ISSN: 0025-0422

A STUDY ON EXTRACTION OF CRUDE OIL FROM PLATIC WASTE

[1]S.Amith Kumar,[2]R.Hanuma Naik,[3]L.Sunil
[1,2,3]Assistant Professor, Department of Mechanical Engineering,
St.Martin's Engineering College, Secunderabad-500 100

ABSTRACT
The increased demand and high price for energy sources are driving efforts to convert organic compounds into useful hydrocarbon fuels. Although much of this work has focused on biomass, there are strong benefits to deriving fuels from waste plastic material. Waste plastic is abundant and its disposal creates large problems for the environment. Plastic does not break down in landfills, it is not easily recycled and degrades in quality during the recycling process, and it can produce waste ash, heavy metals, and potentially harmful gas emissions if incinerated at high temperatures. However, thermal processes can be used to convert plastics into hydrocarbon fuels such as gasoline, diesel, aviation / jet fuel, which have unlimited applications in airline industries, helicopter, heavy transportation, and electricity generation. The method and principal of the production / process will be discussed.

INTRODUCTION

Plastic waste is regarded as a potentially cheap source of chemicals and energy. Lots of us have encountered a variety of products that use plastic materials today. As a result of the increasing level of private consumption of these plastic materials huge amount of wastes are discharged to the environment.
Plastic materials are a type of material that cannot be decomposed easily in a short period of time. Substantial quantities of plastic have accumulated in the natural environment and in landfills. Those wastes can be classified according to their origins. They are

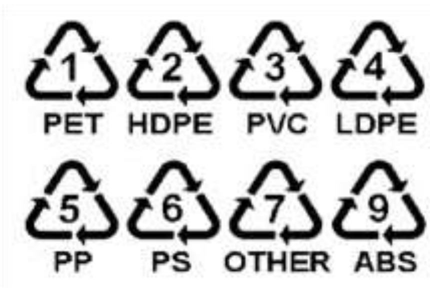
- Industrial
- Municipal

The traditional MSW disposal method is landfill. Because of the longevity of plastics, disposal to landfill may simply be storing problems for the future. For example, plasticizers and other additive chemicals have been shown to leach from landfills. The extent of varies accordingly, particularly pH and organic content.
Recently, the conception of energy recovery from MSW has been a very hot topic. It is also undesirable to dispose of waste plastics by landfill due to poor biodegradability.
An alternative strategy is that of chemical recycling, known as feedstock recycling or tertiary recycling, which has attracted much interest recently with the aim of converting waste plastics into basic petrochemicals to be used as chemical feedstock or fuels for a variety of downstream processes.

PLASTICS

As a brief introduction to plastics, it can be said that plastics are synthetic organic materials produced by polymerization. They are typically of high molecular mass, and may contain other substances besides polymers to improve performance and/or reduce costs.
These polymers are made of a series of repeating units known as monomers. Therefore polymers can be molded or extruded into desired shapes. There are two main types of plastics: thermoplastics and thermosetting polymers.
.Thermoplastics can repeatedly soften and melt if enough heat is applied and hardened on cooling, so that they can be made into new plastics products.

1. PET (Polyethylene Terephthalate)
2. HDPE (High Density Polyethylene)
3. PVC (Polyvinyl Chloride)
4. LDPE (Low Density Polyethylene)
5. PP (Polypropylene)
6. PS (Polystyrene)



SELECTION OF WASTE PLASTICS

Waste plastics are one of the most promising resources for fuel production because ofits high heat of combustion and due to the increasing availability in local communities. Unlike paper and wood, plastics do not absorb much moisture and the water content of plastics is far lower than the water content of biomass such as crops and kitchen wastes.

The conversion methods of waste plastics into fuel depend on the types of plastics to be targeted and the properties of other wastes that might be used in the process. Additionally the effective conversion requires technologies to be selected according to local economic, environmental, social and technical characteristics.

In general, the conversion of waste plastic into fuel requires feedstock which are non-hazardous and combustible. In particular each type of waste plastic conversion method has its own suitable feedstock.

