CHAPTER-VII

7.0 Recovery process for glass

One of the main components of dismantling of monitor and television is the Cathode Ray Tube (CRT). They are considered hazardous due to the presence of Lead in its Funnel Glass as well as the Phosphor coating on the inside wall of the Front Glass. (Common Sense Initiative -CSI- 1998) Improper disposal of CRTs in the backyard operations of informal sector and the resulting disposal of broken CRTs causes environmental and health damage. The present study deals with eco-efficient recycling of CRT glass in a close loop CRT to CRT operation.

Out of the potential annual E-waste generation in India, the desktop estimate of about 86,000 tons, the CRT monitors could be close to 12,250 tons and again out of which the CRT’s alone can be as much as 6,980 tons. In addition the Televisions industries also generate E-waste during end of life, closed to 1, 69,000 nos., of colors TV’s and 142,000 nos., of black and white TV’s. Approximately 6,220 tons of CRT’s are produced from this waste and therefore the total of 13,200 tons per annum of CRT waste is produced in our country.

7.1.1 Benefits of glass recycling

- One tons of glass recycled reduces carbon emission by 314kgs*
- Reduces energy consumption
- Produces less Sulphur dioxide and Nitrogen Oxides (NOx) due to recycling.
- Conserving earth resources, minerals, fuels etc.
- Conserves natural resources
- Does not require high level of technology.
- Fulfills social obligations and helps the economic development of the country

* Total carbon emission reduction estimate in during the course of the present study due to CRT glass recycling is 29,585.08 Kg.
7.1.2 Ecological impacts of glass recycling

- The cost savings of recycling is in the use of energy. Compared to making glass from raw materials for the first time, cullet melts at a lower temperature. So we can save on energy needed to melt the glass.

- Glass produced from recycled glass reduces related air pollution by 20% and related water pollution by 50%.

- Recycling glass reduces the space in landfills that would otherwise be taken up by used bottles and jars.

- The typical glass container is made up of as much as 70% recycled glass.

- It is estimated that 80% of recycled glass, as a whole, will end up as new glass containers.

- Unlike other substances such as paper, glass can be recycled infinitely without any loss of purity or quality.

- In addition to removing lead from the municipal waste stream, glass to glass recycling eliminates the environmental impacts associated with mining and processing raw lead from ore by supplying lead (in the form of CRT glass) for CRT glass manufacturing.

- To create new glass, substances such as sand, Sodium carbonate etc., must be heated to 2,600°F Fahrenheit, which consumes lot of energy and creates pollution from factories.

- Recycled glass first becomes “cullet,” or crushed glass. When making new products from cullets, 40% less energy is consumed in place of making glass from new products, because it melts at a lower temperature than virgin ingredients.

- A glass bottle can take up to one million years to breakdown.

- Most glass bottles are eligible for a cash refund in 11 different U.S. states, meaning that recycling them can earn some money.

- Because glass is made from naturally-occurring materials like sand, it has a low rate of chemical interaction with the contents of the container, which makes it a safe material to be reused.

- Recycled glass can be used in numerous areas, such as creating sports turf, manufacturing kitchen tiles and providing sand to depleted beaches.
The Toxic characteristics Leachate Procedure (TCLP) studies (Timothy et al, 1999) conducted by various researcher have proven that lead containing CRT glass fails in the test indicating clear possibility of lead leaching into the soil, if such glass is land filled, therefore the land fill disposal option in an approved Treatment Storage Disposal Facility (TSDF) is ruled out. The study therefore looks into the closed loop recycling of the such CRT glass to produce another CRT to make the process cradle to cradle.

It is interesting to note that the number of end of life TV’s received for recycling are very low in typical Indian conditions. A few numbers of TV’s received from mainly that of custom bonded goods of R&D of repute. A very few CRT’s were also received from equipments such as oscilloscope, medical scanners, projection system CRT’s etc., all put together amounts to negligible quantity.

The interesting trend of very low quantity of TV’s in the E-waste including that of black & white TV’s are due to the facts:

- A large reuse & refurbish market
- Demand from consumer especially rural areas
- CRT’s are recharged & re-gunned some times even two times re-gunned by the service centre & repair shops.

Therefore, a very few TV CRT’s end up in breaking that too in unorganized sector. The backyards of unorganized sector handling such toxic containing CRT product waste, pose imminent threat and permanent damaged to environment and health.

![Fig 71: CRT’s in unorganized sector, threat to Environment and Health](image)

In order to overcome the above problems, during the present study a simple cost effective solution has been developed and implemented for CRT glass recycling process. The color monitor CRT’s which are difficult to re-gun end up as E-waste streams.
The other reason being replacement of heavy CRT monitors with lighter and more energy efficient Thin Film Transistor Liquid Crystal Display (TFT-LCD) which also consume less work place area.

