Present Scenario of E-Waste Disposal: A Review

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Abstract-*The nature of the man is to make the nature vulnerable. Today due to liberalization, privatization and globalization, there is huge foreign investment in our country in the sector of electronic and electrical commodities, because India is the big market. The role of science and technology is dynamic. The production of such commodities encourages the people to purchase the novelties having new technology which results the scrapping of old technology. Most of the times, methods which are using for collection, dismantling and recycling are not sophisticated which accelerates the problems of environmental pollution, health impacts, etc. As per preliminary estimates, the annual e-waste generation in India has been estimated to be 0.8 million tons by 2012. Considering it necessary in the public interest to enable the recovery and/or reuse of useful material from e-waste, thereby reducing the hazardous wastes destined for disposal, and to ensure the environmentally sound management of all types of waste electrical and electronic equipment, the Government introduced the E-waste (Management & Handling) Rules, 2011.*

Keywords-E-Waste Treatment System, CRT Treatment Technology, E-Waste Scenario.

I. INTRODUCTION

Advances in the field of science and technology brought about industrial revolution in the 18th Century which marked a new era in human civilization. In the 20th Century, the information and communication revolution has brought enormous changes in the way we organize our lives, our economies, industries and institutions. These spectacular developments in modern times have undoubtedly enhanced the quality of our lives. At the same time, these have led to manifold problems including the problem of massive amount of hazardous waste and other wastes generated from electric products.[1]

These hazardous and other wastes pose a great threat to the human health and environment. The issue of proper management of wastes, therefore, is critical to the protection of livelihood, health and environment. It constitutes a serious challenge to the modern societies and requires coordinated efforts to address it for achieving sustainable development. According to the Basel Convention, wastes are substances or objects, which are disposed of or are intended to be disposed of, or are required to be disposed of by the provisions of national laws.[2]

1.1 What is E-Waste

Like hazardous waste, the problem of e-waste has become an immediate and long term concern as its unregulated accumulation and recycling can lead to major environmental problems endangering human health. The information technology has revolutionized the way we live, work and communicate bringing countless benefits and wealth to all its users. The creation of innovative and new technologies and the globalization of the economy have made a whole range of products available and affordable to the people changing their lifestyles significantly.

New electronic products have become an integral part of our daily lives providing us with more comfort, security, easy and faster acquisition and exchange of information. But on the other hand, it has also led to unrestrained resource consumption and an alarming waste generation. Both developed countries and developing countries like India face the problem of e-waste management. The rapid growth of technology, upgradation of technical innovations and a high rate of obsolescence in the electronics industry have led to one of the fastest growing waste streams in the world which consist of end of life electrical and electronic equipment products.[3] It comprises a whole range of electrical and electronic items such as refrigerators, washing machines, computers and printers, televisions, mobiles, i-pods, etc., many of which contain toxic materials. Many of the trends in consumption and production processes are unsustainable and pose serious challenge to environment and human health.

Optimal and efficient use of natural resources, minimization of waste, development of cleaner products and environmentally sustainable recycling and disposal of waste are some of the issues which need to be addressed by all concerned while ensuring the economic growth and enhancing the quality of life.[4] The countries of the European Union (EU) and other developed countries to an extent have addressed the issue of e-waste by taking policy initiatives and by adopting scientific methods of recycling and disposal of such waste. The EU defines this new waste stream as 'Waste Electrical and Electronic Equipment' (WEEE). As per its directive, the main features of the WEEE include definition of

'EEE', its classification into 10 categories and its extent as per voltage rating of 1000 volts for alternating current and 1500 volts for direct current. The EEE has been further classified into 'components', 'sub-assemblies' and 'consumables'.3 Since there is no definition of the WEEE in the environmental regulations in India, it is simply called 'e-waste'. E-waste or electronic waste, therefore, broadly describes loosely discarded, surplus, obsolete, broken, electrical or electronic devices.[5]

II. LITERETURE REVIEW

2.1 Composition of E-Waste

E-waste consists of all waste from electronic and electrical appliances which have reached their end- of- life period or are no longer fit for their original intended use and are destined for recovery, recycling or disposal. It includes computer and its accessories monitors, printers, keyboards, central processing units; typewriters, mobile phones and chargers, remotes, compact discs, headphones, batteries, LCD/Plasma TVs, air conditioners, refrigerators and other household appliances.[6]

