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Plastic Waste Pyrolytic Converter

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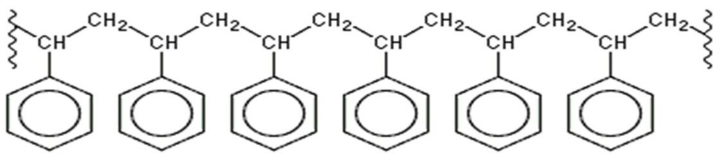
Abstract: Estimates show that less than 5% of the plastic manufactured each year is recycled, with production of the material set to increase by 3.8% every year until 2030, adding to the 6.3 billion tonnes churned out since production began 60 years ago. The majority ends up in our oceans, posing a disruption to marine ecosystems, which researchers predict would take a minimum of 450 years to biodegrade, if ever. The main objective of this study were to understand and optimize the process of plastic pyrolysis for maximizing the diesel range products. The technology is not overly complicated, plastics are shredded and then heated in an oxygen free chamber (known as pyrolysis) to about 400 degree Celsius. As the plastic boil, gas generated is separated out and often reused to fuel machine itself. The fuel is then distilled and filtered. Because the entire process takes place inside vacuum and the plastic is melted-not burned, minimal to no toxic gas are released in the air, as all the gases and sludges 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 fuel that will fairly burn clean. But burn PVC (polyvinyl chloride) and large amounts of chlorine will corrode the reactor and pollute the environment.

I. INTRODUCTION

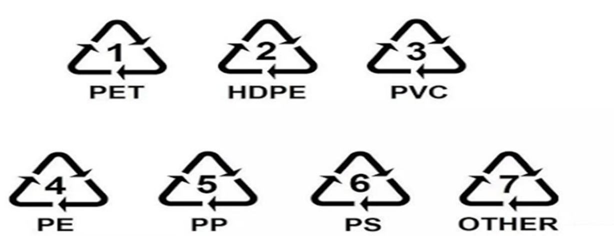
A. Plastic

Plastic is a high molecular weight material that was invented by Alexander Parkesin 1862. Plastics are also called polymers. The term means a molecule up by repetition of simple unit. For example, the structure of polystyrene can be written in a form as shown in Figure 1



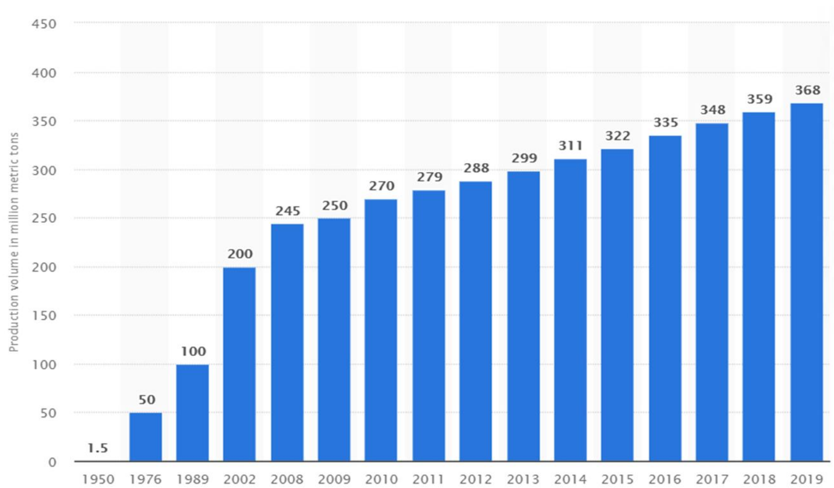
The repeating unit of the polymer is in the brackets with a subscript, n; to represent the number of the unit in this polymer molecule.Plastic is one of the most commonly used materials in the daily life which can be classified in many ways such as based on its chemical structure, synthesis process, density, and other properties.
Industry (SPI) defined a resin identification code system that divides plastics into the following seven groups based on the chemical structure and applications.
PET (Polyethene Terephthalate)
HDPE (High Density Polyethylene)
PVC (Polyvinyl Chloride)
LDPE (Low Density Polyethylene)
PP (Polypropylene)
PS (Polystyrene)
Others

