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Conversion of Plastic Waste into Fuel: A Review

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Abstract *This review paper discuss about the fuel preparation from plastic wastes. Many alternative fuels are used by different researches. Environmental concern and availability of petroleum fuels have brought about interests in the search for alternate fuels for internal combustion engines. Plastics have become common materials of our daily lives, and many of their properties, such as durability, versatility and lightweight, can be a significant factor in achieving sustainable development. Here, the method of changing waste plastic into price additional fuels is explained as available resolution for exercise of plastics. Thus 2 universal issues like issues of waste plastic and issues of fuel shortage square measure being tackled at the same time. Change of waste to energy is one of the recent trends in minimizing the waste transfer as well as could be utilized as a substitute fuel for engines. In this study, a review of analysis papers on varied operational parameters are ready for higher understanding of operational conditions and constrains for waste plastic transmutation oil of both grade fuel and its blends fuelled in internal combustion engine.*

Key Words: Waste plastics, pyrolysis, catalytic cracking, alternative fuel.

1.INTRODUCTION

Plastics play a vital role in day to day life, as in sure application they need a position over typical materials. Indeed, their light weight, durability, energy efficiency, coupled with a faster rate of production and more design flexibility, have allowed breakthroughs in fields ranging from non-conventional energy, to horticulture and irrigation, water-purification systems and even space flight. Plastics are relatively cheaper and being easily available has brought about use and throwaway culture. Plastics waste management has become a tangle world over thanks to their non-degradable property. A majority of landfills, allotted for plastic waste disposal, are approaching their full capacity. Thus recycling is becoming increasingly necessary. [1]

Every year humans produce nearly 280 million tons of plastic, and much of that plastic ends up in the environment, harming marine life and other ecosystems. The chemical bonds that makes plastic so durable makes it equally resistant to natural processes of degradation. Since plastics are non-biodegradable in nature, it is very difficult to eliminate the waste plastics from nature. Since 1950s 1 billion tons of plastic have been discarded and may persist for hundreds or even thousands of years. Expenditure incurred on disposal of plastic waste throughout the globe is around US$ two billion per annum. Even for a small country like Honk Kong spends about US$ 14 million a year on the exercise. The majority of the plastic waste lands up in landfills, and becomes a carbon sink where it may take up to 1000 years to decompose and potentially leak pollutants into the soil and water. Also the plastic wastes area unit drop within the oceans threatening the health and safety of marine life. Converting the waste plastic into fossil fuel can have 2 advantages. First of all, the hazards caused due to plastic waste can be reduced and secondly, we will be able to obtain some amount of oil from it, which can be any sublimate to be used as a fuel in numerous areas like domestic fuel, fuel for vehicles and industries etc. There by, our dependency on fossil fuels will reduce to a certain extent.

1.1. 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.

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. [2]

2. LITERATURE REVIEW

Antony Raja [1] the properties of liquid distillate match with properties (Ex: specific gravity and pour points) of high quality imported crude. The fuels obtained within the waste plastic method area unit just about free from contaminants like lead, sulphur and atomic number 7.

Vijaykumar B. Chanashetty [2] Plastics present a major threat to today's society and environment. Over fourteen million loads of plastics area unit drop into the oceans annually, killing about 1,000,000 species of oceanic life. Though man has awoken to the current threat and responded with developments in making 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 changing plastics to fuel, we solve two issues, one of the large plastic seas, and the other of the fuel shortage. This twin profit, 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 consideration the money edges of such a project, it would be a great boon to our economy.

N. Miskolczi [3] Thermal degradation of plastic waste for production of liquid fuels. It is an endothermic process requiring temperature of 350-500c. The gaseous products obtained by thermal pyrolysis are not suitable for use as fuel products, further refining is required. So, from the studies conducted we can conclude that the properties of the fuel obtained from plastics are just like that of gasolene and more studies on this field can yield better results.

Alkazadagaonkar [4] the experiments on conversion waste plastic into liquid fuels using new technology. We can convert all types of waste plastics into liquid fuels at a temperature of 350-500c.The conversion of waste plastic into liquid fuels having two benefits to recover energy from waste and cut back the environmental issues caused by this waste.

