2011 International Conference on Environment and Industrial Innovation
IPCBEE vol.12 (2011) © (2011) IACSIT Press, Singapore

A Study on Recycling of CRT Glass Waste

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Abstract. The recycling steps of cathode ray tube (CRT) glass waste dismantled from a television(TV) set are composed by collection, separation of panel and funnel, crushing, and washing. CRT glass waste recycling is not well practiced because the transferring TV transmission to high definition (HD) from December 2012 and the shutting down of domestic CRT manufacturers in Korea. In this study, to promote recycling of CRT glass waste which is expected to the increment of generation after such shift of TV transmission method, selected recycling technologies were examined. In addition, draft road map of CRT glass recycling waste was revised and presented with defining the role of producers, recycling centers and government. In CRT glass waste, technologies of panel examined are cement brick, clay brick, and glass wool, and those for funnel are glazing and lead-smelting. As results of cement brick and clay brick in lab-scale tests, the entire samples satisfied the Korean Standard. To apply CRT glass waste recycling at existing technology it was suggested that facilities need to separate panel and funnel glasses exactly and to classify fine sizes after crushing glasses. Roadmap to future recycling strategy was suggested explaining the role of stakeholder to promote CRT glass waste recycling. Producer needs to establish market infrastructure with supply networking of CRT glass waste and to make monitoring system for environmental problem and the government needs to support R&D and reformation of the recycling system.

Keywords: CRT (cathode-ray tube) waste glass, Recycling, Panel, Funnel

1. Introduction

In Korea, the existing analog broadcasting system for television(TV) is planned to stop and by the end of 2012 is planned to convert digital broadcasting system according to "The digital conversion of terrestrial television broadcasting and the special law for promoting digital broadcasting" (2009.4.22). In future if the unchanged households about 400 million (17 million total households in Korea, 44.9%) replace to the digital TV, it is predicted about over 670 million of analog TV to banned in following years. Now the wasted TV release is 120 million/yr which is predicted to increase 150 million/yr in future.

The waste generation from the appliances including CRT from television and computer is rapidly increasing globally. New products with new design and cheap product price in computer monitor, TV, LCD, plasma, etc are increasing. If the digital TV is introduced, the current CRT technique will be not used. For the broadcasting and technical change, new CRT demand is sharply decreased in case of the television and computer. Conventional recycling was mainly depending on use of waste glass to produce a new CRT as raw materials. However such need to recycling will be disappeared and remained waste CRT needs to be treated by alternative technologies. In Korea, the wasted CRT glass was 1500 ton/month in 2009. There is no technique to be commercialized for immediate recycling to the current wasted CRT glass. The main obstacle of wasted CRT recycling is lack of the recycling technique and the demand decreasing about wasted CRT glass of included the lead and other heavy metals.

Commercialization technique able to recycle wasted CRT glass into other products is not globally reported. The wasted CRT glass from Korea is exported to Malaysia for recycling. In future, it is predicted

that the export cost per unit will decreases due to loosing export competition. In this study, the application technology which compare recycling CRT glass waste with waste glass were selected and favorable condition for promoting recycling CRT glass waste. Also, role of producers, recycle-center and the government were suggested with road-map of strategy for recycling CRT glass waste.

2. Material and Methodology

2.1. Methodology

Recycling technique to apply the CRT glass waste was preliminary selected to promote recycling plan of CRT glass waste. For this literature related to existing wasted glass recycling technique were reviewed from articles, newspaper and internet etc. Applicable technique finally selected based on property of matter, site visiting, consultation, self-review and evaluation of CRT glass waste. Roadmap for necessarily political, technical, social alternative for CRT waste promotion was suggested.