The composition of e-waste is diverse and falls under 'hazardous' and 'non hazardous' categories. Broadly, it consists of ferrous and non-ferrous metals, plastics, glass, wood and plywood, printed circuit boards, concrete, ceramics, rubber and other items. Iron and steel constitute about 50% of the waste, followed by plastics (21%), non-ferrous metals (13%) and other constituents. Non-ferrous metals consist of metals like copper, aluminium and precious metals like silver, gold, platinum, palladium and so on.6 The presence of elements like lead, mercury, arsenic, cadmium, selenium, hexavalent chromium, and flame retardants beyond threshold quantities make e-waste hazardous in nature. It contains over 1000 different substances, many of which are toxic, and creates serious pollution upon disposal. Obsolete computers pose the most significant environmental and health hazard among the e-wastes.[7]

2.2 E-waste Treatment Systems

The major options for disposal of WEEE/E-waste in the absence of any treatment option are landfilling and incineration. However, the presence of hazardous elements and compounds in WEEE/E-waste offers the potential of increasing the intensity of their discharge in environment due to landfilling and incineration. Therefore, the major approach to treat WEEE/ E-waste is to first reduce the concentration of these hazardous chemicals and elements through decontamination/ dismantling, recycling and recovery of items of economic value and finally dispose WEEE/ E-waste fractions through either incineration or landfilling or a combination of both. The WEEE/ E-waste treatment options include the following unit operations.[8]

Decontamination/Dismantling: Decontamination/Dismantling is done manually. It includes the following steps.

(i) Removal of parts containing hazardous/ dangerous substances (CFCs, Hg switches, PCB).
(ii) Removal of easily accessible parts containing valuable substances (cable containing copper, steel, iron, precious metal containing parts, e.g. contacts)
(iii) Segregation of hazardous/ dangerous substance and removal of easily accessible parts

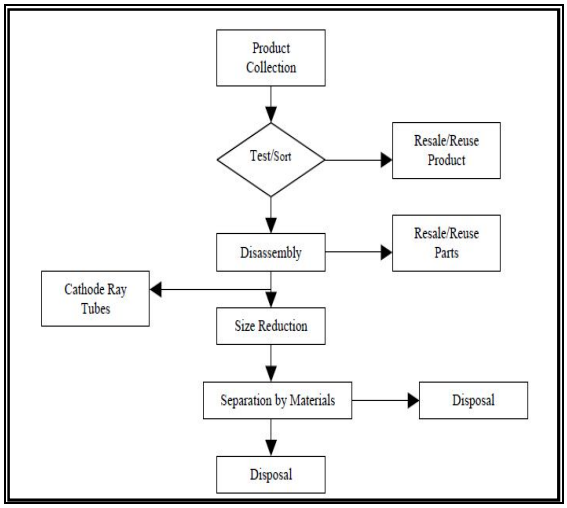
1. Segregation of ferrous metal, non-ferrous metal and plastic: This separation is generally carried out after shredding and followed by mechanical and magnetic separation process.
2. Recycling/recovery of valuable materials:
   WEEE/E-waste fractions after segregation consisting of ferrous and non-ferrous metals are further treated. Ferrous metals are smelted in electrical arc furnaces, non-ferrous metals and precious metals are smelted in smelting plants.
3. Treatment/disposal of dangerous materials and waste: Shredder light fraction is disposed of in landfill sites or sometimes incinerated, CFCs are treated thermally, Poly Chlorinated Biphenyl (PCB) is incinerated or disposed of in underground storages, Mercury (Hg) is often recycled or disposed of in underground landfill sites.[9]

III. METHODOLOGY

3.1 E-Waste Treatment Technology

The simplified flow diagram for E-Waste treatment is given in figure 1. It starts fromproduct collection followed by product testing in order to sort reusable and non-reusableE-Waste separately. Non-reusable E-Waste is disassembled and E-Waste fractions are sorted into reusable and non reusable parts. Non-reusable E-Waste parts undergo size reduction, separation and recovery of different materials, while the remaining E-Waste fractions are disposed.

Fig no. 1 Simplified flow diagram for the recycling of E-Waste.



