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FABRICATION AND PARAMETRIC ANALYSIS OF WASTE PLASTIC TO FUEL – A REVIEW PAPER

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Abstract- ***The study on the fabrication and parametric analysis of waste plastic to fuel as an effort to solve the problem of environmental pollution due to plastics and the need for alternative fuel. It is an alternate solution for mounting plastics disposal into which plastics are converted into bio-fuel which makes environment-friendly. The fabrication of the equipment was based on pyrolysis process. The main components were the heating chamber, condensing chamber, chiller pump, frame, motor, and hopper. The products obtained from pyrolysis are bio-fuel, wax and pyrolysis gas.***

Keywords- Waste Plastic, Pyrolysis, Pyrolysis Oil, Thermal cracking.

I. INTRODUCTION

Majority of plastics that are used are non-biodegradable which creates environmental pollution. It can also be found in nature, they remain in the environment in non-degraded form like container lids, packaging etc. for long period of time. Polypropylene (PP) is which affects environmental quality. Thermal cracking of organic matter at elevated temperatures in the absence of air is termed as pyrolysis. When pyrolysis is performed on organic substances, it produces pyrolysis gas and liquid products termed as bio-fuels and solid residue which is richer in carbon content, wax and char.

Pyrolysis is the process of heating organic material at a high temperature in the absence of oxygen. In the process the oxygen is not present, so the organic material does not combust. Pyrolysis of biomass produces three products namely pyrolysis bio-fuel, pyrolysis gas, and wax. There are three types of Pyrolysis Thermal Pyrolysis, Catalytic Pyrolysis, and Hydrocracking. In the Thermal Pyrolysis, the plastic waste is heated at high elevated temperature. This type is divided into three types Slow Pyrolysis is slow heating of organic matter and the volatiles from organic matter are partly evaporate and charcoal remains for a large part of the carbon in it. Fast Pyrolysis is the rapid heating of organic matter in the absence of oxygen. Flash pyrolysis is basically thermochemical decomposition of biomass and at an elevated temperature of 500°C and achieved higher efficiency compared to another process. [2].

Every year peoples produce nearly tons of plastic, and that affects the environment and ecosystem [12]. Plastic waste is one of a major part of municipal and industrial waste in cities. Even the cities with low economic growth have started producing more plastic waste in the form of containers, bottles, drums, trays, boxes, etc. [13].

II. LITERATURE REVIEW

Oil and Natural gas are the major raw materials used to manufacture plastics. The oil which requires for manufacturing of plastics is the crude oil. The production of plastics begins with the process of distillation of crude oil or natural gas through a process called **cracking** which leads to formation of hydrocarbon monomers such as ethylene, propylene, etc.

Further, processing leads to polymers which are monomers chemically bonded into chains. Monomers combines in various combination which provide wide range of properties and characteristic.

Aishwarya and Sidhu [3], studied the process of pyrolysis by using a microwave oven. This system generates microwaves in continuous cycles. The setup is having gravity feed and nitrogen is used to prevent oxygen to enter in the process. The plastic is heated by microwaves at a specified temperature. Later, product is transferred to the condenser where vapors are converted into liquid oil. Pyrolysis oil was obtained as the product. Microwave pyrolysis is having a valued future as a converting waste plastic into resources. Till now research in microwave pyrolysis only particular type of polymer such as Low-Density Polyethylene, High-Density Polyethylene etc has been taken for converting into resources. Thermogravimetric analysis proved an effective tool to define the products produced from the microwave pyrolysis of plastics. The condensate produced from the waste plastics is a means of transport as a fuel relatively easily, breakthrough the aromatic hydrocarbon into an aliphatic function that may have to be separated to comply with maximum limits for these compounds in these applications. This aromatic hydrocarbon is highly valuable as it is precursors for wide variety of compounds including drugs, lubricants,

detergents, plastics etc.

Seo et al. [4], examined Catalytic degradation of HDPE at an elevated temperature using batch reactor. The pyrolysis performed with an aluminosilicate zeolite had higher yield in the gaseous fraction and smaller yield in the liquid fraction when compared with thermal cracking. Most zeolites, such as aluminosilicate zeolite showed higher catalytic efficiency in cracking. The aluminosilicate zeolite has a three-dimensional pore channel structure and two intersecting channel systems of a specific shape that restrict molecular diffusion into the framework.

