Conversion of Waste Plastic into a Resource

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Abstract - Plastic materials are a type of material that cannot be decomposed easily in a short period of time. It has accumulated substantial portion in the natural environment and in landfills. We are surrounded by lot of plastic materials in our day to day life. As a result of the increasing level of private consumption of these plastic materials, in almost every field, huge amount of plastic wastes are discharged to the environment. . It is undesirable to dispose of waste plastics by landfill due to poor biodegradability. Since the plastic polymers are originated from the petroleum resources, the possible technologies of converting them into fuel have drawn attention to meet the future fuel demand. Thus, converting the plastic polymers into transport fuel through a cleaner combustion process will contribute to saving our environment and Mother Earth. Various thermochemical recycling processes can lead to accomplish an effective recycling of the waste plastic polymers by converting them into transport fuel grade hydrocarbons. It has been observed that the thermal fuel conversion technology, known as thermolysis and the dissolution process of plastic polymers into an acceptable bio-solvent can lead to reduction of plastic wastes effectively. This paper presents a review on various thermolysis processes used for converting waste plastic into a valuable resource.

Keywords: Landfills, waste plastic, thermochemical, recycling, thermolysis.

I. INTRODUCTION

Plastics are synthetic organic materials produced by polymerization process. They are typically of high molecular mass, and may contain other substances like nitrogen, sulfur and chlorine besides polymers to improve performance and/or reduce costs [2]. These polymers are made of a series of repeating units known as monomers. Linear polymers (a single linear chain of monomers) and branched polymers (linear with side chains) are thermoplastic that is they soften when heated. Cross-linked polymers (two or more chains joined by side chains) are thermosetting, that is, they harden when heated. The main components of municipal solid waste (MSW) are food waste, wood, paper, cardboard, plastics, rubbers, fabrics, and metals. Rapid urbanization and industrial diversification has led to generation of considerable quantities of municipal plastic waste. Improper disposal of waste often results in causing diseases and contamination of water bodies and soil. The impacts of this waste on the economy cannot be ignored and managing them has become a major problem. Used plastic often gets mixed with municipal solid waste reduces the composting efficiency by decreasing water permeability as well as air circulation. Plastics pose unique problem in municipal solid waste management due to the considerable amount of time required for degradation.
Because of the characteristics of the plastic we cannot avoid them completely, but at least for managing the waste generated from them we have to think differently. Because of the longevity of plastics, disposal to landfill may simply be storing problems for the future. So ultimately, we come to the strategy of converting this waste to energy.

II. SOURCES OF PLASTIC WASTE

Plastic wastes represent a considerable part of municipal wastes; furthermore a huge amount of plastic waste arises as a byproduct or defected product from various industries like plastic industry, automotive industry etc. The various sources of MSW plastics includes domestic items(food containers, packaging foam, disposable cups, electronic equipments cases, drainage pipe, carbonated drinks bottles, CD and cassette boxes, surface coatings, flooring cushioning foams, thermal insulation foams, etc. The MSW collected plastics wastes are mixed one with major components of polyethylene, polypropylene, polystyrene, polyvinylchloride, and polyethylene terephthalate. The percentage of plastics in MSW has increased significantly in the recent years.

