RECYCLING THE LIQUID CRYSTAL DISPLAYS

Mihai BUZATU[1], Netty Brânduşa MILEA[2]

Începând cu ianuarie 2007, data integrării în Uniunea Europeană, românii vor descoperi că noul lor statut european le aduce, pe lângă drepturi, şi unele obligaţii. Între acestea se înscrie şi alinierea la standardele europene în domeniul protecţiei mediului ambiant, desprinse din directiva europeană 96/2002 privind deşeurile de echipamene electrice şi electronice.

Lucrarea prezintă rezultatele unor cercetări privind elaborarea unei tehnologii ecologice de recuperare a metalelor, plasticelor şi cristalelor lichide ce intră în componenţa afişajelor cu cristale lichide (LCD – Liquid Crystal Display).

Starting from January 2007, the expected date for the Romanian to become part of the European Union, the Romanian will find out their new European position will bring along not only rights, but also commitments among which reaching the European standards of the environment protection of the European Directive 96/2002 on the refuses of the electric and electronic devices.

The paper shows the result of a research to evolve a technology to recover metall, plastic and liquid crystal from the LCD panels (LCD – Liquid Crystal Display).

Keywords: reuse, recycle

1. Introduction

In the century of the consumption society and globalization, the Directive of the European Commission identifies among the priority objectives of its politics, the preservation, protection and improvement of the environment quality, the protection of the human health and careful and rational use of the natural resources [1].

The refuses of the electrical and electronic devices (DEEE) raise a range of issues for the environment because of the continuous growing volume and toxicity of some of sunstances they include (Pb, Mn, Zn, Sn, Co) and which are not properly treated. The most used administration methodes for DEEE are recycling and incineration but each of them raise specific issues both because of some components (such as the above – mentioned ones) and because of the fact

[1] Prof., Dr., Eng., Faculty of Applied Chemistry and Material Science, University POLITEHNICA of Bucharest, Romania, e-mail: mbuzaturo@yahoo.com
[2] PhD., Eng., Faculty of Applied Chemistry and Material Science, University POLITEHNICA of Bucharest, Romania, e-mail: nettybrandusa@yahoo.com

the burning process is delayed by some fire – retardant substances they are treated with.

This process has been used and less during the last years because of the big quantities of damages and the high costs generated by the burning process. This is why the recycling by the tehnologies of physical work is more used as the results of the laboratory researches are more easily transferable in industrial phase.

The implementation of Directive 2002/96/EC provides as main objective till the end of 2007 for Romania to recover minimum 3 kg of DEEE/inhabitant which involves setting up a pilot centre of devices to recycle all these refuses.

Based on the guvernment Decision 448/2005 on the refuses of the electric and electronic devices, on a national level there have started actions to collect DEEE in every country. A weak point of the DEEE management is the fact that at the moment, in Romania, there are not companies to cure glass, plastic and indifferent materials resulted from disjointing electric and electronic refuses. In Romania, in 2002, 185 530 of PC units were commercialised and in 2003 the sales reached 240 643 pieces. This is a reason the recycling of IT parts is becoming an important issue [2].

2. LCD recycling and disassembling

From the range of options to cure liquid crystal displays at the end of their life, which are: reuse, remanufacture, recycling, burning in order to get energy, storage, the most desirable with healthy effects on the environment is recycling by recovering [1].

There are more stages to disassemble LCD panels of the monitors, see (Fig.1):

1. Disassemble the carcass;
2. Demount the props;
3. Extract the wires that supply the leds and the control buttons;
4. Extract the LCD panel;
5. Take out the bed plate;
6. Disassemble the LCD panel;
7. Remove the fluorescent tube;
8. Remove the frame;
9. Take out the LCD panel;
10. Notch off the basic circuit to supply the LCD;
11. Extract the mercury lamps;
12. Extract the plexiglas plate and the translucent foils.

With reference to the mass distribution of the parts of a LCD monitor, type LG Flatron L17159 , it is as in the table 1.