3.2 E-waste treatment system is used at three levels:

1. First level treatment
2. Second level treatment
3. Special treatment processes

1. First Level E-waste Treatment:

Input: E-waste items like TV, refrigerator and Personal Computers (PC) Unit Operations: Following three unit operations occur at first level of treatment.
1. Removal of all liquids and Gases
2. Dismantling (manual)
3. Segregation

All the three unit operations are dry processes, which do not require use of water. The first step is to decontaminate E-waste and render it non-hazardous. This involves removal of all types of liquids and gases (if any) under negative pressure, and their recovery and storage. Further, all other hazardous WEEE/ E-waste residues are dismantled and segregated. These segregated hazardous WEEE/ E-waste fractions are then sent for third level treatment.

Expected Output:

1. Segregated hazardous wastes like CFC, Mercury (Hg) Switches, CRT,Batteries and Capacitors
2. Decontaminated E-waste consisting of segregated non-hazardous E-waste like plastic, circuit board and cables Various steps in the manual dismantling process at a WEEE/E-waste dismantling facility are depicted in figure 4.5. The guiding principles for fixing up the layout of first level WEEE/E-waste treatment facility are given below.

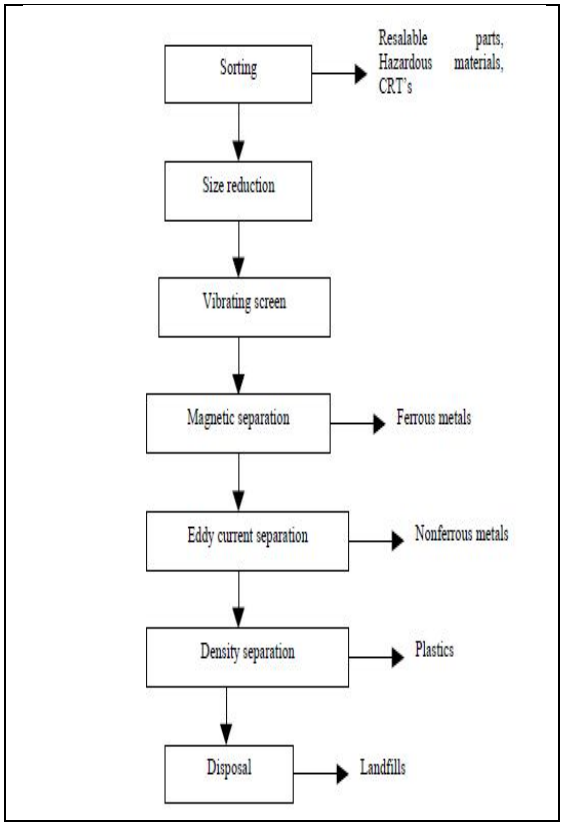
(1) Establish the capacity of WEEE/E-waste treatment facility in terms of WEEE/ Ewaste numbers (or tonnes) per day.
(2) Establish the time taken by an operator/ worker to dismantle one particular WEEE/E-waste item.
(3) Calculate the number of operators/ workers required per day and the number of operating shifts.
(4) Calculate the working area required for each operator/ worker based on dismantling area and location of collection bins for segregated WEEE/E-waste components
(5) Calculate the total area of the facility based on working area requirement for total number of workers and associated utilities.

Step 1: Collected E-waste entering the disassembly line in the dismantling facility
Step 2: Manual dismantling of monitor (removal of plastic back cover and disposal into a plastic bin)
Step 3: Decontamination by manually removing the hazardous items and their collection in bins
Step 4: Complete dismantling and segregation of E-waste fractions.

2. Second Level WEEE/ E-waste Treatment

A simplified conceptual flow diagram for second level E-waste treatment is given In following figure Input, unit operations and outputs are described below.

Fig No.3 Simplified Flow Diagram for second Level E-Waste treatment



Input: Decontaminated E-waste consisting segregated non hazardous E-waste like plastic, circuit board and cables.

Unit Operations: There are three unit operations at second level of E-waste treatment
1. Hammering
2. Shredding
3. Special treatment processes

3. Special treatment processes are given below.

(iv) CRT treatment consisting of separation of funnels and screen glass.
(v) Electromagnetic separation
(vi) Eddy current separation
(vii) Density separation using air or water.

The two major unit operations are hammering and shredding. The major objective of these two unit operations is size reduction. The third unit operation consists of specialtreatment processes. Electromagnetic and eddy current separation utilizes properties of different elements like electrical conductivity, magnetic properties and density to separate ferrous, non ferrous metal and precious metal fractions. Plastic fractions consisting of sorted plastic after first level treatment, plastic mixture and plastic with flame retardants after second level treatment, glass and lead are separated during this treatment. The efficiency of this treatment determines the recovery rate of metal and segregated WEEE/ E-waste fractions for third level treatment.