The above seven types of plastics are marked on various products as follows



B. Plastic Waste: A Global Problem

The world is facing a plastic crisis. Plastic pollution has become a global concern, as our planet is drowning in plastic litter and microplastics. While plastic has many valuable uses, societies have become highly dependent on single-use or disposable plastic — with severe environmental consequences. Plastic waste is now so ubiquitous in the natural environment that scientists have even suggested it could serve as a geological indicator of the Anthropocene era. Due to the convenience to manufacturing and use, the world plastic production has been increasing since it was firstly commercially manufactured from 1.5 million tons in 1950 to 360 million tons in 2019 as shown in figure 1-3. One of the major concern for extensive use of the plastic is the disposal of the plastic waste. In addition, the plastic waste are produced from non-sustainable oil or coal, and thus it is non-sustainable product. We must address the harmful effects of plastics in our environment — the damage to marine and human health, littering of beaches and landscapes, clogging of our waste streams and landfills — and move beyond recycling and into a comprehensive approach to reducing plastic pollution.



C. Plastic Waste: Just how bad is India's Plastic Problem?

Like much of the world, India is struggling to dispose its growing quantities of plastic waste given how ubiquitous it has become — from our tooth brushes to debit cards. India generates close to 26,000 tonnes of plastic a day, according to a CPCB estimate from 2012. Worse, a little over 10,000 tonnes a day of plastic waste remains uncollected.

Uncollected plastic waste eventually ends up in the natural environment — in our seas and oceans or piling up on our lands. By 2050, the amount of plastic in seas and oceans across the world will weigh more than the fishes, says a headline-grabbing estimate by the Ellen MacArthur Foundation. At less than 11 kg, India's per capita plastic consumption is nearly a tenth of the US, at 109 kg. But, the projected high growth rates of GDP and continuing rapid urbanisation suggest that India's trajectory of plastic consumption and plastic waste is likely to increase.

The plastic processing industry in 2018 estimated that polymer consumption from 2017 to 2022 is likely to grow at 10.4 per cent, nearly half of which is single-use plastic. Discarded plastic waste litter the country's roads, rivers and also form huge mounds in garbage dumps across the country. During the monsoon, plastic bottles at the dump accumulate water and are a breeding ground for mosquitoes. Besides the stench, the site poses a major health hazard for the area's residents, exposing them to the mosquito-borne diseases.Many a times, the solid waste has been put on fire by the municipal agency, polluting the air. It can also be fatal for the stray animals, mainly cows and dogs that end up mistaking plastic for food.

II. LITERATURE REVIEW

A. Factors Affecting Plastic Pyrolysis

The major factors influencing the plastic pyrolysis process and pyrolysis product molecular distribution include chemical composition of the feedstock, cracking temperature and heating rate, operation pressure, reactor type, residence time and application of catalyst.

1) Chemical composition of feedstock
2) Cracking temperature and heating rate

The term "heating rate" in this field means the increase of temperature per unit time. The influence of the heating rate on the plastic pyrolysis process and product distribution varies in different studies. In this situation, the heating rate is very high. In a batch process, the plastic is normally heated from room temperature to the cracking temperature in several minutes. It is a slow pyrolysis process.

