Preparation of Fuel by Plastic Waste Using Pyrolysis Reaction

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Abstract— Waste plastic disposal and excessive use of fossil fuels have caused environment concern in the world. Both plastics and petroleum derived fuels are hydrocarbons that contain the elements of carbon and hydrogen. The difference between them is that plastic molecules have longer carbon chains than those in LPG, petrol, and diesel fuel. Therefore, it is possible to convert waste plastic into fuel. All around the globe companies and individuals are starting to produce fuel from waste plastic. As only 8% of waste plastic is recycled in the U.S., 15% in Western Europe, and much less in developing countries, this reuse of plastic could potentially keep enormous amounts of plastic out of landfills and out of the oceans. 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-fifth 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.

Keywords: Plastic Waste, Pyrolysis, Hydro-cracking, Reactor, Shell

I. INTRODUCTION

Plastic is a high molecular weight material that was invented by Alexander Parkes in 1862.Plastics are also called polymers. The term polymer means a molecule made up by repetition of simple unit. For example, the structure of polystyrene can be written in a form as shown in Figure 1.1

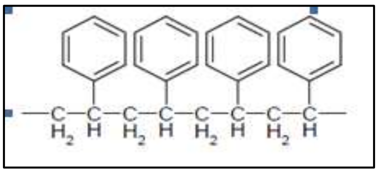

Fig. 1.1: Common expression of polystyrene molecular structure

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 [1]. Plastic is one of the most commonly used materials in daily life which can be classified in many ways such as based on its chemical structure, synthesis process, density, another property. In order to assist recycling of the waste plastic, Society of Plastic Industry (SPI) defined a resin identification code system that divides plastics into the following seven groups based on the chemical structure and applications [5]. 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 in1950 to 260 million tons in 2007. One of the major concerns for extensive use of the plastics is the disposal of the waste plastic. In addition, the plastics are produced from non-sustainable oil or coal, and thus it is a non-sustainable product. There were 30.7 million tons of waste plastic generated in the U.S. in 2007, which accounts for 12.1% of the total municipal solid wastes. In U.K., 4.9 million tons of plastics were consumed in 2007. Europe consumes about 25% of the global plastic production, which is equivalent to 60 million tons per year.

This device works on electricity (3 phase), it has one nichrome coils as heating elements and consumes a total of 2kW (1kW each coil). Heat the plastic slowly to about 350 degrees and just wait till it then. Our device has a capacity of 1 litre and can hold about 2 kg of shredded plastic. The process takes about 1 to 1.5 hours, but it can be shortened considerably by tweaking the design a bit. As we said, this makes a liquid fuel that can be used as multifuel, that means it can be used on diesel engines and also on gasoline engines, but we still need to test it will work on gasoline [7]. It works for diesel engines just fine, that has already been tested. There is a difference in what plastic we use, if we use polyethylene (plastic cans, plastic foil, and all kind of flexible non-break plastics) we will get out liquid fuel that will solidify as it cools into paraffin, it is still good for diesel engines as long as we use a heated fuel tank, because it needs to be heated just about at 30 degrees Celsius to be liquid and transparent.[6] If we don't want that, we can put the paraffin through the device for one more time and we will chop those hydrocarbons even smaller and half of the paraffin will turn to liquid fuel and other half will remain a paraffin, but much denser and will melt at higher temperatures, this is the stuff we can make candles out of and it does not smell at all when burned, maybe a bit like candles.

II. LITERATURE REVIEW

A. Background

All around the globe companies and individuals are starting to produce fuel from waste plastic. As only 8% of waste plastic is recycled in the U.S., 15% in Western Europe, and much less in developing countries, this reuse of plastic could potentially keep enormous amounts of plastic out of landfills *and* out of the oceans. 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 fo]=4=y-8thy5o97pn vjgkbiohp 'nm] this new fairly simple technology, a technology that is available now.

B. Pyrolysis

Prof.S.l. wong, n. Ngadi, t.a.t. abdullah, i.m. inuwa studied the polymer pyrolysis on different polymer and in different reactor. Approach of this study is recent progress in production of fuels and chemicals from virgin and post-consumer plastic waste. Chika muhammad, jude a. Onwudili, paul t. Williams done study on pyrolysis in the presence of zeolite catalysts and they found Pyrolysis of plastics produced from commercial. Waste electrical and electronic equipment produces a mainly oil product containing mostly. S.J. Pickering found that the composites. Industry is responding with a Composites Recycling Concept to manage waste from composites and stimulate recycling activities. A. López , I. de Marco, B.M. Caballero, M.F. Laresgoiti, A. Adrados, A. Torres has done study on Thermogravimetric analyses and catalytic pyrolysis and they analyse the behaviour of different real packaging samples in pyrolysis. M. Punčochářa, B. Rujb, P. K. Chatterjeeb they studied plasma pyrolysis technology and conversion of high calorific value plastic into synthesis gas. Mochamad Syamsiroa, Harwin Saptoadi, Tinton Norsujianto, Putri Noviasria, Shuo Chen work on Sequential pyrolysis and they found that the feedstock types strongly affect the product yields and the quality of liquid and solid product.