Achyut K. Panda [5] Engine was able to run with maximum 50% waste plastic oil- diesel blends. Above 50% blend, detonations occur in the engine and it started vibrating. Brake thermal efficiency (almost same or marginally higher than diesel up to 80% load and somewhat lower at full load) Exhaust gas temperature (Exhaust gas temperature is found marginally higher with blend than diesel operation) Brake specific fuel consumption (Brake specific fuel consumption is marginally less than diesel).

M.F. ali [6] the high yields of liquid fuels in the boiling range 100–480°C and gases were obtained along with a small amount of heavy oils and insoluble material such as gums and coke. The results obtained on the co-processing of polypropylene with coal and petroleum residues are very encouraging as this method appears to be quite feasible to convert plastic waste materials into liquefied coal products and to upgrade the petroleum residues and waste plastics.

Moinuddin Sarker [7] when initial waste plastics sample melted and it's taken about 30 minute to produce vapor to first drop of plastic fuel production. At that state drop of fuel production rate spontaneously increasing and to bring the stable state of fuel production temperature were decreased to 315 ºC. By closely studied on several experiment in NSR laboratory, found that optimum and expected production captured in 300- 315 ºC. End of the experiment to enhance the production yield temperature rose to 420 ºC to reach the maximum yield of production margin. At the higher state of temperature every experiment monitored and controlled very sincerely to overcome any serious incidence and occurrences

Arunkumar B Y [8] In light of audit of our venture, it is presumed that the waste plastic pyrolysis oil speaks to a decent option for diesel and oil motor, in this way should be contemplated later on for transportation reason. Plastics exhibit a noteworthy danger to the present society and condition.

Rajaram.T. Karad [9] In the Pyrolysis reaction different type of oil will be extracted from different type of waste plastic. Such oil acts as petrol, diesel and kerosene. The same pyrolysis reaction produce 10% gas it acts as LPG. For overall pyrolysis reaction using vacuum pump and catalyst oil production will be faster. For 1Kg of waste plastic will get 900ml oil can be extracted and 100gm of gas can be extracted and the remaining thing is carbon block.

3. METHODOLOGY

3.1. Pyrolysis

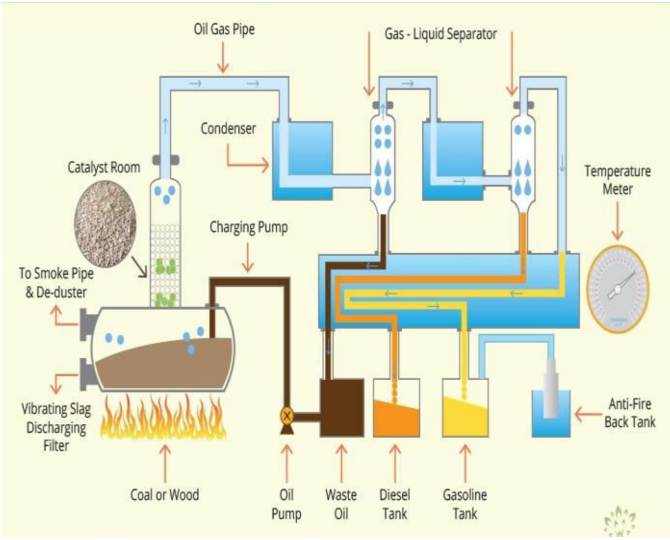

Fig -1: Plastic Pyrolysis Process

Pyrolysis is mostly outlined because the controlled heating of a fabric within the absence of O. In plastics transmutation, the molecule structures of polymers area unit countermined into smaller molecules or oligomers and generally compound units. Further degradation of those sequent molecules depends on variety of various conditions as well as (and not restricted to) temperature, residence time, presence of catalysts and other process conditions. The transmutation reaction will be disbursed with or while not the presence of catalyst. Accordingly, the reaction will be thermal and catalytic Pyrolysis. Since majority of plastic used area unit polyolefin, so extensive research has been done on this polymer which is summarized as below