Table 1

Mass distribution of a LCD monitor, type LG

Ord. no.	Parts	Quantity (g)	Quantity (%)
1	Plastic parts of type PC-ABS FR40	767	17,52
2	Sheet metal	1844	42,11
3	Screws	18	0,41
4	LCD screen	377	8,61
5	Mercury lamps 4 pcs	6,4	0,15
6	Lamp stands	23,6	0,54
7	Plates with integrated circuits	304	6,94
8	Wires	35	0,80
9	Rubber	4	0,09
10	Plexiglas screen	923	21,08
11	Semi – transparent foils	58	1,32
12	White light – tight foil	19	0,43
13	Total	4379	100

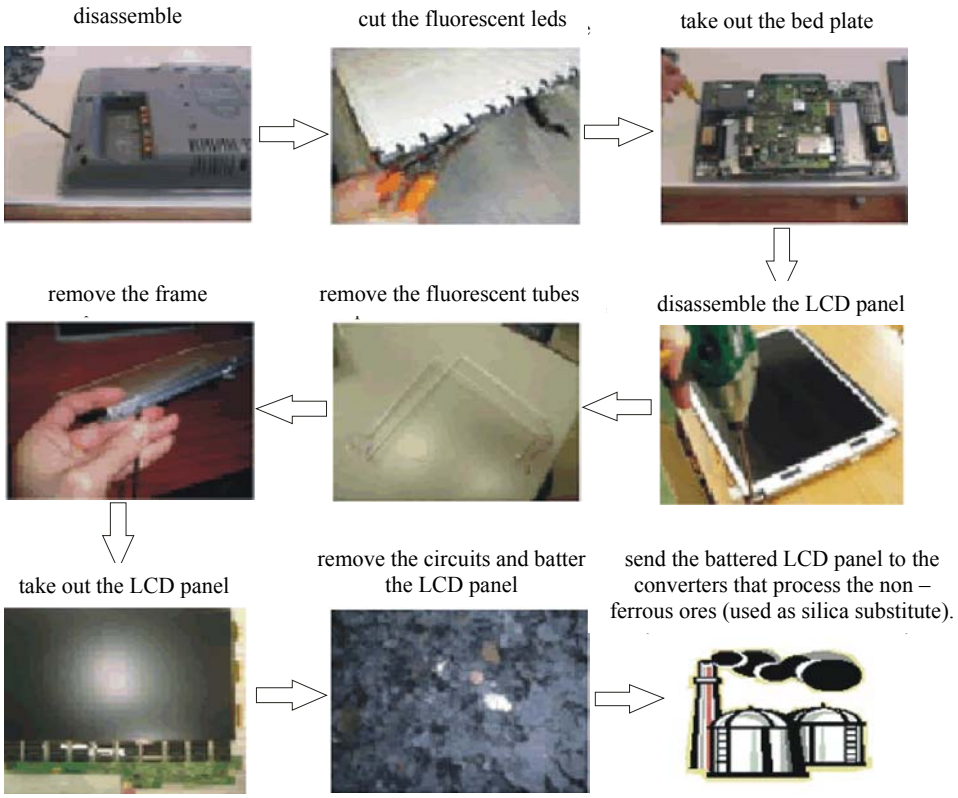


Fig. 1. LCD panels disassembling

The graphic drawing of the percentage of the parts in the LCD monitor, type LG can be seen in fig. 2.

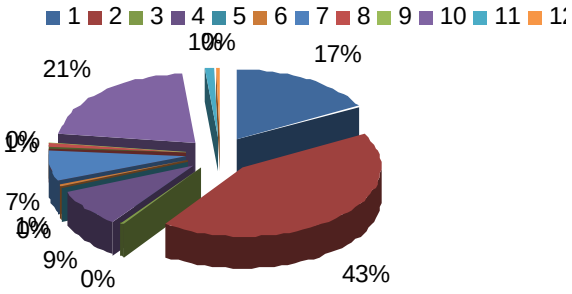


Fig. 2 Percentage mass distribution of a LCD monitor, type LG

1) Plastic parts of type PC-ABS FR40; 2) Sheet metal; 3) Screws; 4) LCD screen; 5) Mercury lamps 4 pcs; 6) Lamp stands; 7) Plates with integrated circuits; 8) Wires; 9) Rubber; 10) Plexiglas screen; 11) Semi – transparent foils; 12) White light – tight foil.

