❖ Options for Plastic Waste Management

Recycling of plastics through environmentally sound manner :

Recycling of plastics should be carried in such a manner to minimize the pollution level during the process and as a result to enhance the efficiency of the process and conserve the energy. Plastics recycling technologies have been historically divided into four general types - primary, secondary, tertiary and quaternary.

Primary recycling involves processing of a waste/scrap into a product with characteristics similar to those of original product.

Secondary recycling involves processing of waste/scrap plastics into materials that have characteristics different from those of original plastics product.

Tertiary recycling involves the production of basic chemicals and fuels from plastics waste/scrap as part of the municipal waste stream or as a segregated waste.

Quaternary recycling retrieves the energy content of waste/scrap plastics by burning/incineration. This process is not in use in India.

Steps Involved in the Recycling Process

Selection The recyclers/reprocessors have to select the waste /scrap which are suitable for recycling /reprocessing.

Segregation The plastics waste shall be segregated as per the **codes 1-7** mentioned in the BiS guidelines (IS:14534:1998).

Processing After selection and segregation of the preconsumer waste (factory waste) shall be directly recycled .. The post consumer waste (used plastic waste) shall be washed, shredded, agglomerated, extruded and granulated

Special Note:

"All medical plastics waste and packings of toxic contents such as pesticides,

Insecticides shall be segregated separately and may be processed through Plasma Pyrolysis Technology (PPT)"

Photo: The Newly Developed Pilot Plant (extruder, control panel & part of pollution monitoring System.

Performance of Built Roadsmade from Plastics Waste:

A study has been entrusted to evaluate the performance of polymer coated built

roads to Thiagarajar College of Engineering Madurai.

The specific task (objectives) of the study are given below

- To measure the roughness of the pavement surface;
- To measure the resistance offered by the pavement surface against skidding of vehicles;
- To measure the pavement macro texture for the geometrical deposition;

- To assess the structural evaluation of flexible pavement for the strength of the same;
- To measure the field density of the road;
- To study the gradation of the road;.
- To carry out different tests on recovered bitumen;
- To examine the condition of the road (Cracks, raveling, potholes, rutting, corrugation edge break etc.).

Special Note:

Polymer blended bitumen shows higher softening point, lower penetration point,

and better ductility. Polymer coated aggregate blended with Bitumen shows

higher Marshall value and better stripping value, hence the polymer coated mix is

more suited for road laying than mixing of shredded plastics into bitumen.

Photo: Mixing of Shredded Polymer on coarse aggregate

Observations of the Field Test

- The coating of plastic reduces the moisture absorption of the aggregate. Normally 2% is the limit for absorption. Whereas the polymer coated aggregate is having almost **nil** absorption.

- The moisture absorption values are correlated with voids. The voids are reduced in Polymer Coated Aggregate. Thus the quality of the aggregate is improved.
- Moreover the removal of voids and the reduction of moisture absorption results into prevention of stripping of bitumen.
- The polymer coating reduces the porosity of the aggregate and hence result in improving soundness of the aggregate. Once the pores are covered with plastics the possibility of entering the salt at the surface is prevented.
- The polymer coated aggregate is practically a plastic laminated aggregate,
  thus prevents wetting with water so there is no stripping.

Results of Field Test:

The coating of plastics over aggregate improves Impact, Los Angels Abrasion and Crushing Value with the increase in the percentage of plastics. After the three phases of field experiments, the following important conclusion have been drawn.

- The extracted bitumen showed almost near value for Marshall stability.
- The entire road was having good skid resistance and texture values.
- All the stretches in the roads are reasonably strong.
- The unevenness index values of these three sections are nearly 3000 mm/km, which indicates a good surface evenness.
- The plastic tar roads have not developed any potholes, rutting, raveling or
  edge flaw, even though these roads are more than two years of age.
- Polymer coated aggregate bitumen mix performs well compared to polymer modified bitumen mix.
- Higher percentage of polymer coating improves the binding strength of the
  mix.

- Foam plastics have better binding values.

Plastics Waste Disposal through Plasma Pyrolysis Technology (PPT)

Plasma Pyrolysis Technology (PPT)- An Introduction

Plasma Pyrolysis is a state of the art technology, which integrates the thermo-chemical properties of plasma with the pyrolysis process. The intense and versatile heat generation capabilities of Plasma Pyrolysis technology enable it to dispose of all types of plastic waste including polymeric, biomedical and hazardous waste in a safe and reliable manner. 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.

Process Technology:

In Plasma Pyrolysis, firstly the plastics waste is fed into the primary chamber at 850^0C 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 plastics 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 1050^0 C. The hydrocarbon, CO and hydrogen are combusted into safe carbon dioxide and water. 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 (CO_2, H_2O) is more than 99% . The extreme conditions of Plasma kill stable bacteria such as bacillus stereo-thermophilus and bacillus subtilis immediately. Segregation of the waste is not necessary, as the very high temperatures ensure treatment of all types of waste without discrimination.

A study has been entrusted to FCIPT ,Institute of Plasma Research (IPR) ,Gandhinagar to evaluate the performance of PPT.