B. Type of Reactor

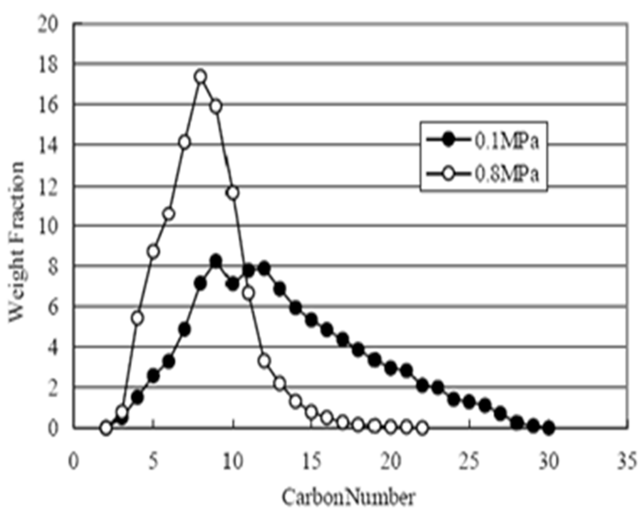
The reactor type for the plastic pyrolysis significantly influences on the heat transferrate, mixing of plastics with pyrolysis products, residence time and the reflux level of she primary products. Reactors can be classified into batch, semi-batch and continuous or classified based on types of reactor bed.

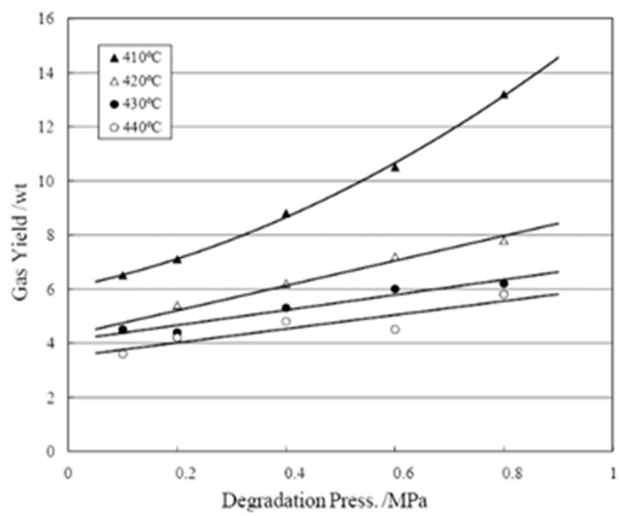
C. Use of Catalyst

In order to optimize plastic pyrolysis reactions and modify the distribution of pyrolysisproducts, catalysts are widely used in research and industrial pyrolysis processes. One of the main purposes of using catalysts is to shorten the carbon chain length of the pyrolysis products and thus to decrease the boiling point of the product.

D. Pressure

Operating pressure has significantly effect on both the pyrolysis process and the products. The boiling points of the pyrolysis products are increased under higher pressure, therefore, under pressurized environment heavy hydrocarbons are further pyrolyzed instead of vaporized at given operation temperature. Figure shows the effect of pressure on hydrocarbon number and their fractions in the pyrolysis





III. METHEDOLOGY

A. The pyrolysis of Plastic Materials

Pyrolysis is a thermal cracking reaction of the large molecular weight polymer carbon chains under an oxygen free environment and produces small molecular weight molecules. Traditional treatments for post-consumed plastics were landfills or incineration. However, landfill of the post-consumed plastics has potential problems because of limited land resource and high durability of plastics. Incomplete incineration may generate poisonous substances and causes serious health problems. Other methods like gasification and bioconversion are mainly used for organic materials. HDPE, LDPE, PP and PS are all hydrocarbons consisting entirely of carbon and hydrogen, which are similar to hydrocarbon fuels such as liquified petroleum gas(LPG), petrol and diesel. Plastics are derived from petroleum and have calorific values in a similar range as those of LPG, petrol and diesel.

B. Project Working

1) Raw Materia: Waste Plastic

(The processor accepts unwashed, unsorted waste plastics. Optimal feedstock includes polyethylene and polypropylene.)