C. Co Pyrolysis

M. Sajdak, r. Muzyka done study on Co pyrolysis of plastic waste as fuel with biomass and he found that the co-pyrolysis of biomass with polypropylene as an additional fuel. Chunfei Wu and Paul T. Williams work on Pyrolysis -gasification and the approach was the influence of steam and the presence of catalyst on gas and hydrogen production from the pyrolysis–gasification of polypropylene and they found that the amount of reacted water, gas production and hydrogen production were increased with both the increase of gasification temperature from 600 to 900˚C.

D. Hydro-cracking

Wiwin Sriningsih, Monica GarbySaerodji, Wega Trisunaryanti, Triyono, Ria Armunanto, IipIzulFalah works on Hydro-cracking of LDPE plastics into fuel over bi functional catalysts and Chemical analysis of fuel. Dezhen Chen, Lijie Yin, Huan Wang, Pinjing studied Pyrolysis by 4 types of reactors viz. Fixed-bed, Rotary kiln, Fluidized-bed, Tubular.The pyrolysis of MSW has shown that most the industrial

Pyrolysis facilities are coupled with gasification or combustion stage and they all equipped with gas scrubbing devices.

III. MATERIALS AND METHODOLOGY

A. Shell

A cylinder is considered thin when the ratio of its inner diameter (d) to the wall thickness (t) is more than 15 or equal. When the ratio of inner diameter (d) to the wall thickness (t) is less than 15 it is considered as a thick cylinder. Boiler shells, pipe tubes, storage tanks are the examples of thin-walled cylinders while hydraulic cylinders, high pressure pipes, gun barrels, submarines are thick-walled cylinders. In this design, the shell used is a thin cylinder type as the shell thickness required is less as compared to the storage capacity or the inner diameter of the vessel.

Fig. 3.1 Shell

B. Compound cylinder

Compound cylinders are advantageous as against simple single layered thickness shell. Such shells are made by a process called Auto frottage wherein two concentric cylinders with outer cylinder is shrunk in the inner one. This induces compressive stresses in the inner one and reduces the net pressure acting on the cylinder. This is carried out by heating the outer cylinder and expanding its diameter and then put on the inner one under gradual cooling which makes it press fitted.

Fig. 3.2: Cylinder (Heating chamber)

C. Anchor Bolt

The bottom of skirt of vessel must be securely anchored to the concrete foundations by means of anchor bolts embedded in the concrete to prevent over turning from bending moments induced by seismic and wind loads. The concrete foundation is poured with adequate reinforcing steel to carry tensile loads. The anchor bolts may be

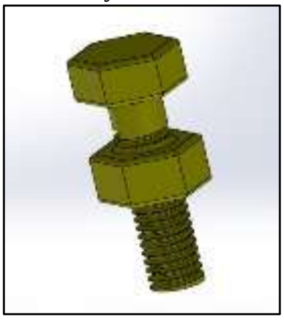

Fig 3.3 Anchor Bolt

Formed from steel rounds threaded at one end and usually with a curved or hooked end embedded in the concrete will bond to the embedded surface of the steel.

D. Condenser Coil

The condenser coil is as shown in below fig. 4.2. The condenser coil is made of cooper material has diameter 6 mm and it is used to cool the vapours after heating the plastic material.

Fig. 3.4: Condenser Coil

E. Gasket and Assembly

The gasket is used to seal the heating chamber and the opening is connected to the condenser. The gasket is as shown fig. below.

Fig. 3.5: Gasket

IV. EXPERIMENTATION

The process is really simple; it is similar to how alcohol is made. If we heat plastic waste in non-oxygen environment, it will melt, but will not burn. After it has melted, it will start to boil and evaporate, we just need to put those vapours through a cooling pipe and when cooled the vapour will condense to a liquid and some of the vapour with shorter hydrocarbon lengths will remain as a gas. The exit of the cooling pipe is then going through a bubbler containing water to capture the last liquid forms of fuel and leave only gas that is then burned. If the cooling of the cooling tube is sufficient, there will be no fuel in the bubbler, but if not, the water will

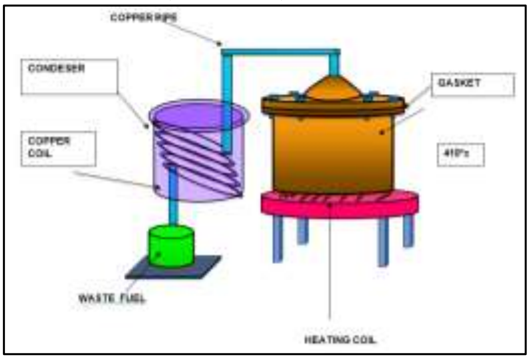

Fig. 4.1: Experiment Set Up.