The composition of the plastics used as feedstock may be very different and sonic plastic articles might contain undesirable substances (e.g. additives such as flame-retardants containing bromine and antimony compounds or plastics containing nitrogen, halogens, sulfur or any other hazardous substances) which pose potential risks to humans and to the environment.

The types of plastics and their composition will condition the conversion process and will determine the pretreatment requirements, the combustion temperature for the conversion and therefore the energy consumption required, the fuel quality output, the flue gas composition (e.g. formation of hazardous flue gases such as NOx and HO), the fly ash and bottom ash composition, and the potential of chemical corrosion of the equipment.

Major factors to be considered while selection are

- Smooth feeding for equipment
- Effective conversion
- Well-controlled combustion

PRODUCT ANALYSIS METHOD

The pyrolysis products of plastics are mainly hydrocarbons presenting in gaseous, liquids and solid wax phases under standard conditions of temperature of 25 ºC and pressure of 100 kPa. Minor amounts of char and hydrogen gas may be found in the products.

The char product can be analyzed by elemental analyzer or electron- microscope dispersive X-ray analyzer. In research.

The New Zealand regulation requirements on the properties of petroleum fuels such as LPG, petrol and diesel adapted standard test methods from the American Society for Testing and Materials (ASTM) and institute of petroleum (IP) testing methods.

The properties of plastic pyrolysis fuels are analyzed in some studies. It was found that the pyrolysis products from PE, PP, and PS are mainly hydrocarbons with molecular weights similar to the petrol and diesel range. A certain amount of non-condensable gases and insignificant amount of heavy wax were also found in the pyrolysis products.

Heavy hydrocarbon wax can be processed into gases or light liquid by further high temperature treatments or catalytic cracking so that the yields of noncondensable gases and wax vary largely in different studies. The plastic derived fuels were also found to have higher unsaturated hydrocarbon content and lower stability than those of commercial fuels.

TECHNOLOGIES AND PROCESSES

The waste plastic pyrolysis plants were developed and built in many countries. The selection of the process and the plant is determined mainly on the feedstock composition and the target products.

FEEDSTOCK EFFECTS

According to a summary of existing processes and technologies reported by Arena and Mastellone, the most important property of plastic feedstock is whether it contains PVC.

PVC pyrolysis has different the thermal cracking process and different products from those of other common waste plastics including PE, PP and PS. In the PVC pyrolysis, the products containing HCl are particularly hazardous for fuels. If the feedstock contains PVC, the plants must have re-treatment system to remove and a solvent scrubber to remove HCl from the pyrolysis products.

The other important property for some current processes is the size of feedstock. The requirement for the feedstock size is to avoid the feeding blockage and to enhance the heat transfer between the heating medium and the plastics particles.

It was found that in most cases, the feedstock is a mixture of various waste plastic in municipal solid wastes or industrial residues. In pyrolysis of the mixed plastics, interactive effects among the different plastic types may occur due to the difference in cracking temperatures and different products. . However, no report has been found where the pyrolysis technology is designed for a specific type of the waste plastic.

TECHNOLOGY

The selection of pyrolysis technology is based on the characteristics of the feedstock and the target products. In general, each pyrolysis technology consists of three parts: feeding system, pyrolysis reactor and separation system.

For example, the cracking temperature of PS is 420 ºC thus any overheating in the feeding system should be avoided. Free-fall feeding system is widely applied in fixed bed and fluidized bed reactors.

PYROLYSIS

The description and classification of pyrolysis reactors are given in Section 2.1 of this thesis and the existing commercial pyrolysis plants use various types of the reactors. Continuous pyrolysis process is applied on most commercial plants with capability to use catalysts in which the plastic retention time is relatively short.

Very few of the commercial plants use high pressure operation condition and most of the plants operate at or slightly above atmospheric pressure. The operating temperature in the reactors varies largely from 250 ºC (Mazda fixedbed catalytic process in Japan) up to 800 ºC (Compact Power fixed-bed pyrolysis in United Kingdom) but most of the pyrolysis reactors operate between 400 ºC and 550 ºC.