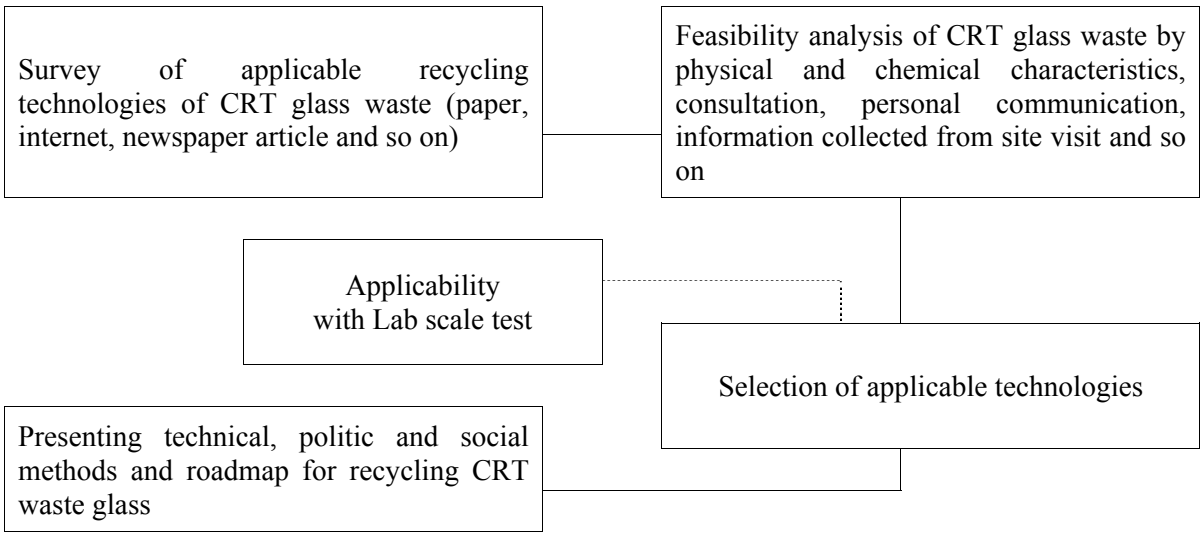

Fig. 1 : Brief overview of studying on recycling CRT glass waste

2.2. Characteristic of CRT glass waste

Generally, the glass raw materials can be separated into main raw material and the supplement raw material. Main raw material consists of silica, alumina, lime, magnesia, boric acid, etc., which are main component of the glass. And the supplement raw materials: used flux, clarifying agent, oxidizing agent, reducing agent, emulsifying concentrate, coloring agent, decolorant, etc. are in small quantity, which are added to give special character to glass.

To compare the properties of CRT glass waste and other wasted glass, CRT glass waste separates the panel and the funnel, then differentiates below 200 ㎛ XRF (X-Ray Fluorescence) analysis was performed. The panel of the CRT glass waste was low melting catalyst components like to K_2O, Na_2O unlike to the bottle glass, plate glass. And it contained about 10% BaO component (for basic refraction of the optical glass). Funnel has some features that were excellent for index of refraction, dispersability and cutting because it 20% PbO. But, it is essential to be separated from panel since it has risk of leaching during recycling.

2.3. Selection of technology for CRT glass waste recycling

Waste glass can be recycled using existing technologies that clay bricks, light forming ceramic, glazing, cement bricks, glass wool, glass beads, road filler, CRT tube, container glass, sheet glass, lead smelting etc. The recycling technologies that of tile, artificial marble, glass beads CRT tube depend heavily on imports. In order to recycling CRT glass waste export because of assumption is established so hardly apply to waste CRT glass. If CRT glass waste was used as secondary raw materials for sheet glass, container glass,

properties changes of produced glass will decline value of new glass. In case of road filler, difficult to apply because of CRT glass waste recycling law does not exist.

2.4. Applicability evaluation of wasted CRT glass as cement brick and clay brick

CRT glass waste was evaluated by making cement blocks and clay bricks but using only panel because funnel of CRT glass has the potential of generating lead lechate. Clay bricks making method was raw materials mixing, compression, molding, drying and firing. Used clay and CRT glass particle size is under 200 ㎛. For preventing clay bricks crack, drying temperature was about 100℃ for at least 15 days, firing temperature is about 1,000℃ for at least 24 hours. Cement bricks making method was raw materials mixing, compression, molding, drying, curing. For stone powder and sand replaced CRT glass, used CRT glass particle size was 1-4mm, drying and curing temperature was about 20℃ during 15 days.