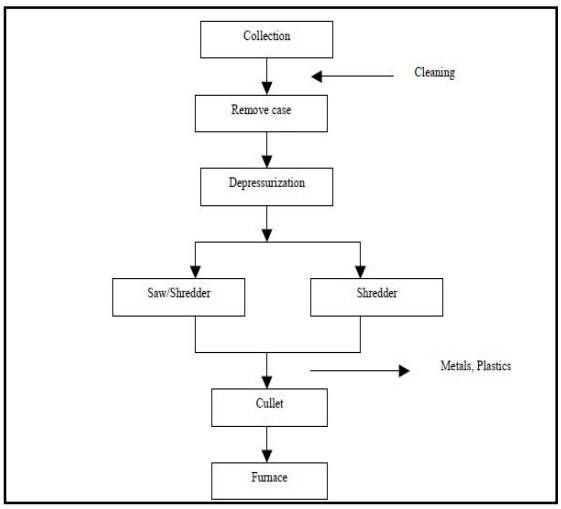
Expected Output: Output from the second level treatment technology is given below.

1. Ferrous metal scrap (secondary raw material)
2. Non ferrous metal scrap mainly copper and aluminum
3. Precious metal scrap mainly silver, gold, palladium
4. Plastic consisting of sorted plastic, plastic with flame retardants and plastic Mixture.

CRT Treatment Technology

A simplified conceptual flow diagram for CRT treatment is given in figure Input, unit operations and outputs are described below.

Fig No.5 Process flow diagram for recycling of CRTs**.**



Input: CRT segregated after first level E-waste treatment
Unit operations:

1. Dismantling: CRT is manually removed from plastic/ wooden casing
2. De-pressurization and Splitting: Picture tube is split and the funnel section is then lifted off the screen section and the internal metal mask can be lifted to facilitate internal phosphor coating.

Different types of splitting technology used are given below.

1. NiChrome hot wire cutting: A NiChrome wire or ribbon is wrapped round a CRT and electrically heated for at least 30 seconds to cause a thermal differential across the thickness of the glass. The area is then cooled (e.g. with a water-soaked sponge) to create thermal stress which results in a crack. When this is lightly tapped, the screen separates from the funnel section.
2. Thermal shock: The CRT tube is subjected to localized heat followed by cold air. This creates stress at the frit line where the leaded funnel glass is joined to the unleaded panel glass and the tube comes apart.
3. Laser cutting: A laser beam is focused inside and this heats up the glass. It is immediately followed by a cold water spray that cools the surface of the glass and causes it to crack along the cut line.
4. Diamond wire method: In this method, a wire with a very small diameter, which is embedded with industrial diamonds is used to cut the glass as the CRT is passed through the cutting plane.
5. Diamond saw separation: Diamond saw separation uses either wet or dry process. Wet saw separation involves rotating the CRT in an enclosure while one or more saw blades cut through the CRT around its entire circumference. Coolant is sprayed on to the surface of the

saw blades as they cut. This is to control temperature and prevent warping.

6. 6.Waterjet separation: This technology uses a high-pressure spray of water containing abrasive, directed at the surface to be cut. The water is focused through a single or double nozzle-spraying configuration set at a specific distance.

Cleaning: Internal phosphor coating is removed by using an abrasive wire brush and a strong vacuum system to clean the inside and recover the coating. The extracted air is cleaned through an air filter system to collect the phosphor dust. Expected Outputs: Metals, Plastic and Glass Cullet Cullet glass is reused as a raw material by CRT manufacturers. Recovered CRT glass also goes to the lead smelter, where they act as fluxing agent in the smelting process.

IV. CONCLUSION

E – waste due to its current growth rate will become a separate and major component of waste. The toxic nature of E – waste makes it of importance for its management. With current available system for management of E – waste, if the options like repair, reuse, recycle are adopted, that will act as a optimization at source. The implementation of E – waste Rules are required to be followed strictly which gives a partly solution to problem of MSW management as till today E – waste management is being practiced in combination with MSW. Government of India should widen the boundaries of categories to be included as E – waste as currently they do not cover the some categories related to electrical gadgets. Also it gives a scope to develop a separate management plan for different levels. This will lead to easy implementation of proper, scientific and sound management practices for E – waste with regards to collection, storage, transport, treatment and disposal.

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