Processing of Glass Containers Using Fusing Technology

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November 25, 2020

Section 2. Climate change and sustainable management of natural resources

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Abstract

Recently, the issue of rational use of natural resources and increasing production waste has become increasingly important. Depending on the added metal, glasses with different softening (melting) temperatures are obtained. The purpose of this study is to reduce glass debris and process glass containers using fusing technology. Fusing is a technique of sintering glass in a furnace, the glass is sintered at a temperature of up to 800 degrees Celsius, at this temperature, the glass becomes homogeneous, fusing with each other. In total, glass container collection sites were investigated for collection and subsequent disposal during the six-month period from January to June 2020 on a quarterly basis. 3 glass container collection points were investigated. In total, during the study, 1075 thousand items of glass containers were collected with a total average of 506.2 ± 409.8 PCs. The most common was bottled glass from under alcoholic and beer products (923 thousand units), which amounted to 57.23% with an average of 289.7±242.2 units. In the production of glass, the so-called C. O. E (Coefficient of Expansion) index of glass is usually used, which serves as a determining factor in determining its compatibility for fusing. Accordingly, the use of alternative measures, accompanied by awareness-raising activities and investments in the collection and processing of glass containers, will further improve and preserve the cleanliness of the environment.

Keywords: processing, glass containers, fusing, environment, natural resources

Introduction

Garbage is one of the categories of human waste.Recycling collection and material separation are critical components of solid waste minimization and aid in conserving natural resources, maintaining healthier environments, and reducing greenhouse gas emissions (USEPA (2008), Fishbein B (1994)). Of all the glass which comes into the market as packaging material, about 75% is returnable and 25% non-returnable (W.L.Dalmijn, 1986). Multiple plastic compositions containing polyethylene, polystyrene, PVC, ABS, Nylon, polypropylene, with various particle morphologies and a narrow range of sizes and size distributions were mixed with similar size brown glass into “glastic” composites having glass compositions of 15, 30, and 45 wt%. These prototypes were molded in a form similar to standard clay bricks at 235°C and were compression tested to more than double the fracture stress of clay bricks at temperatures ranging from 20 to 50°C. These prototypes illustrate the prospects for utilizing waste plastics and glass in simple commercial materials applications and the relief of land fill problems which are now world-wide (V.S. Rebeiz, D.W. Fowler, and D.C. Paul, 1993). The greatest answer to master the environmental effect of glass wastes is to reuse them. Recycling of these wastes principally from glass bottles and flat glasses will benefit in safeguarding the earth's natural resources, diminishing landfill places, and saving energy and money (A. Bartl, 2014, C.R.C. Mohanty, 2011, M.R. Johnson, I.P. McCarthy. 2014, E. Vieitez Rodiguez, P. Eder, A. Villanueva, H. Saveyn, 2011). The manufacturing of glass foams is essentially a way for glass recycling (P. Colombo, G. Brusatin, E. Bernardo, G. Scarinci, (2003). E. Bernardo, G. Scarinci, S. Hreglich, (2005)). Glass containers belong to the category of garbage and their impact on the quality of the environment is confirmed by a growing amount of research on this issue. Therefore, it is a complex problem, especially in urban localities.. Although recommended for limiting the consumption of energy and natural raw materials, the usage of scrap glass in manufacturing new glass articles is possible only after an expensive sorting step, aimed at the separation of glass from other materials, like metallic or ceramic contaminants. This separation leads to a fraction of almost pure glass, ready for the industry, and a fraction enriched in contaminants, which remains practically unemployed, and is mostly landfilled (E. Bernardo, R. Cedro, M. Florean, S. Hreglich, (2007)). Under hydrothermal conditions of 30–40 MPa and 200–300°C with H2O, glass powders can be sintered to form solidified glass materials containing about 10 mass%

H_2O. When the glass containing H_2O is heated again under normal pressure, the glass expands, releasing H_2O to form a porous microstructure. This glass can be used in filters to remove impurities from polluted air and water, or in insulators to control heat transfer. In this chapter, we describe trials of our eco-friendly recycling process (Tanaka T, Maeda S, Takahira N (2006), Jing Z, Ishida EH, Jin F, Hashida T, Yamasaki N (2006)). One of the alternative solutions for glass container recycling is the use of new technologies. The demand for fusing is based not only on the magnificent decorative effects that the technique allows you to achieve. The practicality of sintered glass products is a very attractive quality. The influence of moisture, temperature changes, and aggressive environment does not affect the fusing-stained glass.

In addition, glass processed in fusing technology can take almost any shape: from a small perfectly round bead to fancy glass colors, from a flat sheet to rounded surfaces.

There are some processes that are used to modify glass for specific purposes, such as applying thin-film coatings to control solar radiation and quenching and laminating for safety glass. Optical fibers must meet strict quality requirements. You need to understand these requirements to know why complex processing methods are needed (Bach H, Neuroth N (1995), Bach H, Krause D (eds) (1997) , Bach H, Krause D (eds) (1999), Bach H, Krause D (eds) (1999), Bach H, Baudke FGK, Krause D (2000))

The word “processing” refers to the various ways of recycling and reuse of products from waste and ending with recycling and reuse of various types of products and packaging materials. All these forms of recycling have the same goal-to create conditions and opportunities for the survival of society (Besson J, Abouaf M (1991), Kim KT, Jeon YC (1998), Kim KT, Yang HC (2001))

More than half of the global ceramics market is made up of glass products, which is more than $ 50 billion a year (Van Nguyen C, Bezold A, Broeckmann C (2015), Van Nguyen C, Bezold A, Broeckmann C (2014) ElRakayby H, Kim K (2016)).

