

EXTRACTION OF LIQUID HYDROCARBON FUEL FROM WASTE PLASTIC

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Abstract: This Paper deals with the conversion of Plastic Wastes into alternative fuels. Waste Plastic from municipal solid waste were collected and were sorted based on their types like PET bottles, Polypropylene, Polystyrene, HDPE and LDPE. These Plastic wastes are graded and shredded and then heated in a closed chamber (Similar to a process called Pyrolysis) to attain temperatures up to 150-200⁰C. The Plastic waste is melted and gases produced at this temperature are condensed to liquid state. Both, Condensed and Uncondensed gases can be used as fuel to engines. The Fuel produced is tested for Viscosity and Calorific Value, and is compared with Gasoline and Diesel Fuel and the results Obtained are tabulated.

Index Terms— Plastic wastes, Alternative Fuel, Polystyrene, Pyrolysis, Thermal Cracking and Calorific Value.

I. INTRODUCTION

Use of Plastics is increasing Day by Day and the disposal of waste generated from plastics has been a major concern. Plastics are processed from Crude Oil. The objective is to reverse the process and from flammable fuel from Plastic waste. Besides helping in removal of Tons of waste plastic, which makes a Tidy environment, the Pyrolysis of waste plastics also helps in generating an alternate fuel, a convenient from of fuel to replace Diesel or Gasoline. With the alarming levels of increase in consumption of Petrol, Diesel which are not only non-replenishable but also are the source for major hazardous pollutants that damage the environment, Innovation and search for Alternative fuels falls in its natural order and this Liquid Hydrocarbon obtained from waste plastics might as well save the day and meets the growing demand for Alternative fuels. This however requires a separate and well-planned set of Equipment that can serve the purpose and simultaneously present itself to be pocket-friendly.

The following are the requirements for a successful extraction of Liquid fuel from waste plastics:

Collection, Storage and shredding of Plastics

Develop/ Fabricate a Pyrolysis unit

Conduct different experiments to find the Thermo-Physical properties of the obtained liquid fuel.

II. METHODS AND PROCEDURES

In most of the situations, plastic waste recycling could also be economically viable, as it generates resources, which are in high demand. Plastic waste recycling also has a great potential for resource conservation and GHG emissions reduction, such as producing diesel fuel from plastic waste.

For many years, various methods are tried and tested for processing of waste plastic. The plastic materials are recycled and low value products are prepared. Plastic materials which cannot be recycled are usually dumped into undesirable landfill. Worldwide almost 20% of the waste stream is plastic, most of which still ends up in landfill or at worst it is incinerated.

This is a terrible waste of a valuable resource containing a high level of latent energy. In recent year this practice has become less and less desirable due to opposition from Government and environmentally conscious community groups. The value of plastics going to landfill is showing a marginal reduction despite extensive community awareness and education programs. Research Centre for Fuel Generation (RCFG) has conducted successful 300 successful pilot trials and commercial trials for conversion of waste plastic materials into high grade industrial fuel. The system uses liquefaction, Pyrolysis and the catalytic breakdown of plastic materials and conversion into industrial fuel and gases. The system can handle the majority of plastic materials that are currently being sent to landfill or which have a low recycle value. Catalytic conversion of waste plastic into high value product is a superior method of reusing this valuable resource.

The following table lists the types of Plastics that can be successfully used for Plastic Waste Recycling.

| Symbol | Acronym | Full name and uses |
|--|---------|--|
|  | PET | Polyethylene terephthalate - Fizzy drink bottles and frozen ready meal packages. |
|  | HDPE | High-density polyethylene - Milk and washing-up liquid bottles |
|  | PVC | Polyvinyl chloride - Food trays, cling film, bottles for squash, mineral water and shampoo. |
|  | LDPE | Low density polyethylene - Carrier bags and bin liners. |
|  | PP | Polypropylene - Margarine tubs, microwaveable meal trays. |
|  | PS | Polystyrene - Yoghurt pots, foam meat or fish trays, hamburger boxes and egg cartons, vending cups, plastic cutlery, protective packaging for electronic goods and toys. |
|  | Other | Any other plastics that do not fall into any of the above categories. For example melamine, often used in plastic plates and cups. |

Table 2.1 – Classifications of Plastics:”