Table 2

Mass distribution of a LCD monitor, type Lite-ON

Ord. no.	Parts	Quantity (g)	Quantity (%)
1	Plastic parts of type PC-ABS FR40	1289	29,08
2	Sheet metal	2054	46,34
3	Screws	19	0,43
4	LCD screen	312	7,04
5	Mercury lamps 4 pcs	6,4	0,14
6	Lamp stands	32,6	0,74
7	Plates with integrated circuits	300	6,77
8	Wires	8	0,18
9	Rubber	4	0,09
10	Plexiglas screen	368	8,30
11	Semi – transparent foils	27	0,61
12	White light – tight foil	12	0,27
13	Total	4432	100,00

3. Results and discussion

In our work to apply the recovery procedure we have carried out the following steps after disassembling, the LCD panel was got to pieces with a diamond disc and then ground for 6 minute/batch (50 g) with the help of the mill discs of type Retsch as presented in figure 3.

Fig.3 Mill with discs of type Retsh

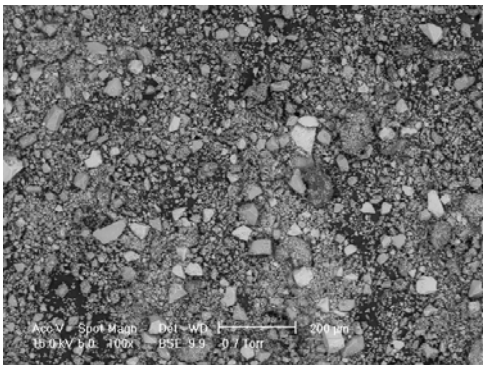
The granulometric analyses was performed on ground powder in water with a content of 0,03 mg/ml withthe help of the granulometric analyser with laser of type Ankersmid. The results of the granulometric analises lead to the following observations:

- The maximum dimension of the granule after grounding is 9 microns;
- The particles have dimensions between 3 and 9 microns;
- The category with the most important granulometric degree is the one between 7 and 8 microns;
- The specific area is 2,8e-006cm^2/ml;
- The average diameter is 5,89 microns.

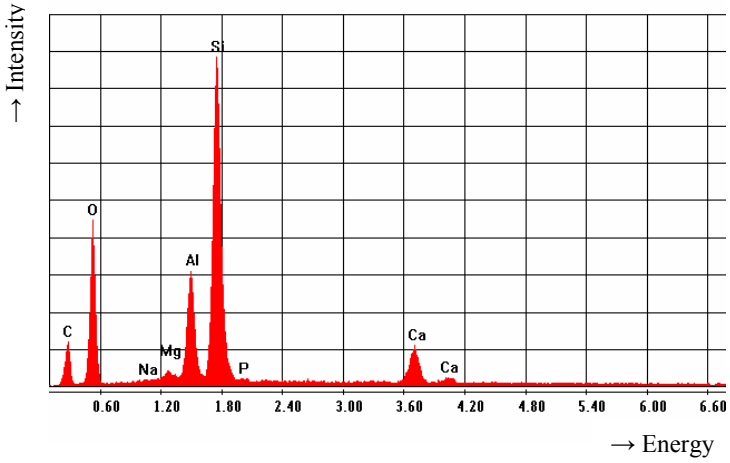
The microstructural analysis of the ground LCD was performed by means of a SEM electron microscope type compled to an EDAX equipment. The results of the analysis are shown in Fig.4.

Element	Wt %
C	26.55
O	35.22
Na	0.35
Mg	0.83
Al	6.88
Si	24.33
P	0.43
Ca	5.42
Total	100

b) Chemical percentage composition of the



a) SEM electron micrograph of the ground LCD screen



c) EDAX spectrum

Fig. 4 Structure and chemical composition of the ground LCD screen

According to the speciality literature on the toxicity of the LCD panels, the main parts contain organic substances which are not dangerous to the environment.

Thus :

- the polarizing contains triacetate of cellulose, polycarbonate, iodine and dyes that are not dangerous;

- ITO layer (oxide of indium -tin) is present in very small quantities (approx. 0,07 mg/cm^2) – it is not dangerous;

- ITO glass (oxide of indium-tin) has a thickness approximate 0,7 mm/layer – it is not dengerous;

- colour filters contain small quantities of dyes – they are not dangerous;

- the binders contain epoxy, polymers in small quantities;

- spacers (in glass or plastic) in very small quantities (approx.0,5 μg/cm^2)

- LC layer: (approx.0,6 mg/cm^2) which in general are not toxic for human and aquatic bodies. There are only a few dangerous substances used in very small quantities. .