Dr. L Nageshwara Rao et al. [5], has performed an experiment for detecting the properties of the pyrolysis oil. A mixture of 1 ton of plastic waste is subjected to produce bio-fuel. The process involves physical cleaning and shredding of waste plastics for several times to ensure dust elimination. Washing of plastics in warm water with ethoxylates can remove more efficient staining. After which the moisture content is removed from the waste by drying it at room temperature. Catalyst '**Aluminum silicate'** is used to accelerate reaction. The mixture is heated at 330°C. Because of this pyrolysis, three products are obtained Pyrolysis oil, Pyrolysis Gas and Carbon Black, Char and Wax. By mixing pyrolysis oil with some part of pure petrol and diesel it can be used in a wide area.
As the confirmation tests of the bio-fuel products obtained are satisfied when compared to diesel and petrol, thus the bio-fuel products obtained through this process can be used as modern fuel. Thermo fuel is a truly sustainable waste solution, producing a highly useful commodity. Results of the experiment are as the Brake power increases the fuel consumption will gradually increases which indicates the engine performance, and the brake power increases the thermal efficiency will be increases which indicate the efficiency of the engine will depend on thermal characteristics of the fuel.

Stella Bezergianni et al [6], presents the two-step process for forming diesel fuel from waste plastics which has been experimentally tested and compared with respect to final fuel yield quality. In the first step, the semi-continuous operating pyrolysis plant produces the plastic waste pyrolysis. This first step contains two steps; Pyrolysis Oil Quality and Mid-Distillate Fraction Quality. In the second step, i.e. Pyrolysis Oil Hydrotreatment is basically the fast pyrolysis that enables removal of an atom that is not carbon or hydrogen and saturation reactions, leading to a
Significant improvement in the quality of the treated fuels.
The successful conversion of plastic waste into diesel fuel by this process is attributed primarily to the improved quality pyrolysis oil and its lighter fractions, and particularly the low density and viscosity as well as low sulphur content, water. The plastic waste pyrolysis oil's properties are superior to those of biomass pyrolysis oil (bio-oil), which is characterized by high water content and is highly acidic and those of scrap tire pyrolysis oil (STPO), which has high sulfur content.

N. Miskolczi et al [7], scrutinized the pyrolysis of waste plastics in a tube reactor at a 793K temperature in the presence and absence of aluminosilicate zeolite. It was found that there was increase in pyrolysis gases, gasoline, and pyrolysis oil if catalyst were present.

The pyrolysis of waste polyolefins was investigated at 793K, with a feed rate of 9 kg/h in a pilot scale reactor system. The used system was a gas tube reactor. Two waste plastics (high-density polyethylene (HDPE) and polypropylene (PP) from agriculture and packaging sectors) were tested in presence of ZSM-5 catalyst to ensure cracking reaction.
Based on the analysis the pyrolysis of waste HDPE and PP results, mainly paraffin and olefins. Pyrolysis of PP results smaller molecules which is heavy oil than HDPE.

Zhang et al. [8], examined the transformation of LDPE into the jet fuel. The catalytic microwave degradation was carried out at 648K with a catalyst to produce different proportions of the compound containing carbon and hydrogen joined together in straight chains.

The microwave-induced degradation of plastics of Low-density polyethylene at moderate reaction condition principally produced unsaturated hydrocarbons within aromatic hydrocarbons as major components. The variation of well-promoted aluminosilicate zeolite in the catalytic microwave degradation could modify the product distribution of compound containing carbon and hydrogen joined together in straight chains.

Abatneh et al. [9] Plastic-derived liquid hydrocarbons at a normal temperature and pressure are termed as liquid fuel. Only several types of plastics which can be remelted into liquid undergo thermal cracking into bio-fuel such as PE, PP, and PS are preferred for the feedstock of the production of liquid hydrocarbons. The method to convert plastics into bio-fuel is by pyrolysis of waste plastics and then condensed into liquid hydrocarbon. After the waste plastics were collected, it was washed to remove the dust tiny particles and then the moisture content was removed from it by drying it. It was taken in the chamber in the form of granules pieces which get easily break down into bio-fuel. Before starting the experiment, it should ensure no leakage in the components.

Then the heat given to the chamber was started, and the pyrolysis continued until the last drop of oil was noticed in the beaker.

Finally, the gas could pass through the metal tube and was directly immersed in the water. As the gas and water are in direct contact there will be heat exchanging between the gas and water. As the crude oil-water are immiscible they can be separated using a separatory funnel. The volume of fuel oil produced with time and temperature was monitored.

