Plasma Pyrolysis : An Innovative Treatment to Solid Waste of Plastic Material

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Abstract—The quantum of solid waste is increasing due to increase in population, activities and socio-economic conditions. Through industrial revolution plastic seemed to be a cheaper and effective raw material. Plastic wastes generated from different places forms a major portion of municipal solid waste (MSW). It is a matter of concern that disposal of plastic waste being non-biodegradable causing many problems resulting into environmental hazards. Plasma Pyrolysis is a state of the art technology, which integrates the thermo-chemical properties of plasma with the pyrolysis process. Plasma pyrolysis is finding its application in treatment and disposal of plastic waste and favors the environmental protection.

Keywords - Plasma pyrolysis, Solid waste, Plastic waste

INTRODUCTION

Municipal solid waste is an urban solid waste that includes domestic waste, commercial waste collected by a municipality within a given area. Municipal solid waste can be in any form like either solid or semisolid biodegradable or non-biodegradable form and generally exclude industrial hazardous waste.

Industries are a major cause for environmental pollution. Reduce, recycle and reuse is the motto of modern days for waste disposal. Industries are classified as small, medium and large-scale. According to the types of the solid waste it generates, it can be classified as industry causing air, water pollution and land pollution.

Plastic is used and found everywhere in present times. It’s used for packaging, protecting and serving all kinds of consumer goods. Today, every sector of life viz. agriculture, packaging, automobile, building construction, communication, infotech etc. has been virtually revolutionized by the applications of plastics. Day by day, use of this non-biodegradable (according to recent studies, plastics can stay as long as 4500 years on earth) product is growing rapidly. Improperly disposed plastic waste can be responsible for causing breast cancer, reproductive problems in humans and animals, genital abnormalities and much more.

Types of Plastics

There are two major types of plastics: Thermoplastics and Thermosetting polymers. Thermoplastics are the plastics that do not undergo chemical change in their composition when heated and can be molded again and again. The examples of Thermoplastic are polyethylene, polystyrene, polyvinyl chloride, and polytetrafluoroethylene etc. Thermosetting polymers can be melt and take shape once; after they have been solidified, remain solid. The raw materials needed to make most plastics come from petroleum products. Thermoplastics make up 80% of the plastics produced today. Examples of thermoplastics include:

- High density polyethylene (HDPE) used in piping, automotive fuel tanks, bottles, toys.
- Low density polyethylene (LDPE) used in plastic bags, cling film, flexible containers.
- Polyethylene terephthalate (PET) used in bottles, carpets and food packaging.
- Polypropylene (PP) used in food containers, battery cases, bottle crates, automotive parts and fibres.
- Polystyrene (PS) used in dairy product containers, tape cassettes, cups and plates.
- Polyvinyl chloride (PVC) used in window frames, flooring, bottles, packaging film, cable insulation, credit cards and medical products.

Thermosetting polymers make up the remaining 20% of plastics produced. They are hardened by curing and are therefore difficult to recycle. They are sometimes ground and used as a filler material. They include:

- Polyurethane (PU) - coatings, finishes, gears, diaphragms, cushions, mattresses and car seats;
- Epoxy - adhesives, sports equipment, electrical and automotive equipment;
- Phenolics - ovens, handles for cutlery, automotive parts and circuit boards (The World Resource Foundation).
Nowadays, the raw materials for plastics come mainly from petrochemicals, although originally plastics were derived from cellulose, the basic material of all plant life.

**PLASTICS WASTE**

Plastics waste forms a wide range. Predominantly it is in the form of film packaging, polythene carry bags, blow moulded containers, and broken and discarded moulded items. The range is wide and includes:

- Discarded PVC chappals/shoes in varied colors and grades of plastics material.
- Discarded PVC mineral water bottles/PET mineral water and liquor bottles and PS ice-cream/cold drink cups/disposable catering plates and grays and expanded PS and PE foam packaging.
- PE, PVC, PP films, packages, shopping bags, and medicine foils, used and discarded moulded items like containers and range of household non-durables, combs, ball point pens, tooth brushes etc.

**SOLID WASTE**

Human activities generate waste materials that are often discarded because they are considered useless. These wastes are normally solid, and the word waste suggests that the material is useless and unwanted. However, many of these waste materials can be reused, and thus they can become a resource for industrial production or energy generation, if managed properly. Waste management has become one of the most significant problems of our time because the cosmopolitan life produces enormous amounts of waste, and most people want to preserve their lifestyle, while also protecting the environment and public health. Industry, private citizens, and state legislatures are searching for means to reduce the growing amount of waste that industries, homes and businesses discard and to reuse it or dispose of it safely and economically. To provide background material on the issues and challenges involved in the management of solid waste (SW) and to provide a foundation for the information on specific technologies should be developed.

**PRESENT PLASTIC WASTE TREATMENT & DISPOSAL**

- Disposal of plastic waste is a serious concern in India. New technologies have been developed to minimize the adverse effect on the environment. Currently world wide accepted technology used for the plastic disposal is incineration. However, if the incinerators are designed poorly, they release extremely toxic compounds (chlorinated dioxins and furans). Due to these reasons there is a strong opposition from various non-government organizations.
- Incineration, Recycling, Land filling are the conventional treatments which are applied for plastic wastes. Some new technologies which are the most favorable nowadays are Plasma Pyrolysis technology, Polymer Blended Bitumen Road, Liquid fuel, Co-prosseeing cement kiln technique.
- Another option for disposal of plastics waste has been considered by CPCB i.e conversion of plastics waste into liquid fuel. The process adopted is based on random depolymerization of waste plastics in presence of a catalyst into liquid fuel. Waste plastics while heating upto 2700 to 3000 C convert into liquid-vapour state, which is collected in condensation chamber in the form of liquid fuel, but it generates the organic gas, which is presently vented due to lack of storage facility that is again dangerous.
- Recycling of plastic waste can be carried out in a manner to reduce pollution and conserve the energy, but it requires a great labour work as it is associated with the system of collection, segregation, cleaning and reuse of ‘waste’ or used materials.