The Environment Agency in Germany states that "Based on the results regarding the eco – toxicology of the liquid crystals, there is not need for special conditions to store LCDs due to the content of liquid crystals"[3].

According to the results establishing the elements with impact upon the environment, the only ane with a content which is above the admitted value in case the lamp is removed and with a breaking risk in case the LCDs are stored in fields is **mercury** [4].

The hidro – metallurgic methods get the mercury resoluble and then they recover it as solid product. The humid chemical techniques to treat/neutralize mercury must meet the following criteria:

- to ensure an advanced recovery of mercury through mercury resolubleness/isolation;
- to get a product that can be sold by reintroducing mercury on the production process;
- the effluents from the applied process should not contain dangerous substances for the environment or they should be purged till they reach the level they are not a danger for the environment any more [4].

Once the circuits are removed and the LCD panels are battered, they are sent to the plants that process the non – ferrous ore of copper and zinc.

The detailed tehnological process to recycle LCD panels in a plants that refines copper and zinc from Japan is shown in Fig.5..

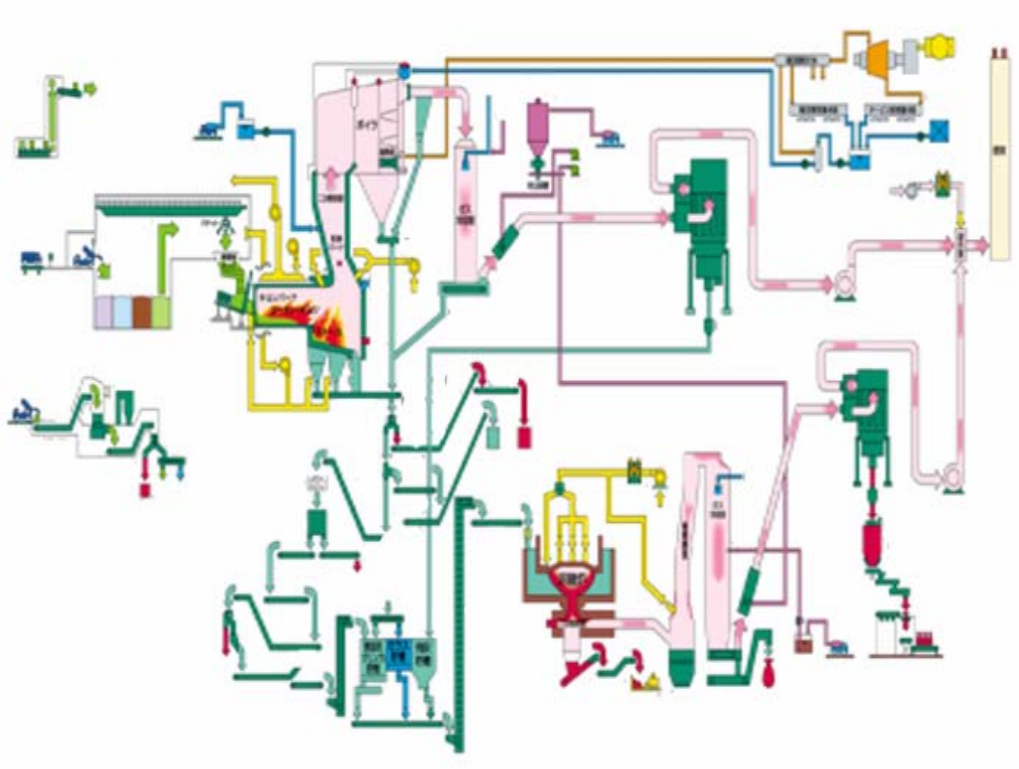


Fig. 5**.** Detailed scheme to recycle LCD panels in the plants that process non – ferous ores (Sharp Corporation – Japonia)

A different way to recycle LCD panels is to manufacture decorative bricks and plates.

By this process, the LCD panels are recovered from computers, TV screens, measure devices, watches, etc and they battered, mixed with feldspar in order to get a thick and dry dough cast according to one's desire. After being cast and baked at high temperatures, they get decorative surfaces.