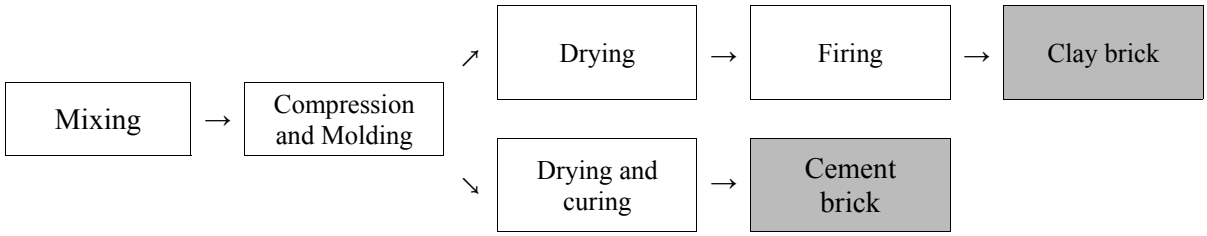

Fig. 2 : Manufacturing process of cement and clay brick

Table 1 shows mixing ratio when producing cement bricks and clay bricks, based on conventional using materials replacing panel 0% to 30 %. The quality of specimens were evaluated using Korean standard method of clay bricks KS F 4419, cement bricks KS L 4201.

Table 1 : Major conditions for recycling CRT glass waste using each technology Unit : %

	Clay brick	Cement brick		
Panel	Clay	Sand	Stone powder	Cement
0	100	30	50	20
10	90	25	45	20
20	80	20	40	20
30	70	15	35	20

3. Results and Discussion

3.1. Investigation of recycling technology to apply CRT glass waste

For the primary selected technique, CRT glass waste of essential factor to recycle is suggested in Table 2. When apply CRT glass waste, most important factor was grain size classification. Cement brick, glass wool, lead smelting are size of some centimeter and clay brick was size some millimeter. Glaze was controlled to some micrometer, so was applicable to the CRT glass waste of the existing process. The CRT glass waste was released to separate panel and funnel from the recycling center.

So to efficiently apply in each recycling technique, the glaze and lead smelting to utilize PbO in glass are the candidates for the funnel, and the cement brick, clay brick, glass wool techniques are for the purpose to replace supply raw material of the existing raw material for the panel. The CRT glass waste useful rate to contrast the existing raw material of each recycling technique proposed on Table 2 is to make on the basis of the verified data to self-text of each recycling company.

For applying the new raw material like as the wasted CRT glass to each technique, commonly the separate supply and controlling of the grain size classification is needed, so a new equipment of crushing and classifying grain sizes is also introduced. First of all, the recycling center needs the exactly separating the panel and funnel part to supply the wasted CRT glass of having constant property of matter. And it is

required the specific facilities for smashing and separate of grain size classification to supply glass of the grain size classification each wanted technique. Besides it is selected that the exclusive storage equipment, mixture equipment following the new raw material supply will need additionally.

Table 2 : Major conditions for using CRT glass waste of each technology

	Cement brick	Clay brick	Glass wool	Glaze	Lead smelter
Panel/Funnel	Panel	Panel	Panel	Funnel	Funnel
Desired size	Several cm	Several mm	Several cm	Several μm	Several cm
Expected rate of substitution	About 10%	About 5%	About 10%	About 20%	About 20%

3.2. Applications of cement brick and clay brick

Cement bricks satisfied with bending strength standard under 5MPa, rate of absorption standard under 7% regardless of panel mixing ratio. As panel mixing ratio increases, curved strength tends to decrease slightly. But absorption rate do not show any definite tendency. Also, that are not find to crack at the appearance and all samples satisfies with size and permissible range of KS F 4419. Clay brick quality evaluation is taken according to KS L 4201. As panel mixed ratio to increase, color of sample tends to get darker that are considered tinted compound like to Fe2O3 in the panel. Meanwhile, compressive strength and rate of absorption rate satisfies with standard at all condition. In case of mixed panel, 30% quality decreases compared to control group.