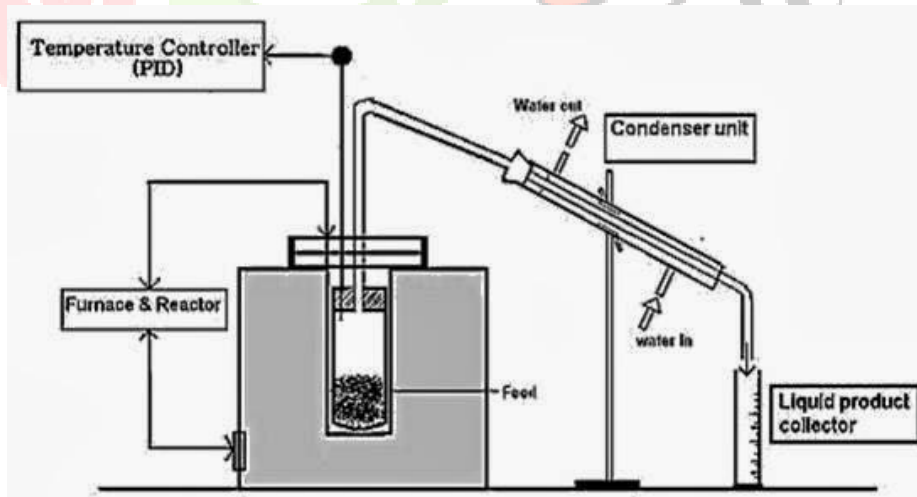


“Fig 2.1-Typical Plastic Landfill”

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II. 1. PYROLYSIS

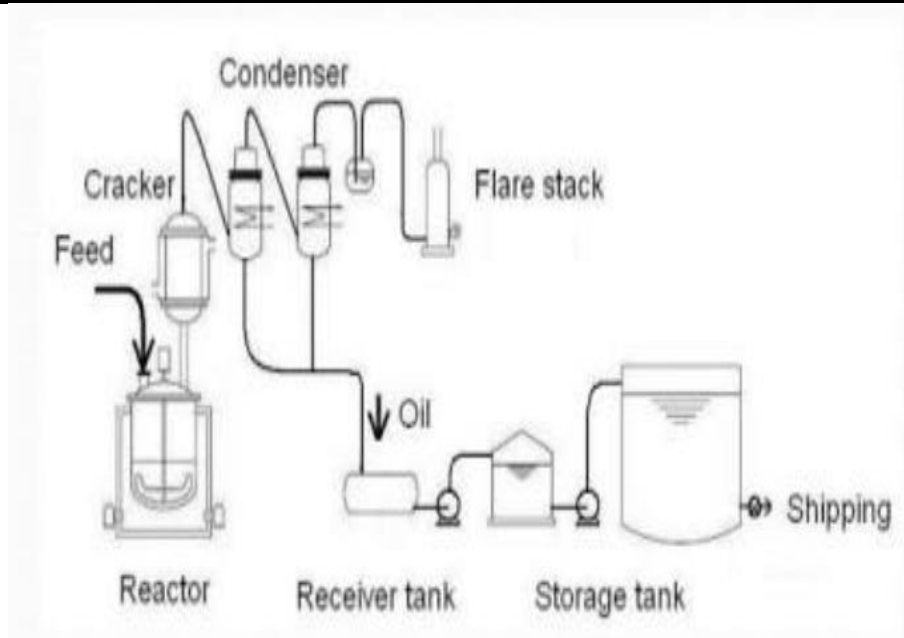
Pyrolysis is a process of thermal degradation in the absence of oxygen. Plastic & Rubber waste is continuously treated in a cylindrical chamber and the pyrolytic gases are condensed in a specially-designed condenser system. This yields a hydrocarbon distillate comprising straight and branched chain aliphatic, cyclic aliphatic and aromatic hydrocarbons. The resulting mixture is essentially the equivalent to petroleum distillate. The plastic / Rubber is pyrolyzed at 350-450°C and the Pyrolysis gases are condensed in a series of condensers to give a low sulphur content distillate. Pyrolysis is a very promising and reliable technology for the chemical recycling of plastic wastes. Countries like UK, USA, and Germany etc have successfully implemented this technology and commercial production of monomers using Pyrolysis has already begun there.



“Fig 2.2- Schematic Diagram of Pyrolysis Unit”

Pyrolysis offers a great hope in generating fuel oils, which are heavily priced now. This reduces the economical burden on developing countries. The capital cost required to invest on Pyrolysis plant is low compared to other technologies. So, this technology may be an initiative to solve fuel crisis and the problems due to disposal of plastics.

The figure below shows the line diagram of a Pyrolysis Unit



“Fig 2.3 Line Diagram of a Pyrolysis Unit”

II.2. PYROLYSIS PROCESS

Under controlled reaction conditions, plastics materials undergo random polymerization and are converted into three products:

- Coke.
- Combination of Gasoline, Kerosene, Diesel & Lube Oil
- LPG range gases.

The process consists of two steps:

- Random de-polymerization of Waste Plastics
- Fractional Distillation-Separation of various liquid fuels by virtue of the difference in their boiling points.

One important factor of the quality of the liquid fuel is that the sulphur content is less than 0.002ppm which is much lower than the level found in regular fuel.

II.3. ALTERNATIVE METHODS

Unfortunately, recycling plastics has proven difficult. The biggest problem with plastic recycling is that it is difficult to automate the sorting of plastic waste, and so it is labor intensive.

Typically, workers sort the plastic by looking at the resin identification code, though common containers like soda bottles can be sorted from memory. Other recyclable materials, such as metals, are easier to process mechanically. However, new mechanical sorting processes are being utilized to increase plastic recycling capacity and efficiency.