capture all the remaining fuel that will float above the water and can be poured off the water. On the bottom of the cooling tube is a steel reservoir that collects all the liquid and it has a release valve on the bottom so that the liquid fuel can be poured out. Here are some pictures to better understand the design as shown in fig. 4.3. This device works on electricity (3 phase), it has nichrome coils as heating elements and consumes a total of 2 kW. We need to heat the plastic slowly to about 350^0 C. This device has a capacity of 1 litre and can hold about 2 kg of shredded plastic. The process takes about 1 to 1.5 hours, but it can be shortened considerably by tweaking the design a bit. As we said, this makes a liquid fuel that can be used as multi fuel, that means it can be used on diesel engines and also on gasoline engines, but we still need to test it will work on gasoline. There is a difference in the type of plastic we use, if we use polyethylene (plastic cans, plastic foil, and all kind of flexible non-break plastics) we will get out liquid fuel that will solidify as it cools into paraffin, it is still good for diesel engines as long as we use a heated fuel tank, because it needs to be heated just about at 30 degrees Celsius to be liquid and transparent. If we don't want that, we can put the paraffin through the device for one more time and we will chop those hydrocarbons even smaller and half of the paraffin will turn to liquid fuel and other half will remain a paraffin, but much denser and will melt at higher temperatures, this is the material out of which candles are made and it does not smell at all when burned. But if we use polypropylene (computer monitor cases, printer cases, other plastics that break easily), we get out only liquid fuel, no paraffin at all. All we need is just filter the fuel out of solids and we are good to go and put it in the gas tank. We have made the analysis and it is almost the perfect diesel fraction. It has no acids or alkaline in it, like fuel from tires does. The unit in the pictures can convert about 8 kg of plastic into 40litres of fuel in one day. Some Japanese companies manufacture such devices, but their price for this size unit is more. We use aluminium oxide bricks to insulate the heat, they are light as foam and can be easily cut in any shape, but any kind of insulator can be used. It can also be made using liquid fuel burners to heat the reactor, this will enable to make the device self-sustainable by using about 10-15% of the produced fuel along with the produced gas. A small farm can use a device of this size and make fuel for itself by converting plastic waste to fuel, farms have very much plastic waste and it is a big problem, at least in our country. The following figure shows actual model of converting fuel from waste plastic.

V. RESULT AND DISCUSSION

I have conducted an experiment on our setup, on the basis of that experiment I got the following results. For performing the experiment, we needed a heating coil which consumed a power of 2kw. Generally, for 1 unit of electricity the rate Rs. 5 it means Rs. 10 for 1 hour. According to the experiment our project takes near about 1.5 hours for producing oil from 1 kg of plastic waste, so the cost of total consumption of power is Rs.15 approximately.

A. Temperature profile

Temperature dominates the cracking of plastic waste hence; it is considered as important factor in the process pyrolysis. The variation of temperature in the reactor is shown in fig. 5.1 Fig. 5.1 shows large temperature gradient between the outer wall of the reactor and the space inside the reactor. After starting the experiment, Wall temperature is higher than inside temperature of reactor during first few minutes. This is because the furnace had just heated up and the heat that reached the pyrolysis reactor was low. At 50 minutes, high rate of heat is transferred at this stage the wall and space temperatures of the pyrolysis reactor reached 80 C and 75 C, respectively. After 70 minutes maximum temperature occurs. The beginning of generation of gas is observed from 35th to 45 th minute inside the reactor which shows vaporization. (shown in Fig. 5.1).

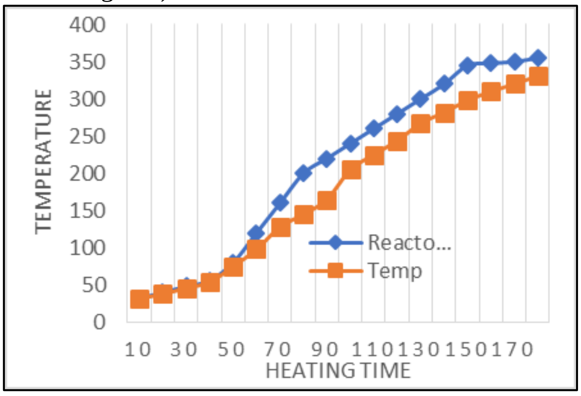

Fig. 5.1: Temperature profile of pyrolysis reactor with sample feed

VI. Conclusion

The production of thermo fuel from waste plastics is one of the better methods to save the environment profitably. From 1kg of raw plastic material we can get up to 100-150g(approximate) of fuel & after distillation we will produce petrol, diesel, kerosene, neptha, carbon & other contents separately. One of the most beneficial part of this project is that "it provides alternative to existing sources of fuels." The contributors also focus on the effectiveness of recent technologies in mitigating environmental impacts, particularly those for managing plastics in the solid waste stream. Plastic and design engineers, polymers chemists, material scientists, and ecologists will find plastics and the environment to be a vital resource to this critical industry.

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