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Methods for Waste Plastic Recycling

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Abstract—This paper reviews most emerging techniques available for plastic waste processing produced in industries and municipal corporations. In general the percentage of plastic waste in total Municipal solid waste is about 7-8%. Still that much non processed waste can cause trouble by blocking sewage, polluting soils and can create pollution, since its natural decomposition is a process of several hundreds of years. Plastic recycling will be having a vast demand in nearest future since usage of plastic and related goods in increasing day by day.

Keywords- *Plastic waste, Recycling , Municipal solid waste.*

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I. INTRODUCTION

Disposal of plastic waste is a serious concern in India. New technologies have been developed to minimize their adverse effect on the environment. Currently Worldwide accepted technology used for the plastic disposal is incineration; however, the incinerators designed poorly, releases extremely toxic compounds (chlorinated dioxins and furans) therefore, raising several environmental issues. In India for safer disposal of plastic waste various technologies have been experimented.

Several end-of-life options exist to deal with plastic waste, including recycling, disposal and incineration with or without energy recovery. Plastic packaging has the longest established system for the recovery and recycling of plastic waste, hence its recycling rates are higher than those of other streams. It is followed by agricultural waste plastic, which although not under direct legislative obligation to increase recovery, is subject to economic incentives linked to the availability of homogenous materials. Although WEEE and construction plastic waste sources have relatively low rates of recycling overall, the rate of energy recovery is relatively high. Overall, total recovery is highest for plastic packaging approximately 80% and lowest for ELV plastics at 15%.

Table I: Terminology used in different types of plastics recycling and recovery

ASTM D5033 definitions	Equivalent ISO 15720 (draft) definitions	Other equivalent terms
Primary recycling	Mechanical recycling	Closed loop recycling
Secondary recycling	Mechanical recycling	Downgrading
Tertiary recycling	Chemical recycling	Feedstock recycling
Quaternary recycling	Energy recycling	Valorization

The preferred alternatives from the available technologies are -

- Mechanical Recycling (consists of producing plastic Granules after removing impurities for molding into goods)
- In the Construction of Tar roads.
- Conversion into Petroleum (Refuse Derived fuel, or RDF)
- Plasma Pyrolysis Technology (PPT)

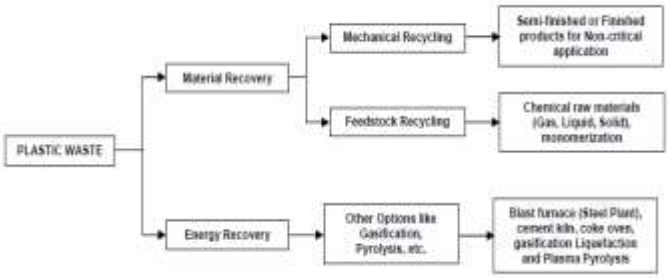

Figure 1. Types of Plastic Waste recycling

II. RECYCLING METHODS OF PLASTIC WASTE

A. *Mechanical Recycling*

Mechanical recycling is reprocessing of materials of waste plastics by physical means, like cutting, shredding, washing etc. into plastic products. Waste plastic is sorted first, then cleaned and directly processed into end products or flakes of consistent quality which can be further used for manufacturing other goods. The succeeding steps for recycling can vary from operation to operation and end application. Many processes like sorting, drying, washing, cleaning and drying and conversion into final flakes are involved in typical process.

In Mechanical recycling the type of plastic is used can be only Thermoplastic. Because it can be re-melted and re-processed into end products. Thermoset plastic can be processed through Cement kilns or Tar roads.

So in short the steps involved in mechanical recycling are:

- Collection/ Segregation
- Cleaning and drying
- Chipping/ Sizing
- Coloring/ Agglomeration

- Pelletisation/ Extrusion
- Manufacturing end product

During the grinding or melting phases, the reprocessed material can be blended with virgin plastics to obtain more superior results.

The requirements of Mechanical recycling are homogenous plastics and relatively clean plastic. It is one of the most used and traditional method used in many countries for plastic recycling. Relatively low cost, but needs initial investment. Method more suited for relatively countries in Asia and Africa.

B. Feedstock or Chemical Recycling

Chemical recycling is an advanced technology which transforms plastic materials into smaller molecules, mostly liquids or gases, very suitable to use as a feedstock material or input for the production of new plastics and petrochemicals. The term chemical is used, due to the fact that an alteration is bound to occur to the chemical structure of the polymer. The final output in chemical recycling is very useful as fuel and it's been proved scientifically. It uses technology called depolymerisation which can be very profitable and beneficial from sustainable point of view.

In advanced processes of chemical recycling there are sub-categories like gasification, pyrolysis, Liquid-gas hydrogenation, steam or catalytic cracking and the use of PSW as reducing agent in blast furnaces.

Many methods for chemical recycling are available, such as direct chemical treatment involving gasification, melting by blast furnace or coke oven and degradation by liquefaction. Condensation polymers such as polyethylene terephthalate (PET) and nylon follows degradation to prepare monomer units, i.e. feedstock or monomer recycling, while vinyl polymers like polyolefin gives a mixture containing numerous components to make use as a fuel. Numerous methods of degradation to obtain petrochemicals are under investigation presently and suitable conditions for gasification and pyrolysis are under extensive research.