3.3. Strategy roadmap to promote CRT glass waste facilitate recycling

In order to effectively recycle waste CRT glass the roadmap is presented in Fig. 3. Considering the waste CRT glass generation until 2020, we suggested the short, middle and long term roadmap. For commercializing the system of waste CRT recycling, research and developments by affiliated organizations such as recycling center, recycling companies, academic, etc. are required. CRT glass waste that is not recyclable to be stored or exported during R&D period. At the same time, the producer has to make infrastructure considering CRT glass waste recycling amount, makes a network supply with monitoring system for environmental problem. And the government needs to support R&D, reformation of the system etc. In the middle term, if R&D were in success, CRT glass waste would be applied to recycle using developed technology, while new better technologies are to be developed at the same time. If R&D failed, the government needs to promote the simple treatment methods like as landfill or road filler. In the long period CRT glass waste recycling ends because of decreasing domestic generation rate.

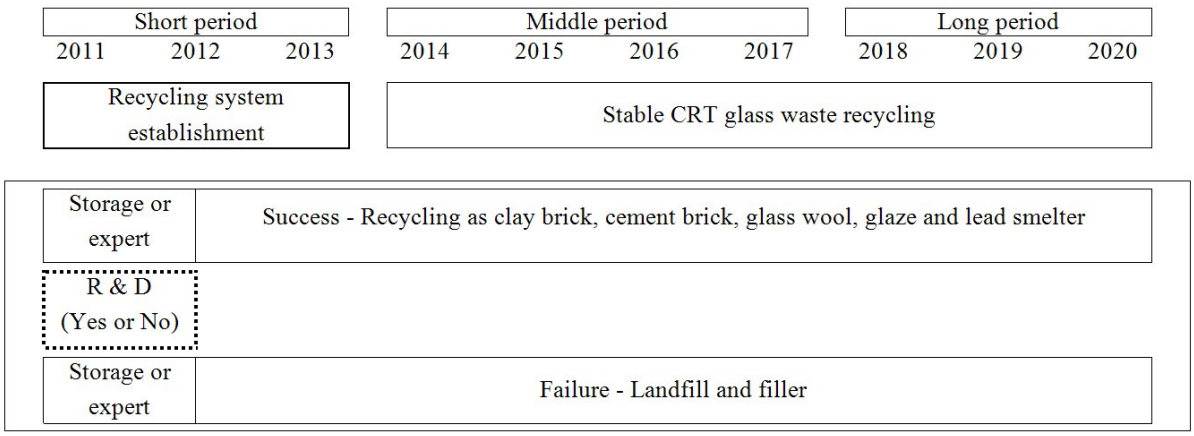

Fig. 3 Road map for recycling CRT glass waste

4. Conclusion

1) The panel of CRT glass waste consists low melting catalyst component like to K2O, Na2O unlike to the bottle glass, plate glass. And it contained about 10% BaO component to make basic refraction of the optical glass high. The funnel has some features that provides excellent for index of refraction, dispersability and cutting because it contains 20% PbO in composition.

2) In waste CRT glasses, candidate application technologies of panel are cement brick, clay brick, glass wool. Also, application technologies of funnel are glazing and lead-smelting.

3) In results of cement brick and clay brick lab-scale test, the entire sample satisfied with KS standard. In the case of clay bricks that are shown disadvantage of color change and appearance crack. In order to evaluate exact technical applicability of recycling technology, it needs to test at commercial facilities and development of technology.

4) In order to apply CRT glass waste recycling at the existing technology, panel and funnel are needed to separate clearly. Also, mixing ratios of CRT glass waste are different at each recycling technology.

5) We suggest draft short- and long-term roadmap to CRT glass waste recycling. In order to commercialize system for waste CRT recycling development, we need research and development at related organizations; recycling center, recycling companies, academic institutes. During the R&D period, storage or export is to be considered. Producer has to establish market infrastructure, supply networking of CRT glass waste and to make monitoring system for environmental problem. Also, the government needs to support R&D, reformation the system.

5. Acknowledgements

This paper is financially supported by Association of Electronics Environment 「CRT glass waste recycling research services」 and Korea Ministry of Environment as 「Human resource development Project for Energy from Waste & Recycling」.

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