Recycling of Cathode Ray Tubes

Vivek Mandot
Associate Professor
V. K. B. Government Girls' College
Dungarpur (Rajasthan), India

Abstract: Electronic waste is increasing with alarming rate. Earlier televisions and computer monitors were all very bulky and having cathode ray tube on which picture was seen. Advancement of electronic technology has introduced liquid crystal display and light emitting diode based television sets that are comparatively much lighter. This has rendered the old bulky televisions as waste and most of them are either already discarded or about to discard and replaced by newer slimmer television sets. Cathode Ray Tubes were extensively being used in televisions and other scientific equipments till the advancement of electronics in recent years. These Cathode Ray Tubes (CRTs) are mostly not in use now and are one of the major bulky parts of electronic waste as these CRTs contain glass with lead that is toxic and irresponsible disposal of it may harm the environment and future ecosystem. Treatment and disposal of this leaded glass is difficult and separation of lead from this glass is also not easy. Technologies are evolving to effectively separate and treat this leaded glass. Popular methods of recycling of cathode ray tubes have been discussed in this paper.

Index Terms- **Electronic waste, Cathode Ray Tube, recycling.**

I. **Introduction**

Cathode ray tube technology was in use for decades as televisions, computer monitors and scientific equipments. It is cheaper and easily assessable device that also has a very long life. With advancement of electronic technology and introduction of liquid crystal display as well as light emitting diode monitors, the cathode ray tubes have become electronic waste. These new monitors are versatile and much more compact as well as lightweight. The CRT technology is still in use because they are the cheapest monitors and are affordable in many poorer countries across the world. With economic development they are gradually becoming electronic waste [1-3].

According to estimates china alone has more than 75 million units of waste household electrical and electronic appliances in 2012 and out of these around 80 percent were television sets containing cathode ray tubes. As these CRTs contain lead and hence toxicity of these CRTs is well acknowledged. In CRTs the lead is mainly concentrated into funnel glass part of it and the lead content ranges from 22 percent to 25 percent. One cathode ray tube contains approximately 1.2kg of lead [4-8]. CRTs should be properly stored and treated because of their hazardous components. If they are not properly disposed then the harmful component may leach into the soil and that in turn will contaminate land and water resources harming ecosystem as well as lives on earth. Therefore CRT wastes are now considered an important part of electronic waste [9-11].

In India also the electronic waste has increased greatly. After liberalisation of 1990 and economic upliftment of population, the electronic gadgets have been replaced by latest models. Thus the old television sets with CRTs were exchanged or replaced in millions. In some cases they are not even disposed off before getting a new one. Such equipments are still in use by many people who are economically not so well and can't afford the new gadgets. Metrocities of India are most ewaste producing cities. It is estimated that around 400000 tons of waste was produced in 2010 itself [12-14]. This problem is increasing and almost all countries are facing this issue at some stage or the other [15]. It is thus important to recycle or reuse the CRTs.

II. Recycling of CRTs

The cathode ray tube contains mainly glass and lead and lead is toxic and particularly harmful for environment. Many parts of the ewaste are recycled because they are easy to manufacture from recycling than from the raw material but this is not the case with CRT. As demand of CRTs has diminished, it is not economical to reuse this CRT material for CRT and therefore this waste is one in which industry is not very interested. Mostly the CRTs are reused in two ways. One way is to reuse waste CRT glass in manufacturing new CRT glass and is known as closed-loop direction while another way is to use this waste to produce materials other than the CRT glass and is known as open-loop direction. The author has tried to introduce different approaches towards recycling the CRTs.

2.1 Cathode ray tube to another CRT

For quite some time this method was very popular and economically viable option as it is easier to produce new CRTs with the waste old CRTs. This process is known as close loop process and in this method the waste CRT is collected and its front panel as well as funnel part are not removed from the waste. The recycling company separates the glass structures as per their contents and sent them to the manufacturer for production of new CRTs [16-17]. The front panel is separated and funnel part is crushed and recycled in the manufacture of new CRT. This method is very popular and many famous companies followed this procedure but with time the demand of fresh CRTs is diminishing at all levels because of introduction of light weight slim and smart modern televisions. Therefore, now the large number of CRTs will not be reused this way and thus new methods are required to get rid of this lead content on the CRT glass.