It must be noted that if the operation temperature is above 800 ºC, the process becomes gasification and the products are mainly short chain hydrocarbons which remains as gases under room temperature and atmospheric pressure.

PRODUCT SEPARATION AND COLLECTION

The products from the plastic pyrolysis are mainly combustible gases and liquids. The liquids can be either combusted for power generation or for further refining to produce high quality fuels. Diesel range products can then be distilled out as in an oil refinery process. The non-condensable gases are mainly made of hydrocarbons, and a minor amount of hydrogen and carbon monoxide. The gases can be liquefied as fuels, or used as fuels to heat the pyrolysis reactor, or if the amount is insignificant, the non-condensable gases are sent to an incinerator flaring off with the air.

3.0 FUEL SYNTHESIS

3.1.1 RAW MATERIAL

The Raw material used for extracting oil by the process of Pyrolysis is Polypropylene (PP).

The Material Safety Data Sheet taken from Indian Oil Corporation gives detailed information about various safety aspects of the material used.

FIRST AID MEASURES

GENERAL INFORMATION

- At room temperature the product is neither an irritant nor gives off hazardous vapors.

- The measures listed below apply to critical situations (Fire, incorrect process conditions).

Skin Contact

If molten material contacts the skin, immediately flush with large amounts of water to cool the affected tissues and polymer. Do not attempt to peel the polymer from skin. Obtain immediately emergency medical attention if burn is deep or extensive.

Eye Contact

Flush eyes thoroughly with water for several minutes and seek medical attention if discomfort persists.

Inhalation

If symptoms are experienced, move victim to fresh air. Obtain medical attention if breathing difficulty persists.

Ingestion

Adverse health effects due to ingestion are not anticipated.

FIRE FIGHTING MEASURES

Flash Ignition Temperature	: 335°C
Auto Ignition Temperature	: 350°C
Flammable Limits	: NA

Suitable Extinguishing Media: Water, Foam, Carbon Dioxide, Dry Chemical Powder

For Safety reasons, unsuitable extinguishing media: None

Protective Equipment: Respiratory & Eye protection for firefighting personnel

Special hazards caused by the material, its products of combustion or resulting gases: In case of fire it can release: Carbon dioxide ($C0_2$), and when lacking oxygen (0_2), carbon monoxide (CO), Ketones &Aldehydes. The products of the burning are dangerous. The formation of hydrocarbons and aldehydes are possible in the initial stages of a fire (especially in between 400°C and 700°C).

Additional information: Heat value: 8000 -11000 kcal/kg

ACCIDENTAL RELEASE MEASURES

Spill and Leak procedure: Sweep up spilled material for use or disposal. Good housekeeping must be maintained to avoid potential slipping problem.

Caution: Keep walking surface free of spilled material to avoid slipping hazard.

EXPOSURE CONTROLS / PERSONAL PROTECTION ENGINEERING CONTROLS:

Use in a well-ventilated area. If handling results in dust generation, special ventilation may be needed to minimize dust exposure. If heated material generates vapor or fumes, use process enclosures, local exhaust ventilation, or other engineering controls to control exposure.

PERSONAL PROTECTIVE EQUIPMENT:

Respiratory system

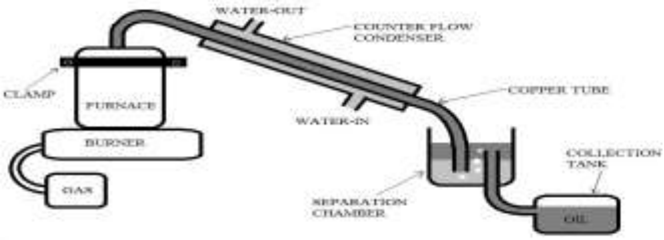
Product processing, heat sealing of film or operations involving the use of wires or blades heated above 300°C may produce dust, vapor or fumes . To minimize risk of over exposure to dust, vapor or fumes it is recommended that a local exhaust system is placed above the equipment, and that the working area is properly ventilated. If ventilation is inadequate, use certified respirator that will protect against dust/mist.