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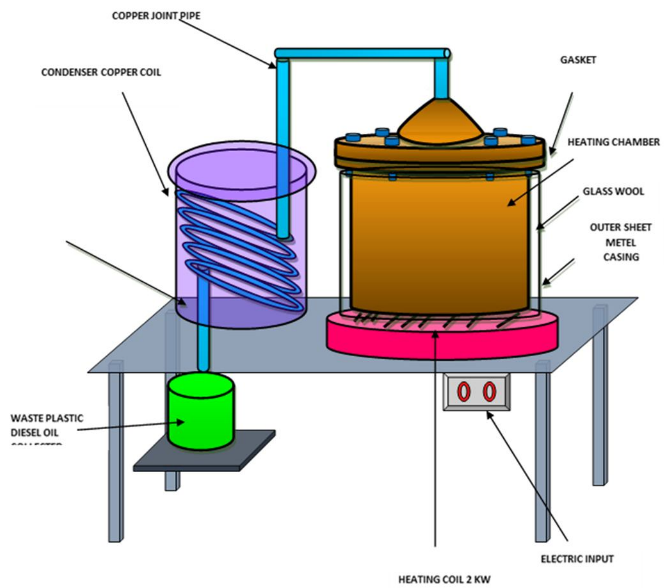
2) *Process Description*

a) Take 1 kg of waste plastics of some kind [ldpe,hdpe] cut it into piece and dry it .
b) The waste plastic is put inside the reactor after drying it.
c) The reactor must designed to withstand high temperature of about 350^{0}c-400^{o}c.
d) It has an inlet at the top for collecting the vapour.
e) Start the burner for heating the reactor and measure the temperature .
f) When the temperature reaches to around 410^{o}c the vapour start to come down to the condenser.
g) The heating is continued for about 1$^{1/2}$ hours till the vapour stop collecting.
h) After 1 or 1$^{1/2}$ hrs the plastics are decomposed.
i) At the time larger carbon molecules are break into smaller molecules.
j) The top of the reactor inlet is connected with the spiral condenser where the vapours are condensed.
k) Finally the fuel from condensed vapours are collected .



C. *Processor*

1) The processor requires only 1X 0.500 meter of operating space.
2) Height requirement is approximately 3 feet
3) Highly automated; very low operator to processor ratio.
4) Modular design allows for easy deployment.

IV. RESULTS

1) The conversion ratio for waste plastic into fuel averages 86%.
2) Approximately 700 ml of fuel is extracted from 1.5kg of plastic.
3) The processor uses 2KW power (3 phase) for heating.
4) Approximately 2-4% of the resulting product is Petcoke (Carbon Black), a high BTU fuel.
5) Emissions are lower than a natural gas furnace of similar size, and the quality of the emissions improve with increased feed rates.
6) The process operates at atmospheric pressure, and is not susceptible to pinhole leaks and/or other problems with pressure and vacuum-based system.
7) The fuel produced is refined and separated without the high cost of a distillation tower.

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A. Resource Usage

1) The processor is designed to use minimal amounts of external energy.
2) As well as being beneficial for the environment, this is also a significant factor in the commercial viability of the process.
3) Water is used for cooling only and usage is minimized through recycling the water . The water is not in contact with the process itself, keeping it clean and uncontaminated.

V. ADVANTAGES

Waste disposal issue is solved.
Waste plastic is converted into high value fuels.
Volume of waste is reduced.
Environmental effect is reduced.
Petroleum products importing can be reduced.

Environmental friendly

VI. CONCLUSION

Plastics present a major threat to today's society and environment. Over 14 million tons of plastics are dumped into the oceans annually, killing about 1,000,000 species of oceanic life. Though mankind has awoken to this threat and responded with developments in creating degradable bio-plastics, there is still no conclusive effort done to repair the damage already caused. In this regard, the catalytic Pyrolysis studied here presents an efficient, clean and very effective means of removing the debris that we have left behind over the last several decades. By converting plastics to fuel, we solve two issues, one of the large plastic seas, and the other of the fuel shortage. This dual benefit, though will exist only as long as the waste plastics last, but will surely provide a strong platform for us to build on 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 petrol and further studies on this field can yield better results.