**PROBLEMS ASSOCIATED WITH TREATMENT & DISPOSAL**

- Garbage containing plastics, when burnt may cause air pollution by emitting polluting gases.
- Garbage mixed with plastics interferes in waste processing facilities and may also cause problems in landfill operations.
- One major problem due to plastic is that; the plastic material is eaten by cattles and other animals which is unsuitable for their health and hygiene.
- Recycling industries operating in non-conforming areas are posing hygiene problems to the environment.
-Causes occupational hazard.
- Contamination of soil and groundwater.
- Littered plastics spoils aesthetics of the city and choke drains and make important public places dirty.

**PLASMA PYROLYSIS**

In early 1990s, Plasma Pyrolysis emerged as a technology, which provided a complete solution to destroy medical, industrial and other hazardous waste safely.

- Plasma is the fourth state of matter.
- It is an ionized gas that exists in nature.
- It is produced and harnessed in industry through plasma torches.
- Plasma creates extremely high temperatures equivalent to nuclear fusion/fission or the surface of the sun.
- It provides the most effective medium to completely dissociate all components (organic and inorganic) into their elemental compounds for recovery and recycling.
- Plasma Gasification - also called "Plasma Pyrolysis" - is the thermal disintegration of carbonaceous material into fragments of compounds in an oxygen-starved environment.
- It exploits the plasma’s ability to rapidly initiate a variety of chemical reactions including decomposition, evaporation, pyrolysis and oxidation.
- Inorganic materials can be heated to high temperatures where they melt and are transformed into molten slag and metal phases.
It renders most waste streams, including medical/hospital waste, chemical waste, hazardous waste, and even low-level radioactive waste, completely safe and inert.

It offers a means of achieving the high temperatures required for the safe destruction of hazardous and toxic wastes.

Materials, such as PCBs, dioxins, DDT, furans, halogenated hydrocarbons, as well as military chemical agents, pose serious problems to the environment and to the public. Facilities employing plasma process for the destruction of such materials has resulted in safe disposals with emissions below regulatory requirements.

Plasma gasification of typical hazardous waste generates almost eight to ten times as much energy per unit of waste than the energy required to destroy the waste.

Plasmas are generated in gases by heating, by applying a voltage, or by injecting electromagnetic waves. Pyrolysis is the thermal disintegration of carbonaceous material in oxygen-starved atmosphere. When optimized, the most likely compounds formed are methane, carbon monoxide, hydrogen carbon dioxide and water molecules.

The results is that the gas particles, the atoms and molecules, begin to move faster in the three spatial dimensions but simultaneously acquire higher rotational and vibration energies. Due to collisions between the particles, the atoms and molecules are 'pulled apart', giving rise mainly to the positively charged ions on the one hand, and to electrons that are freed from the atoms and molecules on the otherhand.

Plasma sources differ greatly from one another; some operate at very low gas pressures, others at atmospheric pressure. Plasmas can be excited by direct or alternating current, or by the effect of high-frequency electromagnetic fields. Plasma sources can be operated either continuously or in pulsed mode.

Plasma Pyrolysis: For plastic wastes initially, the plastics waste is fed into the primary chamber at 8500°C through a feeder. The waste material dissociates into carbon monoxide, hydrogen, methane, higher hydrocarbons etc. Induced draft fan drains the pyrolysis gases as well as plastic waste into the secondary chamber where these gases are combusted in the presence of excess air. The inflammable gases are ignited with high voltage spark. The secondary chamber temperature is maintained at 10500°C. The hydrocarbon, CO and hydrogen are combusted into safe carbon dioxide and water.

ADVANTAGES OF PLASMA PYROLYSIS

- The process conditions are maintained such that it eliminates the possibility of formation of toxic dioxins and furans molecules (in case of chlorinated waste).
- The conversion of organic waste into non toxic gases (CO₂, H₂O) is more than 99%.
- The extreme conditions of plasma kill stable bacteria such as bacillus stereo-thermophilus and bacillus subtilis immediately.

There are no liquid industrial effluents and no floor washings as it is a dry process.

Segregation of the waste is not necessary, as the very high temperatures ensure treatment of all types of waste without discrimination.

Plasma can provide permanent treatment for difficult-to-treat contaminants and waste.

Plasma has the potential for significant reductions in the cost and the time required for treatment of municipal and industrial wastes.

Recent demonstrations with industrial prototype plasma systems have verified plasma processing of waste materials is ready for commercialization.

CONCLUSION

Plastic Waste Management has assumed great significance in view of the urbanization activities. Plastic waste generated by the polymer manufacturers at the production, extrusion, quality control & lab. Testing etc., stages, as well as, by the consumers require urgent disposal and recycling to avoid health hazards. Various strategies are being devised to mitigate the impact of plastic waste in India.

Plasma pyrolysis is an Eco-friendly option of treating wastes and this method is accepted as a means to reduce global warming under the Kyoto Protocol. It operates at zero discharge philosophy and all input materials are recycled back into nature or market in a manner to protect human health and environment. One technology which potentially can use various types of waste, produce electricity and hydrogen without emitting dioxin, furan and mercury, is plasma technology. Municipalities can install a plasma facility which will eliminate land filling” – EPA.

Plasma pyrolysis is an ultimate solution for treatment and disposal of not only plastic waste but also for all kinds of wastes.

REFERENCES


[8] Sikka. Dr. Pawan, Plastic Waste Management In India