PRODUCTION METHOD

The production method for the conversion of plastics to liquid fuel is based on the pyrolysis of the plastics and the condensation of the resulting hydrocarbons. Pyrolysis refers to the thermal decomposition of the matter under an inert gas like methane.

After the resulting hydrocarbons are distilled from the reactor, some hydrocarbons with high boiling points such as diesel, kerosene and gasoline are condensed in a water-cooled condenser. The liquid hydrocarbons are then collected in a storage tank through a receiver tank.

Gaseous hydrocarbons such as methane, ethane, propylene and butanes cannot be condensed and are therefore incinerated in a flare stack. This flare stack is required when the volume of the exhaust gas emitted from the reactor is expected to be large.



Schematic

The plastic waste material is feeded in the furnace and closed with the lid. For sealing, aluminium foil is used and the lid is clamped. After the process has started the melted plastics will evaporate and flow through the furnace outlet i.e. through copper tube.
The copper tube is cooled by the counter flow condensor. Vapour to liquid phase transcition takes place during the condesation process.
The remaining un condensed vapors coming from the reactor are enters into the condenser where these vapors condenses to liquid hydrocarbon fuels. If we want we may distill these crude oils in a fractional distillation column.
Due to the formation of carbonous matter in the reactor, which acts as a heat insulator, in some tank reactors the stirrer is used to remove the carbonous matter rather than for stirring.
After the liquid product of the pyrolysis is distilled, the carbonous matter is taken out either with a vacuum cleaner or in some cases reactors are equipped with a screw conveyor at the bottom of the tank reactor to remove the carbonous matter.

FILTRATION & PURIFICATION

The fuel collected in the collecting chamber will be impure. There will be wax, grease, and other impurities. So to remove the impurities, the following processes were carried out.

- Gravity seperation.
- Filteration with filter paper.

Gravity seperation is the basic process. In this process the impure fluid is poured in a container in which the bottom part is like a funnel. So when the fluid is poured, the most denser liquid will settle down below. Most probably the water was found.
Then the waxy and greasy substance which was pale greenish yellow was found immediately above the water. Finally, most of the polypropylene oil is seen above in the topmost layer. So by opening the valve at the bottom, all the unwanted substance are removed. Remaining oil is processed further.
In filteration process, the substances which are in colloidal state can be removed. The filter paper will allow the molecules which are smaller than its pores. So the various size of smaller pores will give more clean fuel.
Thus the collected samples are to be tested by appropriate methods. In such a way we analyzed the products for their existence in the range of gasoline, diesel and petroleum.

FUEL TESTING AND ANALYSIS

The purified fuel is to be tested to find out its characteristics. In order to interpret the quality and properties of fuel, various tests were carried out in the laborotary under various testing conditions. The tests performed were: Colour, Density, Viscosity, Calorific Value, Flash Point, Fire Point, Cloud Point , Pour Point, GC/MS Test, FTIR Test
(GC/MS - Gas chromotography / Mass Spectroscopy)
So with these tests, the results were interpreted in the following chapter.

RESULT INTERPRETATION

Physical Properties	Pyrolytic oil	Reference with	
		Diesel	Furnace oil
Density (kg/m3), 30°C	935.1	820 to 860	890 to 960
Kinematic Viscosity @40°cSt	6.59	3 to 5	45
Flash Point °C	37	≥ 55	70
Pour Point °C	-7	-40 to -1	10 to27
Gross Calorific Value (MJ/Kg)	37.98	42 to 44	42 to 43

FTIR Test Results

The fuel is flammable and combustible at room temperature which according to test was **23ºC**. The high combustibility of the fuel means it is capable of having a much lower flash point that actually found. However the flash point ofgasoline is much lower.