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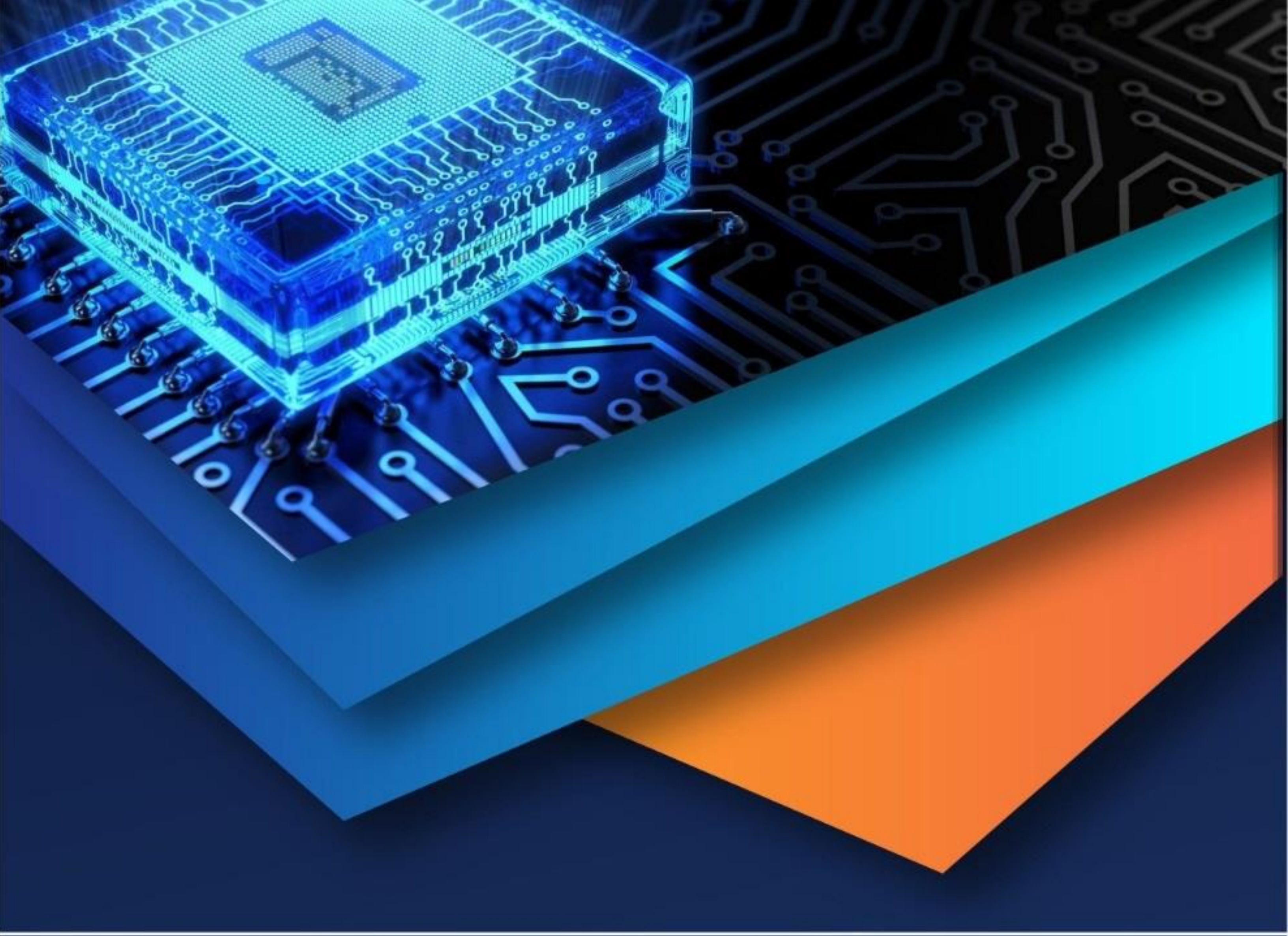

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