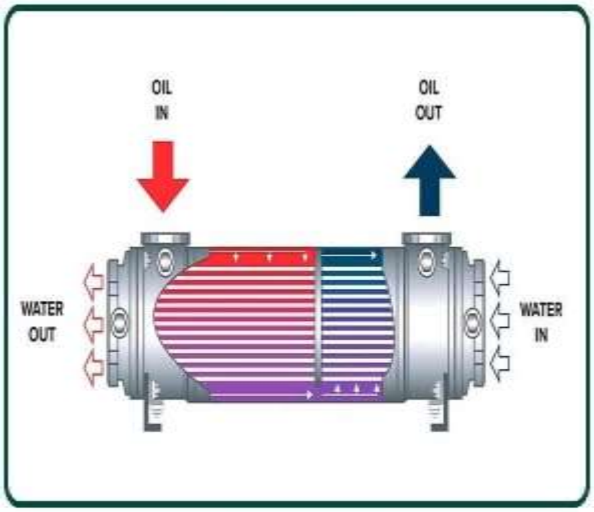

Fig 6 Cooling condenser

2. REACTOR:

It is a stainless-steel tube of length300mm, internal diameter 225mm, outer diameter 230mm sealed at one end and an outlet tube at the other end. The reactor is placed under the LPG burner for external heating with the raw material inside. The reactor is made with the following: stainless steel, mild steel and clay for lagging. The reactor is heated to a temperature of about 450°C and more.

Fig 7 Reactor

11. PROCESS:

Description Thermal cracking process without catalyst was used in converting waste plastic into liquid fuel. Two types of waste plastic are selected for this particular experiment. By weight 50% of each Low density polyethylene and polypropylene was selected for the experiment. Both waste plastic are solid hard form. Collected waste plastic was cleaned using liquid soap and water. During waste plastics are cleaned is cerates waste water. This waste water is purified for reuse using waste water treatment process. Washed waste plastics are cut into 3- 5 cm size to fit into the reactor conservatively. For experimental purpose we used 600gm sample 300gm of PP and 300gm of LDPE. A vertical steel reactor used for thermal cracking and temperature used ranges from100° C to 400° C.

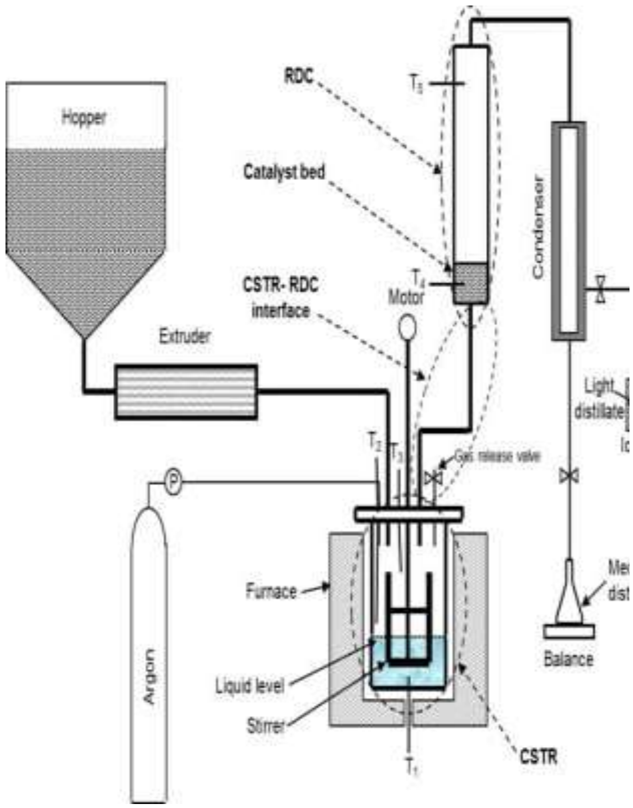

Fig 8 Pyrolysis Devices

12. WORKING PRINCIPLE:

12.1 PYROLYSIS:

Pyrolysis is the thermal degradation of organic materials at temperatures between 400°C and 1,000°C in the absence of oxygen. This results in the devolatalisation and decomposition of the feedstock, but the absence of oxygen means that no combustion occurs.

Pyrolysis produces gas, liquid and solid char, the relative proportions of which depend upon the method of pyrolysis and the operating conditions of the pyrolysis reactor, chiefly the rate of heating, the operating temperature and residence time within the pyrolysis reactor.

12.2 CATALYTIC DEPOLYMERIZATION:

Catalytic depolymerization is similar to pyrolysis in that it promotes the break-up of the polymer chains in the absence of oxygen to produce smaller molecules. It achieves this at lower temperatures (270–400°C) than pyrolysis by using a catalyst, typically an alumina silicate zeolite. The decomposition of the feedstock results in the deposition of carbon on the catalyst's surface as a result of the net hydrogen deficiency of the process described above, thus reducing the effectiveness of the catalyst. Some processes introduce hydrogen to overcome this problem, therefore lengthening the life of the catalyst and lowering spent catalyst disposal costs. Some processes use a carrier oil to assist with the mixing and dispersion of the molten plastic and catalyst.

Catalytic depolymerization produces gas, liquid and solid residues, and information from the technology suppliers suggests the outputs. However, it should be noted that the majority of these suppliers use all of the gas and up to 10% of the liquids produced to provide heat for the process. Owing to this, yields are quoted in the range of 700–800kg per dry tones of plastic fed into the reaction vessel.

13. CONCLUSION:

It is very difficult to find out alternative of plastic. Even plastic´s demand is increasing every day as well as their waste. This project analysis has observed the use of waste plastics, a factory planning and its feasibility in Metropolitan City. It is easily assumed that, when the use of waste plastic will increase then the solid waste management will search more ways to find out to collect them. The implementation of this project can develop so many opportunities in the city. It can be a solution to control waste plastic, develop a new technique or idea, and detect the source of diesel for the country. Bangladesh is such a country where this kind of project could be very promising and effective in the future.

The use of plastic pyrolysis oil in diesel engine in the aspect of technical and economical is compared and found that oil is able to replace the diesel oil. Though the plastic pyrolysis oil offers lower engine performance, the plastic waste amount is enormous and it needed to be process to reduce the environmental problems. Moreover, the engine can be modify follow the combustion condition of plastic pyrolysis oil. The waste plastic used in the process must be PE or PP or LDPE in order to protect the contamination of chlorine in the oil.

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