7.2 Reuse of monitors and crt’s

The other interesting finding of the present study is that original CRT monitors are directly reused by internet parlors, computer training institutes etc.

7.2.1 Color monitors reused as color TV’s

Color CRT monitors is suitably modified with additional electronic circuits and work as a low cost high definition TV’s and is being increasingly used by both urban and rural population Fig 71.

![Image of monitors]

Fig 72: Monitors can be refurbished and used as low cost televisions

7.2.2 Regunning of CRT’s

The regunning process involves heating of the tube in an oven after which the tip of the tube is cut. The electronic gun is removed and the tube is regunned. Regunning is possible only for those monitors whose terminal pin (diode pin) of electron gun has not broken in the process of removing yoke from gun. The success ratio of the regunning is 4:1.

It is well known that functioning CRT tubes from computer monitors can undergo regunning process after which they can easily be used to assemble black and white and colour television sets. The regunned picture tubes are used in the manufacture of televisions of local brands and screens for video games. Due to their larger screen, imported monitors are in greater demand for regunning.
With such an excellent reuse and refurbish supply chain by the backyard sector, the CRT waste generation is greatly reduced and becomes an example for waste source reduction. However it is interesting to note that the color CRT from monitors are generally not re-gunned due to complex design and technology used for the high definition computer monitors which are generally viewed at close quarters.

7.3 Characterization of CRT

The composition of typical color CRT is shown in Table 39

Table 39 Composition of CRT

<table>
<thead>
<tr>
<th>SL No</th>
<th>Components</th>
<th>Weight in Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Electron gun</td>
<td>0.101</td>
</tr>
<tr>
<td>2</td>
<td>Adhesive cloth</td>
<td>0.006</td>
</tr>
<tr>
<td>3</td>
<td>M.S.hoop</td>
<td>0.36</td>
</tr>
<tr>
<td>4</td>
<td>Cu/Be alloy</td>
<td>0.004</td>
</tr>
<tr>
<td>5</td>
<td>Barium getter</td>
<td>0.003</td>
</tr>
<tr>
<td>6</td>
<td>Shadow Mask</td>
<td>0.538</td>
</tr>
<tr>
<td>7</td>
<td>Front Glass</td>
<td>4.01</td>
</tr>
<tr>
<td>8</td>
<td>Funnel Glass</td>
<td>1.946</td>
</tr>
<tr>
<td>9</td>
<td>Phosphor</td>
<td>0.002</td>
</tr>
<tr>
<td>10</td>
<td>Holding Studs</td>
<td>0.008</td>
</tr>
</tbody>
</table>

CRT's of a color picture tube contains different lead composition of glass at different geometrics for e.g. The front glass contain 1-2% of lead, the funnel glass contain upto
30% of lead, frit glass that enables the joining of front & funnel glass contains up to 80% of lead, therefore it is clear that for effective efficient recycling of these glasses, they are to be effectively separated and segregated for close loop recycling to make another CRT (EPA Addressing Cathode Ray Tubes Recycling, 2002).

7.4 CRT dismantling pictorial flow diagram

Fig. 75. CRT Dismantling
7.5 Crt cutting equipment

CRT’s are taken into a special chamber designed exclusively for the CRT handling Fig 74:

Fig 76: CRT Dismantling Equipment and Inside view of CRT Dismantling Equipment

7.5.1 Design Development

In this chamber the entire CRT separation breaking and hazardous phosphor isolation take place as shown above in the monitor dismantling flow diagram, without direct contact by the operators, who work through glow compartments and the entire chamber maintained at partial negative pressure of 2-4mm water gauge, using a draft fan provided in cyclone separator which is followed by a bag house. CRT’s are conveyed through a set of rubber rollers generally recovered from dot matrix printers. Initially the CRT is lightly tapped at the end of electron gun end such that the fused glass tip is broken and there by the vacuum inside in CRT’s is released. Next the electron gun is also broken by light tapping with a metal object at the neck area. The CRT’s is cut by two different methods (E.S. Geskin, 2002) developed. 1. Hot wire cutting 2. Diamond saw, to separate the funnel glass from the front glass.

Fig 77: Hot wire Method of CRT Cutting

The separation takes place exactly at the frit area that joins the funnel with the front glass. The funnel glass is removed; the shadow mask is released from the funnel
glass and returned for recycling after removal of the barium getter. This is followed by suction of the phosphor coating with a separate vacuum device provided with filters. The operator working within gloves, maneuvers the vacuum pipe with a small brush in such a way that the loose dry phosphor powder coating is totally sucked. Now the panel glass is totally free from phosphor.