2.2 Recovering lead from CRT

Recovering the lead content from the CRT is very complicated process and need high research as well as efficiency. This is very important to separate the lead from the glass matrix so as to minimize the chances of lead leaching into soil or ground.

One of the very popular methods is pyrometallurgy and is being used for a long time. In this process the high temperature is used to separate the lead. It is observed that lead and other metals are present as oxides and silica is also present in the CRTs. Silica sand is used as flux agent in lead smelting. Some process substances like carbon are added. Almost all lead content can be recovered through this process and temperature is kept below 1000 degree centigrade to reduce chances of lead evaporation [18]. Controlling this process is very complicated and hence recently hydrometallurgical methods have become popular.

Generally the lead in the CRT glass matrix has very high bonding and direct hydrometallurgical leaching methods are not very efficient and thus pretreatment of CRT glass before hydrometallurgical process is undertaken [19-20]. By subcritical method the CRT funnel glass is pretreated and then funnel glass is leached into nitrate acid solution and in this way lead recovery rate of 93% has been observed [19]. In another approach the solubility of lead is increased by pretreatment. In alkali fusion technique the CRT funnel is mixed with alkaline compounds such as Na_2CO_3 and it is sintered in high temperature. This method destroys the glass structure and it is filtered with lead acid solution. Using different variation of this alkaline fusion method lead recovery rate of 97% has been reported [20-21].

2.3 CRT glass to other products

Though CRT glasses have lead content and leaching of it may be toxic but still it has been used safely in various products. One such product is glass foam. It is lightweight product and is extensively used where heat and sound insulation is required. It has long shelf life and is non-inflammable as well as has waterproof properties. To produce foam glass generally a gas producing material is added to powered glass and then baking it to trap the gas bubbles in the glass. It is produced at temperatures of 700º C to 900º C [22-23].

This waste glass is also being used as cement additives. Generally Panel and funnel glass part of CRT are separated and then they are mixed in such a way that percentage of leaded glass is below 25%. This is ensured so that lead does not harm environment. Generally the panel glass and funnel glass are separately grinded and then mixed as per requirement in brick formation and cement as additive [24-25].

CRT waste can be used in ceramics products as these products are not regularly come in contact with humans. Researchers have used CRT waste as an additive in ceramic industry for ceramic glazes and adding around 5% of CRT waste does not interfere with desired properties of ceramics. It has also been observed that glazes with CRT glass are similar to conventional glazes [26].

2.4 Recycling of other parts of Monitor

A monitor also contains non-glass materials like Printed circuit board, electron gun, deflection yokes etc along with CRT. The electron gun contains glass, steel, copper and other polymer materials. The electron gun is the part where electron beam is formed. It has cathode and anode and potential difference between them varies between 100-1000V. It is very important part of the monitor. The metals are recovered from this electron gun and appropriately recycled.

Deflection yokes are copper coil that are used to direct the rays coming from the electron gun. Copper part of it is easily recycled and other materials are carefully separated. The printed circuit boards contain copper, solder and many precious materials. These materials are separately recycled or metal is extracted from them with different technologies. Plastic parts of printed circuit boards are recycled and metal is reused. The printed circuit board also contains precious metals like silver, gold, nickel in very small quantities. These materials are recovered by different mechanism [27-28].

III Conclusions

Cathode Ray Tubes are now becoming obsolete very fast and because it contains lead that has a good binding with CRT glass, the proper recycling of CRT is crucial. Lead is toxic and it may leach into soil as well as groundwater if waste CRT or partially treated CRTs are indiscriminately stored. They cannot be dumped also because of its environmental impact. Therefore, it is important that more advanced and automated techniques are developed to recycle CRTs. Infrastructure for efficient recycling of CRTs may not be available in developing countries and thus the developed countries should share technology with all under developed countries so that the world environment does not get adversely impacted.

References

[1] Gregory, J. R., et al., 2009. Evaluating the Economic Viability of a Material Recovery System: The Case of Cathode Ray Tube Glass. Environ Sci Technol, 43:9245-9251.
[2] Yamashita, M., et al., 2016. Leaching behavior of CRT funnel glass. J Hazard Mater, 184:58-64.