3.2. Thermal Pyrolysis of Polyolefin

The non-catalytic or thermal Pyrolysis of polyolefin is a high endothermic process temperature of at least 350–500 °C. In some studies, high temperature as 700–900 °C is essential in achieving decent product yields. The extent conjointly the} nature of those reactions rely each on the reaction temperature and also on the residence of the product within 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 kinds of reactors are reported within the literature, the most frequent being fluidized bed reactors, batch reactors and screw kiln reactors. Characteristics of thermal degradation of significant hydrocarbons will be represented with the subsequent points;

- High production of C1s and C2s in the gas product.
- Olefins are less branched.
- Some olefins made at high temperature.
- Gasoline selectivity is poor; i.e. oil product area unit a large distribution of mass.
- Gas and coke products are high.
- Reactions are slow compared with catalytic reactions.

Thermal transmutation of each virgin and waste plastics also as different hydro-carbonaceous sources has been studied extensively within the past. A good variety of those thermal cracking studies area unit on synthetic resin, On the other hand, only a few have worked on the thermal decomposition of other common plastics such as polyvinylchloride, poly methyl methacrylate, and polyurethane and polyethylene terephthalate. Generally, thermal cracking ends up in liquids with low hydrocarbon worth and better residue contents at moderate temperatures, thus an inefficient process for producing gasoline range fuels. The vaporize product obtained by thermal transmutation doesn't seem to be appropriate to be used as fuel product, requiring any refinement to be upgraded to useable fuel product. A few researchers have sought-after to enhance thermal transmutation of waste polyolefin while not using the utilization of catalysts; but these changes either yielded insignificant enhancements or superimposed another level of complexity and costs to the system.

3.3. Catalytic Cracking of Polyolefin's

Addition of catalyst enhances the conversion and fuel quality. As compared to the strictly thermal transmutation, the addition of catalyst in polyolefin Pyrolysis

1) Significantly lowers Pyrolysis temperatures and time. A significant reduction within the degradation temperature and response time beneath chemical action conditions ends up in a rise within the conversion rates for a large vary of polymers at a lot of lower temperatures than with thermal Pyrolysis.

2) Narrows and provides better control over the hydrocarbon products distribution.

3) Increases the gaseous product yields. Under similar temperatures and reaction times, a much higher gaseous product yield is observed in the presence of a catalyst for polyethylene.

4. MAIN DEVICES USED IN THE PROCESS

4.1. Condenser

It cools the whole heated vapour kicking off of the reactor. It has associate degree body of water associate degree an outlet for cold water to run through its outer space. 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.

4.2. Reactor

Fig-2: Stainless steel 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.

4.3. Process Description

Thermal cracking process is done without using catalyst to convert waste plastic into liquid fuel. Two styles of waste plastic are chosen for this explicit experiment. By weight five hundredth of every tenuity polythene and polypropene was chosen for the experiment. Both waste plastic are solid hard form. Collected waste plastic was cleansed exploitation 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 thirty five cm size to suit into the reactor guardedly. For experimental purpose we have a tendency to used 600gm sample 300gm of PP and 300gm of LDPE. A vertical steel reactor used for thermal cracking and temperature used ranges from100° C to 400° C.

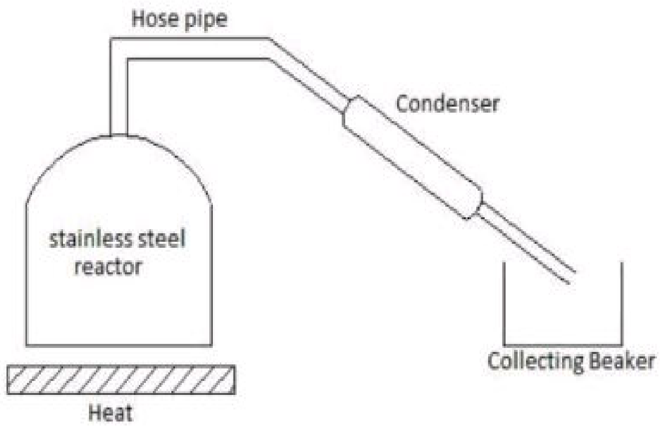

Fig -3: Photograph of Experimental setup.

