3rd National Conference on Green Technology and Science for Sustainable Development
© 2020 IJSRST | Volume 5 | Issue 6 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
International Journal of Scientific Research in Science and Technology

Conversion of Waste Plastic to Fuel

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ABSTRACT

Over 1.3 billion metric ton of plastic is being manufactured every year to meet the demands of modern world. Plastic is made by polymerization of hydrocarbons. These hydrocarbon are of typically high molecular mass and may contain some other additives to enhance the capabilities of the final product. Plastic is an important material which is strong, durable, and cheap and has numerous other properties. Disposal of waste plastic is of great concern for everybody as it takes decades to decompose if left at its own. On the other hand, continuous increase in industrialization and urbanization has created measurable rise in the demand of fuels. Nowadays it has become the need to seek the alternate energy sources in the place of conventional fuels. In this scenario, Conversion of plastics to fuel is a hope to solve both the problems. Pyrolysis is a process which involves thermochemical decomposition of organic matter at high temperature (>370◦C) in the absence of oxygen. Products of this process are Pyrolysis Oil, Carbon Black, and Hydrocarbons. This review paper is focusing the most efficient and widely used method of converting plastics to fuels: 'Pyrolysis' and its effectiveness on resolving the both issues of waste plastic management and the requirement of a good alternative fuel for use.

Keywords : Pyrolysis, Decomposition, Plastic Waste, Green Technology, Waste Management

I. INTRODUCTION

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 [1]. Plastic are non-degradable polymers which contain carbon, hydrogen and others elements (chlorine, nitrogen, etc.). Due to its nonbiodegradable nature, this compound contributes significantly to the problem of waste management [2]. Plastic has played a vital role in enhancing the standard of living for more than 50 years. It is the key to the innovation of many products in various sectors, such as construction, healthcare, paint, electronics, automotive, packaging, and many others. The demand for plastics has been increasing due to the rapid growth of world population and industrialization [3]. solar1energy, nuclear1energy, etc.

Waste plastic to liquid1fuel is also an alternate energy1source path, which can1contribute to depletion of fossil1fuel as in this process1liquid. Fuel with similar properties1as that of petrol fuels1is obtained.

In order to overcome the challenges faced for recycling such as the needs of sorting that is labour intensive, a much more reliable method is established. Nowadays, converting the waste into valuable energy resource has been a brilliant way to fully utilize the waste in order to meet the increased energy demand. Plastic wastes can be turned into valuable energy since they are derived from petrochemical source which having significant calorific barrels per day in 2007 to 92.1 million barrels per day in 20201 and 1110.6 million barrels per day in 12035 and natural gas consumption increases from1108 trillion cubic feet in 20071to 156 trillion cubic feet in 2035. This way, the oil and gas reserve available can meet only 43 and 1671years further. Thus mankind has1to rely1on the alternate/renewable1energy sources like biomass, hydropower, geothermal1energy, wind1energy value.

The conversion can be made possible through several thermal treatments technologies such as gasification, pyrolysis, plasma process and incineration .Among all these methods, pyrolysis is the most desirable process since the initial volume of the waste is significantly reduced, more energy can be recovered from the plastic waste by producing varieties of products, requires lower decomposition temperature and low capital cost[4].

Fig. 1 Waste plastic.

Plastics1 contains1 mainlyhigh1 density1 poly1ethylene, polyethylene, polypropylene, low1density polyethylene. According to national survey approximately 10000 tons plastic wastes were produced every day in our country, but out of which only 60% waste plastics are recycled [5].

II. Fuel Demand

The present rate of economic growth is unsustainable without saving of fossil1energy like crude oil, natural1gas or coal. International1Energy Outlook 2010 reports1the world consumption of liquid and1petroleum products grows from186.1 million barrels per day in 2007 to 92.1 million barrels per day in 20201and1110.6 million barrels per day in12035 and natural gas consumption increases from1108 trillion cubic feet in 20071to 156 trillion cubic feet in 2035. This way, the oil and gas reserve available can meet only 43 and 1671years further. Thus mankind has1to rely1on the alternate/renewable1energy sources like biomass, hydropower, geothermal1energy, wind1energy, solar1energy, nuclear1energy, etc. Waste plastic to liquid1fuel is also an alternate energy1source path, which can1contribute to depletion of fossil1fuel as in this process1liquid. Fuel with similar properties1as that of petrol fuels1is obtained [5].