Fig 78: Removal of Phosphor powder

Fig 79: Vacuum device with filters kept below the chamber

After this the funnel glass and panel glass are separately crushed with simple tools and broken to pieces and dropped in the respective chutes in such a way that both are collected separately. The crushed glass at that point is called glass culets. Care is taken to ensure these glass culet are free from phosphor, metal objects, foreign matter etc., that can contaminate in the respective melting furnaces.
The glass cullets of front and funnel glass are separately handled, stored and transported to CRT manufacturing facility, who can recycle them for production of fresh CRT’s (Monochamp et al 2001). This is typical examples of “cradle to cradle” recycling approach.

The hazardous phosphor is temporarily stored in “hazardous waste room” and disposed off in the near by TSDF.

7.6 Cullet recycle and reuse process

During the course of the present study, for recycling of CRT glass two CRT glass manufactures within India have been identified.

1. Videocon Industries Ltd., Bharuch, Gujarat, who mainly uses these recycle glass culets of production of color pictures tubes for TV.

2. Samcore Glass Ltd., Kota, Rajastan, who recycle and re-manufacture into monitor CRT’s.
Fig. 81. The flow chart of process adopted at Videocon

SOURCE OF CULLET

IMPORTED  PLANT COLLECT  INDIGENOUS

STORED IN CULLET

SEGREGATING

FOREIGN MATERIAL (UNWANTED)

(WASHING TO REMOVE MATERIALS (B.M., ALUMINA & GRAPHITE))

PANEL

WASHING TO REMOVE MATERIALS (ORGANIC, METAL, CERAMICS, STUDS, ETC) FUNNEL

SENT TO SCRAP YARD COATING

FUNNEL MATERIAL

IWT PLANT FURNICE (PRODUCTION)

REJECTION

WASTE

SEND TO REJECTION

SOLID WASTE USED TO MAKE BRICKS
Up to 30% of recycled glass cullets are used along with the virgin glass materials, which results in huge cost saving in terms of raw materials, power, water and at the same time reduced environmental burden.

Alternative uses of glass cullets are to manufacture glass beads used in shot peening, as a substitute in cement concrete aggregates and also by the Ferozabad based informal glass industries who manufacture various glass artifacts such as glass bangles, chandeliers etc., predominately using backyard practices and child labor. During the course of the present studies and the experience gained by recycling about 108 tons of CRT glass cullets has set an example and model for close loop recycling of CRT glass.

The glass based CRT industries already stand still in developed countries like Europe, USA & Japan with the introduction of LCD, LED’s and plasma displays. However the developing countries like India the glass based CRT market is expected to continue for another 10 years at least due to the market driven demand. Separation of lead from leaded glass is only is carried out in academic research involving high temperature molten glass electrolysis which is therefore a complicated process.

7.7 End of life tube lights and compact fluorescent lamp (cfl) recycling

The present study also covers recycling of Lighting Devices and has come out with a solution for the end of life disposal of lamps.

A simple, low cost lamp crushing setup which is developed to recycle all types of lighting device in a safe and environmental friendly manner.
7.7.1. Process Flow Chart

Lighting Devices like tube lights, CFL etc

Lamp Crushing Setup

Crushed glass and other materials to Tumbling

Segregation of Crushed glass, metals and other

Water with Mercury and phosphor

Extraction of mercury and phosphor which goes to secure

Cleaned crushed glass cullets

Further recycling to manufacture new product

Metals and other materials for further recycling

Fig 82: Flow Chart for fused tube light recycling

Fig 83: Tube light crushing setup
The process includes:

- Crushing of lamps
- Cleaning of glass cullets along with other materials in tumbling machine
- Segregation of glass cullets, metals and other materials
- Extraction of hazardous materials like mercury and phosphor which go for secure landfill to TSDF, and
- Collected cleaned glass cullets go to further recycling.

![Tumble cleaning Machine for crushed Tube light](image)

**Fig 84:** Tumble cleaning Machine for crushed Tube light

The final product from the process is the raw material glass which goes directly to further recycling process. This is how a product becomes a raw material. In the tumbling machine, alum is added in order to allow the phosphor powder to settle down at the bottom of the machine along with the fine pieces of glass and can be collected by siphoning the water. The wet phosphor powder is then dried in a series of natural Solar drying pits and finally dried phosphor powder goes to TSDF for secure landfill. Water from the tumbling machine is re-used and recycled using a series of filters, then the finally water is sent through an absorption column with ion exchange resins in which mercury is absorbed. The resins are of regeneration type, which can be regenerated using acids.

The two methods of isolating mercury are by Dry distillation method and chemical immobilization into a natural occurring form.