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Optimization of Thermal Pyrolysis of Waste Plastic into Liquid Fuel

[1]Mr. Nirav Vaychal, [2]Dr. Lavendra Bothra, [3]Ms Sancia Boothello

[1,2,3] *Alamuri Ratnamala Institute of Engineering and Technology,Thane*

ABSTRACT

Plastic pollution involves the accumulation of plastic products in the environment that adversely affects wildlife, wildlife habitat, or humans. Many types and forms of plastic pollution exist. Plastic pollution can adversely affect lands, waterways and oceans. The prominence of plastic pollution is correlated with plastics being inexpensive and durable, which lends to high levels of plastics used by humans. India has witnessed substantial growth in the consumption of plastics and an increased production of plastic waste. Polyolefin (A polyolefin is any of a class of polymers produced from simple olefins a monomer, also called alkenes with the general formula CnH2n. For example, polyethylene is the polyolefin produced by polymerizing the olefin ethylene) account for the major share of 60% in the total plastics consumption in India. Packaging is the major plastics consuming sector, with 42% of the total consumption, followed by consumer products and the construction industry.

The purpose of project is to reuse the waste plastic of category HDPE/LDPE which is usually used in packaging, food storage containers, milk & detergent bottles, bottle caps & plastic bags. This HDPE/LDPE waste plastic is converted to alternative diesel fuel using the Pyrolysis process (Pyrolysis is a thermo chemical decomposition of organic material at elevated temperatures in the absence of oxygen. It involves the simultaneous change of chemical composition and physical phase, and is irreversible.) Plastic derived diesel is suitable as a blend component for petroleum diesel fuel. It's an innovation that redefines recycling of a greener future. It creates partnership for sustainable energy production. It's an alternative energy investment that makes sense. It can be achieved on small scale & within small capital investment. A household plastic waste can be put forth to use to get fuel for domestic applications such as household diesel generator or water pump, other burning purpose. The aim of the project is to construct a device which will convert the house hold plastic into a multi-purpose fuel.

We will approach to this project on various experimental aspects which will do in this project preparation time and come to final result with our project guide.

1. INTRODUCTION

Plastic products have become an integral part in our daily life as a basic need. It produced on a massive scale worldwide and its production crosses the 150 million tons per year globally. In India approximately 8 Million tons plastic products are consumed every year (2008) which is expected to raise 12 million tons by 2012. Its broad range of application is in packaging films, wrapping materials, shopping and garbage bags, fluid containers, clothing, toys, household and industrial products, and building materials. It is a fact that plastics will never degrade and remains on landscape for several years. The recycled plastics are more harmful to the environment than the virgin products due to mixing of color, additives, stabilizers, flame retardants etc. Further, the recycling of a virgin plastic material can be done 2-3 times only, because, after every recycling, the strength of plastic material is reduced due to thermal degradation. It is to mention that no authentic estimation is available on total generation of plastic waste in the country however, considering 70% of total plastic consumption is discarded as waste, thus approximately 5.6 million tons per annum (TPA) of plastic waste is generated in country, which is about 15342 tons per day (TPD).

Plastics are durable and degrade very slowly; the molecular bonds that make plastic so durable make it equally resistant to natural processes of degradation. Over 500 billion pounds of new plastic is manufactured each year and roughly 33% of that is single use and thrown away. As so little plastic is recycled, we need to reframe plastic waste as an underused resource vs. landfill destined. If all plastic waste made it into the landfill,

it would surely be mined in the future, but currently all plastic waste does not make it into our landfills. The United Nations estimates plastic accounts for four-fifths of the accumulated garbage in the world's oceans. We need to stop polluting our oceans with plastic before it is too late, and start collecting all plastics suitable for this new fairly simple technology, a technology that is available now.

The technology is not overly complicated; plastics are shredded and then heated in an oxygen-free chamber (known as pyrolysis) to about 400 degrees Celsius. As the plastics boil, gas is separated out and often reused to fuel the machine itself. The fuel is then distilled and filtered. Because the entire process takes place inside a vacuum and the plastic is melted - not burned, minimal to no resultant toxins are released into the air, as all the gases and or sludge are reused to fuel the machine.

For this technology, the type of plastic you convert to fuel is important. If you burn pure hydrocarbons, such as polyethylene (PE) and polypropylene (PP), you will produce a fuel that burns fairly clean. But burn PVC, and large amounts of chlorine will corrode the reactor and pollute the environment. Burning PETE releases oxygen into the oxygen deprived chamber thereby slowing the processing, and PETE recycles efficiently at recycling centers, so it is best to recycle PETE traditionally. HDPE (jugs) and LDPE (bags and films) are basically polyethylene as usable as fuel as well, just slightly more polluting as a thicker heavier fuel is created. But additional processing can turn even HDPE into a clean diesel.

1.1 Objective

The objective of the project is to investigate pyrolysis of the hydrocarbon polymers, HDPE/LDPE, PP and PS both theoretically and experimentally in a lab-scale reactor for maximizing the diesel oil products. Factors which affect the pyrolysis process have been identified and quantified from the investigation. Based on the achievements, the distribution of the product and the process was optimized. A semi-scale plant was built based on the results of studies on the lab-scale reactor.

- From the experiments on the HDPE/LDPE pyrolysis, three types of products can be produced which include non-condensable gases, condensed liquid hydrocarbons (oil) and char. The distribution of the product varies greatly under different reaction conditions. Littered plastics give unaesthetic look in the city, choke the drain and may cause flood during monsoon.
- Recycling industries operating in non-conforming areas are posing threat to environment to unsound recycling practices.