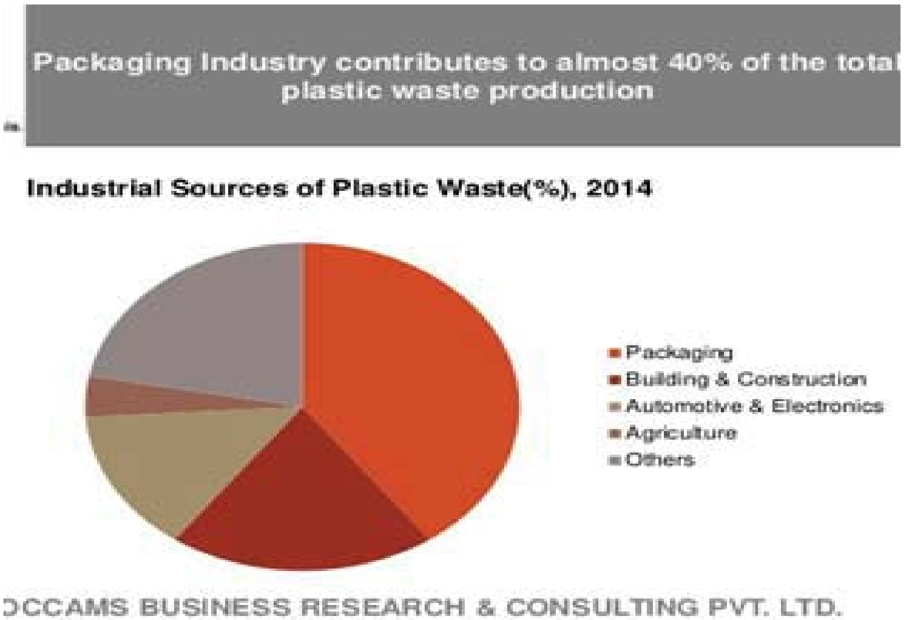

Fig. 1: Industrial sources of plastic waste for year 2014.

III. WASTE TO ENERGY

Since plastic polymers originated from the petroleum resources, the possible technologies of converting them into fuel will be the best option for their management. To produce energy from waste plastics, various methods can be used like catalytic cracking, non-catalytic cracking, steam degradation etc. Here some of the methods of waste to energy conversion are discussed.

3.1 Pyrolysis Process:

Pyrolysis refers to the thermal decomposition of a material in an oxygen-free or limited oxygen environment. The process of thermal decomposition is modeled after natural geological processes that produce fossil fuels. Thermal decomposition breaks down complex polymer molecules into shorter hydrocarbon chains through a process known as depolymerization. Pyrolysis used for PTF (plastic to fuel) conversion involves introducing a polymer feedstock material into a high temperature chamber ranging between 430-5500C to produce a vapor. Vapors are then condensed into condensable (synthetic crude oil) and non-condensable (synthetic gas) fractions. Depending on the technology offering, synthetic crude oil may then be fractionated onsite, usually by way of fractional distillation, into a range of light, middle and heavy distillate fuel oils. If fractionation does not occur onsite, the liquid petroleum product, typically classified as a light sweet synthetic crude oil, is sold to a refinery for further processing. Secondary byproducts can include char, syngas and wax (Figure 2). Output quality and quantity from the pyrolysis processes depends on feedstock (quantity and composition) and the technology.

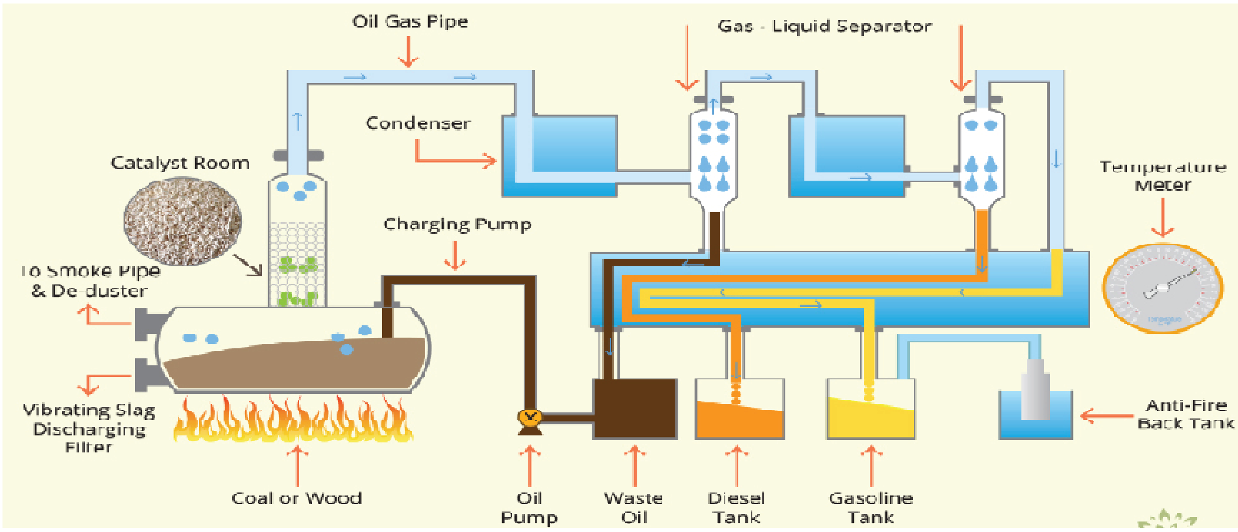

Fig. 2: Pyrolysis process for plastic to fuel conversion.