When temperature is exaggerated to 270° C liquid suspension turns into vapour and also the vapour then passes through a condenser unit. At the end we collect liquid fuel. Between 100º C and250º C around twenty -30% of the fuel is collected then once raised to 325º C consecutive four-hundredth is collected and eventually once command at 400º C the yield is fully completed. During the thermal cracking method plastic parts aren't countermined straightaway as a result of plastics have short chain organic compound to long chain organic compound. 1st stage of warmth applied breaks down solely the short chain organic compound. When temperature profile is exaggerated the plastic carbon-carbon bond breakdown slowly. As the temperature is exaggerated the long chains are breakdown step by step. During this thermal cracking method some lightweight gas like methane series, ethane, fuel and paraffin are made. [2, 8, 11]

4.3.1 Properties and Purity of Fuels

The properties of liquid distillate match with properties (Ex: specific gravity and pour points) of high quality imported crude. The fuels obtained in the waste plastic process are virtually free from contaminants such as lead, sulphur and nitrogen. In the process (i.e.) the conversion of waste plastic into fuels, the properties mentioned above of petrol & Diesel fractions obtained are of superior quality with respect to regular commercial petrol and diesel purchased locally and has been proved by the performance test. During the process, hazards related to health and safety is reduced to 90% as compared to regular refinery process.

4.3.2 Quality of Fuels

The quality of gasoline and diesel fractions obtained in the process is not only at par with regular fuels in tests like sp – gravity is 0.7365 /15 °C CCR (conradson carbon Residue) Ash, calorific value etc but it is also better in terms of quality in test like flash point, API gravity. Table 2 gives the comparison of plastic derived petrol with regular petrol [4].

4. 3.3 Additives

Regular fuels obtained from crude oil like gasoline and diesel are subjected to many reactions and various additives are added to improve combustion and meet BIS characteristics before it is introduced to market. However the fuel (Gasoline, Diesel) fractions obtained in the process can be utilized without much processing. 3.5 Yield The average percentage output yield of the products in the first phase of reaction depending on the composition of the waste plastic is as follows:

Liquid Distillate> 110% - 115 % ;

Coke> 09 % - 10%;

Gas > 21 % - 22%;

LPG > 14% - 16%;

Hydrogen > 01% - 02 %.

The percentage of liquid distillate is mentioned in terms of weight by volume whereas percentage of coke & gas are mentioned in terms of weight by weight. [1]

During the second phase of reaction (i.e.) fractional distillation, the average percentage yields of various fuel fractions depending on the composition of the waste plastic are follows:

Gasoline: 60%;

Diesel: 30%;

* Lubricating oil: 8–10%.

5. ADVANTAGE

1. Problem of disposal of waste plastic can be solved by converting waste plastic into fuel.

2. Industrial and automobile fuel requirement shall be fulfilled to some extent at lower price.

3. By converting plastics to fuel, we solve two issues, one of the large plastic seas, and the other of the fuel shortage.

4. No pollutants during cracking of plastic.

5. The crude oil can be used for generation of electricity. Thus our dependency on fossil fuels will reduce to a certain extent.

6. Desirable process as energy is obtained from renewable sources like municipal solid waste or sewage sludge.

7. Conversion of plastic waste into fuels reduces hazardous effects of plastics on to the environment.

8. Conversion of plastic waste into fuels reduces importing of petroleum products.

6. CONCLUSIONS

The experiments on conversion waste plastic into liquid fuels using new technology. We can convert all types of waste plastics into liquid fuels at a temperature of 350-5000c.Conversion of plastic waste into fuels reduces importing of petroleum products, so serious efforts from present Indian government need to be taken to make our planet healthier and cleaner for our next coming generations. As there is a high demand of crude oil and due to its sky reaching prices, we could take up this Project to setup large or small scale industries and produce the fuel locally at much cheaper rates directly benefiting the National economy and also a step towards SWACH BHARAT by recycling the waste plastic.

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