[3] Singh, N., et al., 2016. Waste cathode rays tube: an assessment of global demand for processing. Procedia Environ Sci, 31:465-474.
[4] China Household Electric Appliances Research Institute, 2012. *White Paper on WEEE Recycling Industry in China*.
[5] Lairaksa, et al., 2013. Utilization of cathode ray tube waste: Encapsulation of PbO-containing funnel glass in Portland cement clinker. J Environ Manage, 117:180-186.
[6] Yuan, W., Jinhui, Li., Zhang, Q., et al., 2012. Innovated application of mechanical activation to separate lead from scrap cathode ray tube funnel glass. Environmental Science and Technology, 46, 4109-4114.
[7] Williams, E., Kahhat, R., Allenby, B., et al., 2008. Environmental, social, and economic implications of global reuse and recycling of personal computers. Environmental Science and Technology, 42: 6446–6454.
[8] Mear, F., Yot, P., Cambon, M., et al., 2006. The characterization of waste cathode ray tube glass. Waste Management, 26: 1468-1476.
[9] Gable, C. and Shireman, B., 2001. Computer and Electronics Product Stewardship: Are We Ready for the Challenge? Environ Qual Manage, 11:35-45.
[10] Andreola F, et al., 2005. Cathode ray tube glass recycling: an example of clean technology. Waste Manag Res, 23:314-321.
[11] Nnorom IC, et al., 2011. Global disposal strategies for waste cathode ray tubes. Resour, Conserv Recycl, 55:275-290.
[12] Alexandra, et al., 2010. The Challenges of E-Waste Management in India: Can India draw lessons from the EU and the USA? ASIEN, 117:7-26.
[13] Wath, S. B., et al., 2010. A roadmap for development of sustainable E-waste management system in India. Sci Total Environ, 409:19-32.
[14] Garlapati, V. K., 2016. E-waste in India and developed countries: Management, recycling, business and biotechnological initiatives. Renew Sust Energ Rev, 54:874-881.
[15] Ciftci, M. and Cicek, B., 2017. Ewaste: A review of CRT recycling, Research reviews, Journal of material science, Vol 5, 2, DOI: 10.4172/2321-6212.1000170.
[16] Yu, M., et al., 2016. An overall solution to cathode-ray tube (CRT) glass recycling. Procedia Environ Sci, 31:887-896.
[17] Menad, N., 1999. Cathode ray tube recycling. Resour, Conserv Recycling, 26:143-154.
[18] Chen, M., et al., 2009. Detoxification of cathode ray tube glass by self-propagating process. J Hazard Mater, 165:980-986.
[19] Miyoshi, H., Chen, D., Akai, T., 2004. A novel process utilizing subcritical water to remove lead from wasted lead silicate glass, Chemistry Letters, 33(8): 956-957.
[20] Okada, T. and Yonezawa, S., 2013. Energy-efficient modification of reduction-melting for lead recovery from cathode ray tube funnel glass. Waste Manag, 33:1758-1763.
[21] Zhang, C., et al., 2013. Recovering lead from cathode ray tube funnel glass by mechano-chemical extraction in alkaline solution. Waste Manag Res, 31:759-763.
[22] Mear, F., Yot, P., Cambon, M., et al., 2006. Characterization of porous glasses prepared from cathode ray tube (CRT). Powder Technology, 62(1): 59-63.
[23] König, J., et al., 2015. Fabrication of highly insulating foam glass made from CRT panel glass. Ceramics Int, 41:9793-9800.
[24] Lee, J. S., et al., 2016. Recycling of cathode ray tube panel glasses as aggregates of concrete blocks and clay bricks. Waste Manag, 18:552-562.
[25] Ling, T. C. and Poon, C.S., 2012. A comparative study on the feasible use of recycled beverage and CRT funnel glass as fine aggregate in cement mortar. J Cleaner Prod, 29-30:46-52.
[26] Andreola, F., et al., 2007. CRT glass state of the art A case study: Recycling in ceramic glazes. J Eur Ceramic Soc, 27:1623-1629.
[27] Ghosh, B., et al., 2015. Waste Printed Circuit Boards Recycling: An Extensive Assessment of Current Status. J Cleaner Prod, 94. DOI: 10.1016/j.jclepro.2015.02.024
[28] Szałatkiewicz, J., 2014. Metals Content in Printed Circuit Board Waste. Polish J Environ Stud, 23(6):2365-2369.