Objectives of the Study:

The disposal of plastics waste is ever increasing problem and no holistic approach could be developed. Considering the grave concern for plastics waste management, an effective technology has been put forth. To ascertain the performance of PPT, a Memorandum of Understanding (MoU) has entered between the Institute of Plasma Research, acting through its Facilitation Centre for Industrial Plasma Technologies and Central Pollution Control Board, Ministry of Environment & Forests, Government of India., The objectives of the study are reiterated below;;

- To conduct a performance study of the Plasma Pyrolysis Technology on 15 kg/hr prototype demonstration system developed by FCIPT/IPR for proper disposal of plastics waste and also monitor parameters e.g suspended particulate matter(SPM), carbon monoxide(CO), hydrocarbon(HC) benzene, dioxins, furans etc. with regards to gaseous emissions.

- To conduct experiments on safe disposal of plastics waste using higher capacity (approx. 50 kg/hr) plasma pyrolysis system as developed by FCIPT.

- CPCB may set up prototype plasma pyrolysis plant on demonstration basis (15 kg/hr waste disposal capacity) as specific locations(hilly and pilgrimage) identified by CPCB in consultation with States.

Conversion of Plastics Waste into liquid fuel

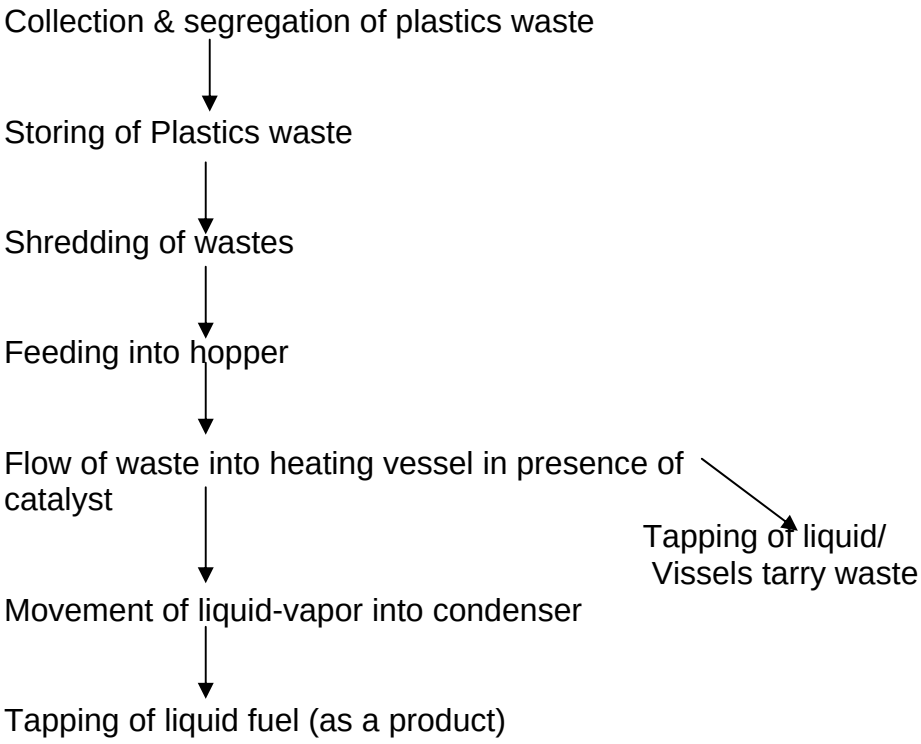
Another solution for disposal of plastics waste has been consider by CPCB i.e conversion of plastics waste into liquid fuel.

Process Technology

A Research-cum-Demonstrative Plant was set up at Nagpur for conversion of

waste plastics into liquid fuel oil. The process adopted is based on random de-polymerization of waste plastics in presence of a catalyst into liquid fuel. The entire process is undertaken in closed reactor vessel followed by condensation, if required. Waste plastics while heating upto 270^0 to 300^0 C convert into liquid-vapour state, which is collected in condensation chamber in the form of liquid fuel. The tarry liquid waste is topped-down from the heating reactor vessel. The organic gas is generated which is presently vented due to lack of storage facility, however, the gas can be used in dual fuel diesel-generator set for generation of electricity.

The process includes following steps;



Environment Related Observations

- There are no liquid industrial effluents and no floor washing as waste material is not washed.
- There is no organized stack and process emissions are let out.

- Odour of volatile organics has been experienced in the processing area due to some leakages or lack of proper sealing

- Since, absolute conversion of liquid-vapor was possible into liquid, some portion of gas (about 20%) is connected to the generator. However, the process will be improved in full scale plant.

- PVC plastics waste is not used and if used, it was less than 1%. In case PVC is used, the chlorine can be converted into hydrochloric acid as a by-product.

- The charcoal (Charcoal is formed due to tapping of tarry waste) generated during the process has been analysed and contain heavy metals, poly aromatic hydrocarbon (PAH) which appears to be hazardous in nature. The source of metals in charcoal could be due to presence **of additives** in plastics and **multilayer & laminated plastics**.