The succession of the operations to recycle LCD panels in order to get decorative plates is presented in Fig. 6.

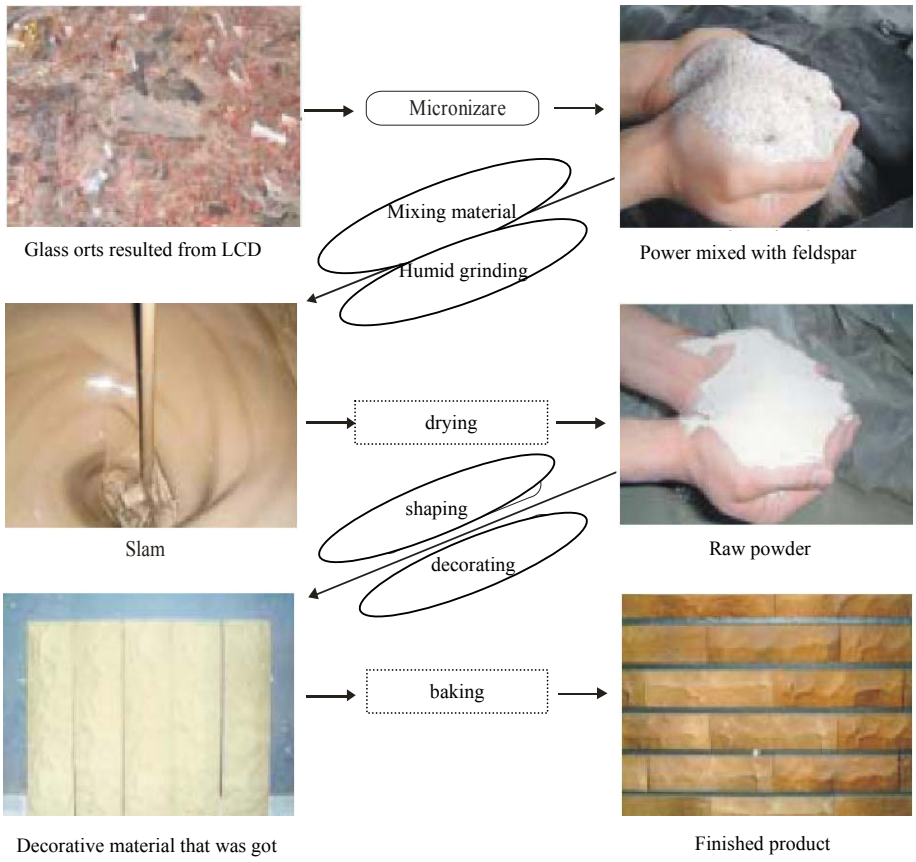


Fig. 6**.** Making decorative ceramics from LCD panels

The LCD panels are recycled in parallel with the recycle of the plastic carcasses. They follow the battering, pelletizing and reshaping stages of the carcass.

If under natural conditions the plastic carcasses resulted from the computers being dissembled would degrade in approximately 20 year, at the present, there is the possibility to recycle them by battering, separating the colour, dye membrane etc, pelletizing the powders that result, curing them with specific binders and finally to reshape (manufacture) other carcasses.

4. Conclusions

The disassembling process includes the separation and disjointing the parts of a DEEE in order to use or put its parts to special treatments.

The conditions under which this process is put into practice result on the one hand into the guarantee the polluting component are extracted and/or they possible reuse of certain parts.

The glass screens of the LCD monitor and laptops as well as the glass TV screen with LCD contain inconsequent quantities of elements subject to the regulations below the maximum limits for all criteria.

In interior TV screens with plasma are much above the limit values for lead.

REFERENCES

[1] *INCDMRR*, The deacidification dangerous substances contained in LCD panel, proceed from DEEE, Bucharest, may 2007

[2] *INCDMRR*, Study concerning recycling equipments IT, Bucharest, 2006

[3] (http:/www.umweltbundesamt.de/uba-info-daten-e/daten-e/lcd.htm)

[4] *D.F. Foust*, Hidrometalurgical Removal of Mercury from Contaminated Soil, 2 Selection of Extracting Agent, 92CRD216 (October 1992)