III. CLASSIFICATION OF PLASTICS

Plastics are classified into two types, they are
1) High-density polyethylene
2) Low-density polyethylene
1) High-density polyethylene

Polypropylene and polystyrene. Also, plastics are classified by their chemical structure of the polymer's backbone and side chains. Some important groups in these classifications are the acrylics, polyesters, silicones, polyurethanes, and halogenated plastics. Plastics can also be classified by the chemical process used in their synthesis, such as condensation, poly addition, and cross-linking [6].

2) Low-density polyethylene

Low-density polyethylene (LDPE) is used for its toughness, flexibility, and relative transparency. LDPE is used to make bottles that require extra flexibility. To take advantage of its strength and toughness, it is used to produce grocery bags and garbage bags, squeezable bottles, shrink wrap, stretch films, and coating for milk cartons. It can also be found in toys, container lids, and packaging. Polypropylene (PP) is known for its high melting point, which makes it ideal for holding hot liquids that cool in the bottles (for example, ketchup and syrup). It can be manufactured to be flexible or rigid. PP is used to make containers for yogurt, margarine, takeout meals, and deli foods. It is also use for medicine bottles, bottle caps, and some household items [6].

IV. LITERATURE SURVEY

In order to have a proper background study on technologies available for conversion of waste plastics to fuel, literature survey is carried out to know its various applied method throughout the globe, they are summarized below. From this crude oil various products petrol, diesel and kerosene etc. can be obtained by distillation. This process can convert all HDPE waste plastic to different grade fuels and specially jet grade fuel. After reviewing these various literatures, we can see that different forms of Pyrolysis processes have been employed for the conversion of plastic wastes to efficient fuels and also successfully tested as well [6].

V. METHEDOLOGY

A. Pyrolysis

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. Since majority of plastic used are polyolefin, so extensive research has been done on this polymer which is summarized as below.

B. Thermal Pyrolysis of Polyolefin

The non-catalytic or polyolefin is a high energy, endothermic process requiring temperatures of at least 350–500 °C. In some studies, high temperature as 700–900 °C is essential in achieving decent product yields. The extent and the nature of these reactions depend both on the reaction temperature and also on the residence of the products in the reaction zone, an aspect that is primarily affected by the reactor design. In addition, reactor design also plays a fundamental role, as it has to overcome problems related to the low thermal conductivity and high viscosity of the molten polymers. Several types of reactors have been reported in the literature, the most frequent being fluidized bed reactors, batch reactors and screw kiln reactors [6].

VI. MAIN DEVICES USED IN THE PROCESS

A. 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 – 35°C.

B. Reactor

It is a stainless steel tube of length 300mm, 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[6].

C. 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 35 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 forthermal cracking and temperature used ranges from100° C to 400° C

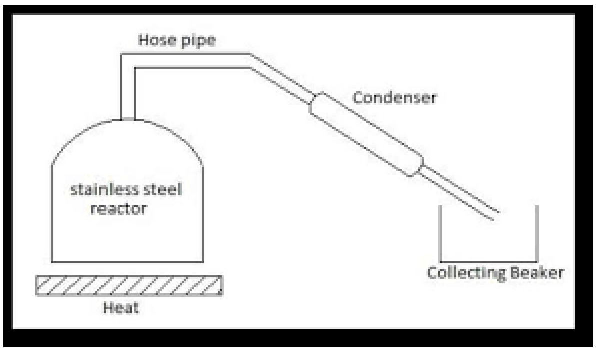

Fig. 1. Photograph of Experimental setup.

When temperature is increased to 270° C liquid slurry turns into vapour and the vapour then passes through a condenser unit. At the end we collect liquid fuel. Between 100º C and250º C around 20 -30% of the fuel is collected and then when raised to 325º C the next 40% is collected and finally when held at 400º C theyield is fully completed [6].

VII. RESULTS AND DISCUSSION

By the process of Pyrolysis, plastics can be converted into fuel and in most scenarios three major products are obtained at the end of the process. These products are namely- Pyrolysis Oil, Carbon Black and a Gaseous mixture. All these three are arranged in order of their composition in the product. The properties of pyrolysis oil can be improved by hydrogenation. The pyrolysis oil is a good substitute ofconventional fuel and in various test run by Dr. Rao and team it is found that the oil when blended with conventional fuel like petrol & diesel, shows same characteristics as pure fuel dose.

VII. CONCLUSION

Pyrolysis method is both Ecological and Economical 1Kg of Waste plastics is converted into 75% of useful liquid hydrocarbon fuels without emitting any pollutants. It would also take care of hazardous plastic waste and reduce the import of crude oil. The properties of produced plastic liquid fuel are almost similar to that of Diesel fuel, hence plastic fuel represents a good alternative fuel for diesel engine and therefore it can be used for diesel engine vehicles.

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