- The cloud point and pour point are low as **-37.7ºC** and **-43.8ºC** respectively, as a result this fuel can be used in extreme cold conditions with ease.
- The above fuel has no ash content as compared to diesel which as an ash content of <0.01.
- The Calorific value of the fuel is as high as **49163 KJ/Kg** which is better than both Diesel and Petrol and hence can be used for heavy duty Diesel engines.
- From the above GC/MS test, the fuel has a major Hydrocarbon range from C7-C30 which is similar to the Hydrocarbon range of Diesel. So this fuel has the characteristics more or less of that of Diesel.
- TheFTIR test result shows the presence of Polypropylene on a large scale as a result Secondary and Tertiary Pyrolysis can be carried out and more commercial Gasoline like products can be obtained.

CONCLUSION & FUTURE SCOPE

CONCLUSION

Pyrolysis of hydrocarbon polymers is a very complex process, which consists of hundreds of reactions and products. Several factors have significant effects on the reactions and the products.

Based on previous research, this chapter investigated the fundamental plastic processes and reactions. With temperature increasing, plastic will go through glassy state, rubbery state, liquid state, and decomposition. Decomposition of plastic in an inert environment into liquid is called pyrolysis. There are four stages of reactions during the plastic pyrolysis process: initiation, propagation, hydrogen transfer, and termination reactions.

It was found that heavy molecular weight hydrocarbons produced from primary cracking can be further cracked into light molecular weight products through a secondary cracking process. This secondary cracking process has significantly influence on the distribution of the product. This process converts heavy hydrocarbons into gas or light liquid product.

FUTURE SCOPE

The project shows some light on the possibility of manufacturing liquid fuels which could be used as feed stock refinery for further modification or commercial use. By using this technology we could solve the waste plastic problem and also significantly reduce the landfills-which are the cause of infertility of Agriculture land. Waste plastics can also become a very good source of energy and an alternative to fossil fuel which have caused an environment imbalance.

REFERENCE

1. *Yuan, X., Converting Waste Plastics into Liquid Fuel by Pyrolysis: Developments in China, in Feedstock Recycling and Pyrolysis of Waste Plastics, J. Scheirs and W. Kaminsky, Editors. 2006, John Wiley & Sons, Ltd: Changsha, P.R. China.*
2. *Material Safety Data Sheet Polypropylene (PP)*
3. *Ciliz, N.K., E. Ekinci, and C.E. Snape, Pyrolysis of virgin and waste polypropylene and its mixtures with waste polyethylene and polystyrene. Waste Management, 2004.*
4. *Aguado, J., D.P. Serrano, and J.M. Escola, Catalytic Upgrading of Plastic Wastes, in Feedstock Recycling and Pyrolysis of Waste Plastics, J. Scheirs and W. Kaminsky, Editors. 2006, John Wiley & Sons, Ltd: Mostoles, Spain.*
5. *Williams, P.T., J. Scheirs and W. Kaminsky, Editors. 2006, John Wiley & Sons, Ltd: Leeds. Yield and composition of gases and oils/waxes from the feedstock recycling of waste plastic, in Feedstock Recycling and pyrolysis of waste plastics,*
6. *MoinuddinSarker, Mohammad Mamunor Rashid and Muhammad Sadikur Rahman. International Journal of Modern Engineering Research*
7. *(IJMER), Vol.2, Issue.4, July-Aug. 2012 pp-2168-2173, ISSN: 22496645. Natural State Research, Inc. Department of Research and Development USA.*
8. *British Plastics Federation website: http://www.bpf.co.uk/Recycling and Sustainability.*
9. *Preliminary study on the conversion of different waste plastics into fuel oil, Munich, GRIN Verlag, http://www.grin.com/en/ebook/206451/preliminary-study-on-the-conversion-of-differcnt-wastcplastics-into-ruel.*
10. *European Association of Plastics Recycling website:http://www.eproplasticsrecycling.org*
11. *CONVERTING WASTE PLASTICS INTO A RESOURCE*
12. *(Compendium of Technologies) United Nations Environmental Programme Division of Technology, Industry and Economics*
13. *International Environmental Technology Centre Osaka/Shiga, Japan.*