3.2 Catalytic cracking:

Catalytic materials successfully convert polyolefin into liquefied fuels. The fuels obtained by this Technique are of transport fuel grade annulling further requirement of chemical processing and are also eco-friendly. Most widely used catalysts are Zeolite base catalysts like ZSM-5, silica, alumina, basic catalysts like BaCO3, Bimetallic catalyst like Al-Zn composite, and FCC catalyst. Mostly, the Zeolite type catalysts are used with a ratio of polymer-to-catalyst as 1:1. This process is advantageous due to lower reaction temperature, faster processing time, shorter residence timing, and lesser volume requirement of the reactors and controlling the formation of the unexpected products than those of thermal treatments without catalysts. FCC catalysts have been employed on an industrial scale in the petroleum refining industry and were developed mainly for cracking heavy oil fractions from crude petroleum into lighter and more desirable gasoline and liquid petroleum gas (LPG) fractions. The feedstock products fall under four major classes of HCs: Paraffins, Olefins, Naphthalenes and Aromatics (PONA distribution). Gasoline range fuels consist of paraffin and olefins in the C5-C12 range. Within aromatics, products of polyolefins, especially polystyrene, are grouped as BTX (benzene, toluene, and xylene).

The main effects of catalyst addition in plastics pyrolysis are as follows:

- The pyrolysis temperature for achieving a certain conversion is reduced drastically and as the catalyst/plastics ratio is increased, the pyrolysis temperature can be further lowered.
- More iso-alkanes and aromatics in the C5–C10 range can be produced which are highly desirable gasoline-range hydrocarbons.
- The reaction rate is increased significantly.

Catalysts may decrease the temperature of the process, change the selectivity and the composition of the products, they may give more gas products, the catalysts are quickly deactivated and recovering and regeneration of them is not easy.

3.3 Thermal cracking:

In thermal catalytic cracking, the reaction is performed within temperature range of 350 to 8000C and plastic material is degraded in absence of both air/oxygen and catalyst. Various parameters affect the performance of the process like type of plastic used, temperature, residence time, reactor, heating rate, operating pressure etc. Gases, light oils, and char are the main products of the process depending on the governing parameter and needs further process to convert it to transport grade fuel like condensation, hydro-treating, distillation etc. Typical pyrolysis process has some drawbacks like cooking of reactor walls, sticking of plastic to the reactor walls etc. due to which there is reduction in heat transfer efficiency and reduced yield of bio-oil. Periodic cleaning is mandatory in this case. Thermal cracking process inpresence of nitrogen is called Pyrolysis and similar reaction in presence of hydrogen is called Liquefaction.

IV. DISCUSSION

Worldwide the problem of plastic waste pollution is grabbing attention of the engineers & environmentalist. Land filling & incineration are also not proving that much effective from environment point of view. Plastic waste is posing serious health hazards among society.

Thermal liquefaction in presence of hydrogen gas can produce more liquefied hydrocarbons than nitrogen based system. Catalytic cracking followed by thermal liquefaction can facilitate effective conversion of waste plastic to into liquid fuel. Only catalytic process causes production of more chars and wide range of hydrocarbons.

Thermo catalytic process can reduce process temperature. Liquefied and gaseous hydrocarbons can be easily mixed with the catalysts. Hence there is less expenditure on the process.

V. CONCLUSION

Based on the reviewed articles of various applications and technologies, it can be inferred that there is potential advantage of converting waste plastics into fuel. It can effectively reduce the hazardous impact of waste accumulation on the earth. Thermo catalytic process is having potential of effective conversion of waste plastic to fuel. Various type of catalysts can be found effective in converting waste plastic to desired fuel category.

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