- Monitoring of process fugitive emissions in the work area as well as emissions from the engines/diesel generator sets, where this liquid fuel is used, for various parameters such as CO, HCl, Styrene, Benzene, VOCs is necessarily required.

Recommendations of CPCB:

- As regard technology is concerned, the process could be adopted only for converting post-consumer plastics waste into liquid fuel. The process may work well with the selected plastics waste. For other

category of plastics waste, further research need to be carried out. The technology needs to be established for demonstrating use of post-consumer plastics to reduce menace of plastics waste disposal along with municipal solid waste (MSW)

- There should be proper utilization of unconverted gas and in no case such gaseous emission should be let out freely.

- As far as possible, use of PVC waste should be avoided and in case it is used, it should be converted into hydrochloric acid and no emissions be let out.

- The gaseous emissions may be tested in case the liquid fuel is used for **furnaces/ boilers** and generator.

- In the processing area, monitoring of VOCs should be carried out to check concentrations of various **hazardous air pollutants**.

- Metal and organic concentration need to be checked in charcoal to ascertain its **hazardous nature.**

- The fuel quality may be checked by the concerned agency like **Indian Oil Corporation Limited (IOCL**), which may certify the liquid fuel quality as per the specifications and suggest for its best use.
- As far as prescription of environmental standards are concerned, no standards to be prescribed for liquid effluents. For gaseous emissions, the entire process is to be closed and no leakages are expected. In working area, VOC standards could be worked out. No gaseous effluents are expected to be let out and if any, these are to use in generators.
- When PVC is used, complete conversion to HCl and no emission of HCl vapors could be stipulated. Further, disposal of HCl may also be ensured.

- In case of use of unwashed/unsegregated post-consumer plastics waste (as in the present case), the quality of fuel is expected to be deteriorated as well process fugitive emissions may vary, therefore, it needs to be evaluated and compared with clean waste before technology approval.
- It is proposed to carry out detailed **air quality monitoring** by SPCBs/PCCs of requisite parameters in work area Besides, emission monitoring of **DG sets/engines**, in which this liquid fuel is used, shall also be carried out to ascertain compliance of parameters prescribed by SPCB/CPCB for DG sets.

Biodegradable Plastics

Generally plastics are non-biodegradable; the environmentally degradable polyolefin films are defined as those materials that contain degradation process of polyolefin article (bag/film/sheet) under conditions of composting. Often queries are raised regarding biodegradability of plastics but clear-cut answer is not available about the biodegradability of plastics. In view of above, CPCB has entrusted a comprehensive study to Central Institute of Plastics Engineering and Technology (CIPET) to establish the biodegradability and compostability (e.g. fragmentation rate, degradation rate and safety) of known and unknown polymeric material available in India and abroad .Microorganisms use the carbon substrate to extract chemical energy for driving their life processes by aerobic oxidation of glucose and other readily utilizable C-substrate as shown by the following equation:

$$C_6H_{12}O_6 + 6\ O_2 \longrightarrow 6\ CO_2 + 6\ H_2O\ (\ \Delta G^0 = -\ 686\ kcal/mol\ )$$

The main objectives of the proposed study include the followings:

- To inventories/assess the manufacturing status of biodegradable plastics in India particularly with reference to processing technologies and the environmental issues etc.
- To establish the degradation rate (change in chemical structure, decrease in mechanical strength, fragmentation or weight loss) of the

polymeric material or plastics material under laboratory scale composting conditions

- To find out self-life and its impact on environment (soil, water of plastics w.r.t. colour/additives once it is disposed);
- Effect on foodstuffs w.r.t. natural colour/additives

Process Methodology:

To test the biodegrability following procedure has been adopted;

(a) Inventorisation of Manufacturing units of biodegradable /degradable plastics & collection of sample from Industries/Hospitals/Hotels/Restaurants

(b) Analysis of biodegradable/degradable films through ASTM and international consensus standard on biobased content qand biodegrability . The following ASTM specification has neen used in present investigation;

ASTM D-5209; Standard Test method for determining the Aerobic Biodegradation of plastic materials in presence of Municipal Sludge.

ASTM D-5338: Standard Test method for determining the Aerobic Biodegradation of plastic materials under controlled composting conditions.

ASTM D-6400: Specifications for Compostable Plastics

(c)Disintegration

(d)Safety

(e)Collection of D2W additives & analysis of its toxicity

Results of the lab study:

- The study is still going on. The test results of the films collected from certain industries have the average biodegradation to the tune of 4.40% 6.66% & 40.35 % respectively.

- The test results of the sample from the hotels / Restaurants & Hospitals showed biodegradation ranging from 8.46% to 29.97% respectively.

- The minimum percentage of biodegradation of a product made from a single polymer
- should be 60% in 45 days span in the present context & standards practiced world wide.
- In the present study samples collected so far are not conforming to the requirement of prescribed biodegradation level as per ASTM D -6400. (Clause 6.3.1)
- The toxicity level of masterbatch additives is under investigation