Developments are taking place in the field of active Disassembly, which may result in more consumer product components being re-used or recycled. Recycling certain types of plastics can be unprofitable, as well. For example, polystyrene is rarely recycled because it is usually not cost effective. These un-recycled wastes are typically disposed of in landfills, incinerated or used to produce electricity at waste-to-energy plants.

II.4. EXPERIMENTAL PROCEDURE

- 200g of weighed plastic granules are fed into the modified pressure cooker. The pressure cooker is modified by attaching a pressure gauge to maintain pressure and a thermocouple is attached to measure temperature.
- Heat is provided by using Nichrome coil heater which may be between 150°C-200°C. It is the temperature at which plastic begins to melt and vaporize.
- These vapors are passed through copper tubes which are connected to shell and tube heat exchanger. At the end of the heat exchanger, the distillate is collected. The amount of distillate obtained is measured.
- The color of the distillate is noted. The time and temperature at which the distillate is obtained is also noted.
- This experiment is repeated with different plastics such as LDPE, HDPE, PP, PS, plastic wastes (mainly plastic carry bags, CD case etc.)

The figure below shows the experimental set-up used to obtain the Liquid fuel from plastic waste



“Fig. 2.4- Experimental Setup”

The different polymers that are used as the feed for waste plastics are:

- High Density Polyethylene (HDPE)
- Polypropylene (PP)
- Polystyrene (PS)

The figure below shows Plastic samples used for Pyrolysis



“Fig. 2.5-Samples of Shredded Plastic Waste”

III. STEPS INVOLVED IN THE EXPERIMENTAL PROCEDURE

Feeding: Feed the feedstock's to reactor through feeder and closes the feeder inlet.

Heating: To increase the temperature of reactor, heat the product of reactor inside by using heating source.

Condensing: The plastic get evaporated at high temperature, this vapor is condensed to atmospheric temperature by using straight and spiral tube condensers.

Liquid collection: Out coming product from the condenser is collected at liquid collector. At the end of condenser provide a cyclone separator to separate the plastic liquid fuel and non-condensable gases. These non-condensable gases are reuses to heat the Pyrolysis unit.

RESULTS AND DISCUSSIONS

Pyrolysis process of shredded Polystyrene resulted in production of Bio-Oil obtained contained the following constituents by % Volume:

- Pyrolytic oil – 48.6%
- Wax- 40.7
- Pyrogas-10.1%
- Char- 0.6%.

The Operating Temperature during the entire process is 275⁰C and was carried out in a modified pressure cooker of capacity 1 Liter (Approx 1.2Kg of Polystyrene by mass) without Catalyst. Use of Catalyst increases the yield of Pyrolytic Oil and Pyrolytic Gases.

The following figure shows Pyrolytic Oil collected after Pyrolysis of Polystyrene.



“Fig 3.1- Sample collected from Pyrolysis of Polystyrene”

III.1 TEST FOR CHARACTERIZING OUTPUT

Different tests have been carried out to study and compare the fuel characteristics of different samples and those of petrol and diesel which are used as the standard reference.

The characteristics which are studied are:

CALORIFIC VALUE

INSTRUMENT USED: BOMB CALORIMETER

VALUE OBTAINED = 46,057 kJ/kg



"Fig 3.2 Bomb Calorimeter"

VISCOSITY

INSTRUMENT USED: SAYBOLT VISCOMETER

VALUE OBTAINED: 2.1 Centi-Stokes



"Fig. 3.3 Saybolt Viscometer"

FIRE POINT

Instrument used: FIRE POINT APPARATUS

Value: FIRE POINT = 41°C.



Fig3.4 Flash and Fire Point Test Apparatus

DESINTY

Instrument used: GRADUATED BEAKER

Value obtained: 691.666 kg/m³



Fig 3.5 Plastic fuel in a Graduated Beaker

The Thermo-Physical properties are calculated and found using the mentioned Instruments and the results obtained are tabulated and compared with the conventional fuels like Gasoline and Diesel in Table 3.1

| S.No | Properties | Plastic Oil | Gasoline | Diese l |
|------|-----------------------------|-------------|----------|------------|
| 1 | Calorific Value(kJ/kg) | 46,057 | 48,000 | 42,000 |
| 2 | Density(kg/m ³) | 691.66 | 719.7 | 812 |
| 3 | Viscosity(Centistokes) | 2.1 | 0.71 | 3.05 |
| 4 | Fire Point(⁰ C) | 41 | 40 | 74 |

“Table 3.1- Comparison of Properties of Plastic Oil with conventional fuels”

III. CONCLUSION

- Pyrolysis method is both Ecological and Economical
- 1Kg of Waste plastics is converted into 75% of useful liquid hydrocarbon fuels without emitting any pollutants.
- It would also take care of hazardous plastic waste and reduce the import of crude oil.
- The properties of produced plastic liquid fuel are almost similar to that of Diesel fuel, hence plastic fuel represents a good alternative fuel for diesel engine and therefore it can be used for diesel engine vehicles.

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