For the purpose of selective degradation, use of catalysts such as ZSM-5, Zeolites (natural and synthetic), silica alumina and mesoporous materials is done in Catalytic cracking. They efficiently transforms polyolefins into liquid fuel, producing much lighter fractions as compared to thermal cracking.

The ability of treating mixed plastics and contaminated polymers with limited use of per-treatment makes catalytic recycling more advantageous. If segregation is tedious task and recycler wants to reduce or eliminate it, he may use chemical recycling as a viable solution.

C. Construction of Tar roads

In this method the collected plastic waste (cups, polythene bags etc.) made from PE, PS and PP is separated out. It is cleaned if needed and finely chopped or shredded into small pieces. Those granules are heated in the Mini hot Mix Plant and the chopped plastic is added into it. Due to temperature it gets softened and coated over aggregate. The hot Bitumen is added immediately and mixed well. Since the polymer and bitumen are in molten state, they get mixed and the blend is formed at surface of the aggregate. This final mixture is transferred to the road and road is formed.

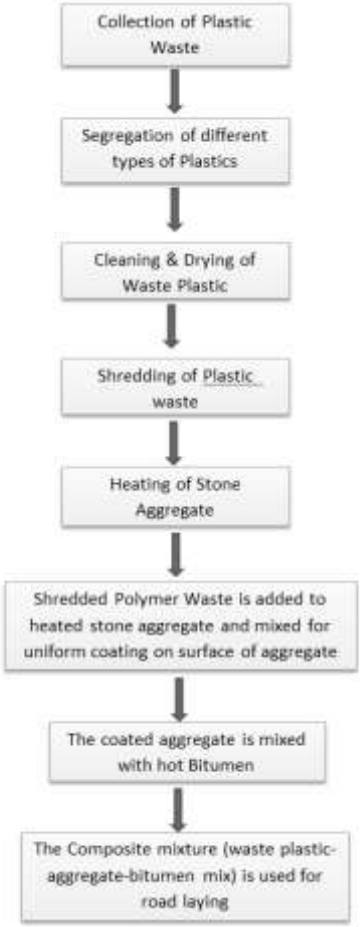

Figure 2. Flow diagram for construction of road from tar

D. Conversion into Petroleum (Refuse Derived fuel, or RDF)

- Catalytic cracking

One of the actual alternative for feedstock recycling can be considered as catalytic cracking since products produced by it are very valuable. Number of polymers like HDPE, PP and LDPE contributing about 60% of plastic waste can be processed through this technology. Further it can be also applied for efficient depolymerization of certain polyamides. Any kind of plastic can be recycled by using exact catalyst in right reaction and at specifically correct time. Due to economic consideration it has less industrial applications, though technically it's efficient. Still there is a wide scope for research and applications since crude oil prices are hiking day-by-day.

- Co-processing of plastic waste as Alternative Fuel and Raw Material (AFR):

Co-processing means using waste materials in industrial processes like cement or production of steel, aluminum, lime and power stations or energy production plants. It indicates use of raw materials by waste recovering industry and different materials from waste instead of primary fuel. Plastic waste can be used for co-processing and referred to as Alternative fuels and Raw materials (AFR). It is a very good option for recycling of plastic waste since it solves waste management issue of municipal corporations at very much extent. Also it saves primary fuel, beneficial from economic point of view and eco-friendly.

E. Plasma Pyrolysis Technology (PPT)

The main purpose of MPW pyrolysis is to recover liquid products in many processes. For example, the famous BP polymer cracking process, Fuji process and Hamburg process are all designed to recover oil products. To obtain high-quality, market-ready oil, the pyrolysis recycling of MPW usually consists of two processes. The first is the degradation of MPW for the production of heavy oils, and the second is a catalytic cracking process that converts the heavy oils into useful hydrocarbons.

Table II: Calorific value comparison

Material	Calorific Value
Polyethylene	46.3
Plypropylene	46.4
Polystyrene	41.4
PVC	18.0
Coal	24.3
L.P.G.	46.1
Petrol	44.0
Kerosine	43.4
Diesel	43.0
Light fuel oil	41.9
Heavy fuel oil	41.1

The output products from the commercial system are mainly power or heat; reformed syngas and /or char is exported only in rare cases, but technologies for exporting gas and /or char are more flexible and desired.

A great advantage of pyrolysis technology over incineration is to export high quality products of oil or gas instead of heat, especially for the small-scaled systems.

III. CONCLUSION

There are various types of methods are available for plastic waste management in municipality and industry. From those methods mechanical recycling is one of the traditional methods. But it has limitation due to thermal degradation of plastic after further recycling.

Feedstock recycling is one of the new techniques fetching Synthetic gas (Syngas) which can be further utilized for energy generation. But still the energy content in syngas has limitations and needs further improvisation.

One of the new and emerging techniques is Plastic plasma pyrolysis in which plastic is melted at higher temperatures in oxygen starved environment to produce oil, which can be further used in industrial purposes or blended with other minerals to get improved results.

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