Thermal cracking was performed at a different temperature on different waste plastic to obtain pyrolysis oil. Finding out which plastic yield higher amount of oil was done by measurement of carbon content, wax, Pyrolysis oil, and Pyrolysis gas produced. The reduction in the bio-fuel oil is due to the effectiveness of the heating chamber which means the gases going to condenser are leaking out. Because, the bond of thermo-plastics is weaker than the bond of Thermosetting plastics. Therefore, yields from C-C combination plastic is more than C-H combination plastic. From the work, it has been tried to conclude that polymer structure, the operating temperature and the hold time are the major parameter which affect yield of oil from waste plastic.

Anthony et al. [10], Pyrolysis process is one of the most effective results compared to other methods. The process abstraction of fuel from waste plastic is in three parts which are as follows are Physical cleaning and Shredding of waste plastics, Cracking of plastics, Fractional distillation of crude oil, Neutralizing the non – condensing gases.
The basic plastic waste preferred for Pyrolysis is Polyethene (PE) plastics(bags) which are cleaned and shredded into small pieces. Its help on easily melt of plastic on applying heat and to form hydrocarbons in the form of liquid state or gaseous state depending on the output required.

The heating chamber should be provided with the suitable heat source, the heat source should be good enough to attend high temperature in a very short time as all the above conditions are satisfied, the cleaned and shredded plastic waste are transferred inside the chamber for further process. As the plastic waste is transferred into the chamber, the chamber is then heated by the preferable source of heat in the absence of oxygen. When the waste plastic is burnt in the absence of oxygen it will not catch fire, instead, it will burn and forms a gaseous state. From the chamber, the gaseous fuel is then sent to condenser to cool down the temperature when the temperature cools down the gaseous state changes to a liquid state which is partial fuel and gases. After the extraction of partial fuel from waste plastic the fuel is then sent to the container where the distillation process takes place. Fractional distillation is basically use for the separation of the components obtained from the condenser. It is a special type of simple distillation.
In this process, the partial fuel which we get again undergoes heating at a lower temperature compared to the pyrolysis process, at last the fuel produced from the container after the distillation process is contained in a Vessel for storage.

Patil et al. [11], Pyrolysis is cracking performed in the absence of air. Plastic & Rubber waste is continuously treated in a heating chamber and the pyrolysis gases are condensed in a condenser system. The cost required to convert waste plastics into bio-fuel is low compared to another process. So, this process is better to solve the fuel crisis and the problems due to plastics. Plastics materials undergo polymerization consist of different products such as Random de-polymerization of Waste Plastics and Fractional Distillation. Pyrolysis method is both Ecological and Economical. The properties of produced plastic liquid fuel are almost like that of Diesel fuel, hence plastic fuel represents a good substitute fuel for diesel engine and therefore it can be used for diesel engine vehicles.

Vijay Kumar et al. [12], Most of the plastic waste produced by peoples ends up filling up the lands causing land degradation. Also, the plastic wastes are dumped in the oceans which cause water pollution affecting both human and water life. Plastic waste recycling can provide a chance to collect and disposal of plastic waste in the most environmentally friendly way or it can be converted into a resource as a bio-fuel.
Thermosets or thermo settings plastics can be re-melted into the liquid only once. They are not suitable for producing bio-fuel as because of a weak C-C bond.

III. CONCLUDING REMARKS

- In view of the survey for our work, it can be closed that those waste plastic pyrolysis oil represents a good substitute for diesel and petrol engine. Dumping of Plastics leads to degradation of the ecosystem.
- Plastics exhibit a remarkable danger to the current society and state. More than 140 lakh ton of plastics is deserted into the seas yearly, slaughtering around a 10 lakh types of sea life. The transformation of this plastic into fuel spares the sea marine life.
- Pyrolysis has been found one of the better conversion of waste plastic to fuels. It is to find that the fuel obtained by Pyrolysis is better than conventional fuels.

- The Pyrolysis process was carried out Grade 5 type of plastic materials. 1.65lt. of oil is obtained by using 1.5 Kg of plastic. Quantity and quality of oil can be varied by using different quantity of plastics of various grades.
- Pyrolysis of LDPE does not only recover the energy contained in the plastic but also manage the environment by alternate disposal technique of the waste plastic.

After pyrolysis, the product is produced that is crude oil and hydrocarbon gas.
Pyrolysis Oil: -Burners of Boilers, Burners of Furnaces, Electric Generators.
Pyrolysis Gas: -Used as fuel to heat the plastic to oil reactor.

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