2. LITERATURE REVIEW

Hiroyuki Fujimura [2]: The US patent 6,902,711 B1 mentioned to provide a method and apparatus for treating wastes by gasification. This can recover and resources of the wastes, open up a road to separation and reuse of the resources. This is also can produce synthesis gas having desired components for the use synthesis of ammonia (NH3) by partial combustion. Solving various problems caused by incineration or dumping of organic wastes, and obtain low cost hydrogen (H2) which is used for synthesis of MMONI. The apparatus contains of: (a) a fluidized bed reactor for partially combusting wastes at a temperature of from 450°C to 650°C;(b) a combustor that separated from fluidized bed reactor and operable at a temperature sufficient to melt an ash content of char, for receiving the gaseous material and the char from outlet of fluidized bed reactor and for gasifying the gaseous material and the char to form synthesis gas; (c) a cooler to cool the synthesis gas to form cooled synthesis gas;(d) a CO converter to receive the cooled H2 and CO2;(e) a separator to separate H2 from the CO2. In this patent, does not mention the amount of synthesis gas that can be produced.

Hans-Ulrich Dummersdorf, Helmut Waldmann [3]: According to US patent 5,369,947 the high energy content of mixed plastic waste of any composition could be efficiently converted into power in the form of electricity. At the same time, it would enable the plastic waste to be disposed of completely and safely without any formation pollutants. It would be saved a high percentage of fossil raw materials to preserve raw material resources and the environment. Thus problem has been solved by coupling a plasma pyrolysis process with a combines gas or steam turbine processes, so that both processes together in their coupled form represent a highly effective “plastic-driven power generator”. The plastic waste is reacted in a plasma reactor under reducing conditions in a plasma containing substoichiometric oxygen at temperatures above 1200°C to form a plasma pyrolysis gas consisting of low molecular weight carbon fragments which is then cooled to temperature below 1500°C. It is then delivered in compressed form as a fuel of high calorific value and high temperature to a gas turbine for generating power. The waste heat of this gas turbine is used to generate steam which is fed into a steam turbine for generating more power. The calorific value of this gas is 37,000 kJ/m3. The process of

apparatus on this patent is too complex. It needs reacting the plastic waste in a plasma reactor (temperature of >1200°C), cooling it (temperature of <1500°C), compressing it (pressure of > 10 bar). It needs a steady state cycle. If the pressure is less than 10 bar, it would not be produces the heat and if it is more the max pressure standards (which is not mentioned in the patent), it will blow up the apparatus.

3. PYROLYSIS PLANT

Pyrolysis plant is an industry that converts waste plastic & tires into Pyrolysis Oil, Carbon Black & Hydrocarbon Gas. End products are used as industrial fuels for producing heat, steam or electricity. Pyrolysis plant is also known as: Pyrolysis unit, plastic to fuel industry, tire to fuel industry, plastic and tire recycling unit etc. Pyrolysis plant falls under following categories of industrial projects:

- Waste to energy project
- Waste plastic and tire pollution control equipment
- Renewable energy project
- Petrochemical

We establish large scale pyrolysis plants on turnkey basis (View photos). The total turnkey supply includes of machinery designing & simulation, equipment manufacturing, supply, installation, commissioning, technology transfer and operational training. We are one of the prominent leaders in establishing pyrolysis plants on turnkey basis.

4. METHODOLOGY

4.1 Extraction of oil from waste plastic

Plastics are shredded and then heated in oxygen free reactors 1 & 2 (known as Pyrolysis) to about 400°C. As the plastic boils, gas is separated out and often reused to fuel the machine itself. The fuel is then distilled and filtered because the entire process takes place inside a vacuum and the plastic is melted not burned minimal to no resultant toxins are released in to the air as all the gases and or sludge aw reused to fuel the machine.

Impact of type of Plastics that can be used

- Burn pure hydrocarbons such as PP,PE will produce a fuel that burns fairly clean, & burn PVC and large amount of chlorine will corrode the reactors and pollute the environment.
- Burning PETE releases oxygen in to the oxygen deprived chamber there by slowing the processing and PETE recycles efficiently at recycling centers

It is best to recycle PETE traditionally. HDPE (jugs) and LDPE (bags and films) are basically PE, as usable as fuel as well, just slightly more polluting as thicker heavier fuel is created. But additional processing can turn even HDPE into clean fuel.

5. FUTURE SCOPE OF WORK

In order to commercialize the Pyrolysis technology to recycling of the waste plastics and to better understand the Pyrolysis process, the following work is recommended for further studies: In the semi-scale plant, the current continuous feeding system has minor leaks and needs some modification. The feeding system should be able to control the required feeding rate and prevent back-flow of the high temperature Pyrolysis vapor. On the other hand, the oxygen leaking into the feeder must be prevented better and effective distillation columns should be applied on the semi-scale plant for refining of the Pyrolysis products.

The non-condensable gases were flared off in the experiment. It would be valuable to collect some of the gases and investigate its composition. The diesel range product should be separated out of the condensed products in the semi-scale plant. It is worthwhile to add hydrogen into the reaction to saturate the hydrocarbons thus to modify the product to increase the target diesel products. Hydrogenation can significantly improve the product quality towards transport use. Many oil refinery factories apply this process to convert alkenes into alkane in order to get higher stability oil.

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