Secondary use of glass is accompanied by the following benefits:

- Reducing greenhouse gas emissions, i.e. CO_2. For example, in the production of glass containers, the amount of greenhouse gas emissions in the atmosphere is reduced by 5% if 10% of glass chips are used as raw materials.
- Reduce power consumption. The production of 1 ton of glass from sand, soda and other materials requires 3 times more energy than from used glass.
- 100%, i.e. an infinite number of times the material is recycled, and the quality of the glass does not deteriorate during processing.
- The most resource-saving packaging material, since glass production has a large amount of ready-to-use raw material and does not require fossilized fuel for cleaning the material.

Thus, the purpose of this study was to evaluate the categories of glass containers handed over by the population at reception points, as well as to suggest alternative technologies for recycling glass containers in order to reduce household waste and harm the environment and human health. When using glass as recyclable materials, the main problem is the different colors of the glass. When mixing white, green, and brown glass chips, you can't get clear glass. Although there are no restrictions in the production of green glass from mixed glass chips, green glass does not need to be produced in such quantities as to use all the mixed glass chips. Refractory additives, such as porcelain, also cause problems when processing glass. Collection of glass containers and glass waste and their reuse are widespread in Estonia. Traditionally, a reusable glass bottle is widely used in the bottling of alcoholic beverages (primarily beer). Since glass containers are produced in Estonia, there are very good opportunities for using waste from glass containers as recyclable materials. The capacity of glass container manufacturers to handle glass significantly exceeds the amount of glass chips produced in Estonia. Also, the distance for transporting glass chips to the factory is not so great. Since the possibility of reuse of glass containers and their waste and the share of reusable containers from the total mass of containers in Estonia is quite high, it would be necessary to promote the use of this type of packaging and develop this area.

Production of glass wool begins with the delivery and processing of raw materials. The crushed glass particles of bottles and flat glass used as raw materials are processed at the appropriate suppliers in the collection and cleaning centers. The glass chips that come out of these manufacturing plants may come from car windshields, glass waste that occurs when disassembling greenhouses, or from wine bottles.

Isover glass wool manufacturer Saint-Gobain Finland Oy is the largest secondary consumer of glass in Finland. Of the raw materials used for the manufacture of glass wool, recycled glass is 60-80%. Glass wool production is an important part of the glass waste circulation system in Finland. The use of recycled glass significantly reduces the impact of glass wool on the environment. The use of recycled glass in the production of glass wool saves the raw materials used to make glass (sand, soda and limestone), helps to reduce energy consumption in the production process, and to some extent also reduces air pollution that occurs when the raw material is melted.

Methods

When developing the General methodological framework, the guidelines for collecting glass containers were used, according to TR CU 005/2011 Technical regulation of the Customs Union "on packaging safety" (№261845-5). Sampling was carried out by the same group throughout the study to ensure the objectivity of the sample.

In total, for the six-month period from January to June 2020, 3 glass container acceptance points were investigated. At each point, glass containers were collected quarterly 4 times in 3 months.

Glass fusing technology is extremely popular in modern decorative and design art. Like classic stained glass, the decor made with the help of fusing finds its application in window panes, double-glazed Windows, door structures, interior partitions, niches, in the design of winter gardens, showcases, pavilions, ceiling inserts and even shower cabins. Decorative panels and false Windows in this technique look great. Due to the plasticity of fused glass, fusing is simply irreplaceable in the decoration of exclusive furniture items, the production of original vases, creative glass sculptures, etc.

Composition and varieties of glass containers

Glass containers are glass packaging or containers that are used for storing and transporting industrial goods and food products. An important advantage is the chemical safety of glass containers and the possibility of their secondary use, including in everyday life. A serious disadvantage is the fragility of the glass. The main varieties are bottles and cans. At the same time, each manufacturer of food or industrial products, promoting its brand, tries to use its own type of glass containers. The collected glass containers were sorted by category.

Expenditure

At the collection points of glass containers, glass containers were received daily, mainly glass bottles at 5-10 tenge per piece, while in three points the number varied from 5 thousand to 7 thousand bottles. Then the bottles of good quality were selected and processed using fusing technology. At the same time, the cost of glass containers rose.

Glass index

Currently, the most popular glasses are "Moretti" with SOY 104, system 96 with SOY 96 (SPECTRUM, UROBOROS, etc.), a group of glasses with SOY 90 ("BULSEYE", "ARTISTA", etc.), and "Float" with SOY 82-84. Also, very important factors when choosing glasses are the invariance of color during fusing, and the resistance of glass to turbidity during heat treatment.

Results and Discussion

The total population of the city of Uralsk is 313,173 people, one person accounts for 178 kg of household waste, where the third part is occupied by glass containers. In Kazakhstan, today only 6 organizations are engaged in receiving glass containers and one organization is engaged in fusing technology, which is located in Almaty and geographically remote from our city.

Glass is one of the first materials to be separately assembled and reused. Glass is a unique material that can be used repeatedly to make new glass products without compromising their quality. Production of glass from crushed glass in comparison with production from primary raw materials (sand, soda and limestone) requires much lower energy costs. The glass recycling sector is growing at an average rate of 10% per year. International trade in glass chips is still not so highly developed, which is primarily due to the high cost of transporting this material compared to its value.

Three objects with different types and levels of human activity were selected. These sites have been selected in such a way as to represent with due attention to the site's accessibility, extent of impact, and use of activities.

The collection of glass containers in the Central market area of Uralsk

The Central market is the Central part of the city, where there is a large concentration of population and is the most profitable for collecting glass containers. It was estimated that 50% of the total number of glass containers was delivered at this point.

The collection of glass containers in the area of the Aigul market in Uralsk

Aigul market is located at the crossroads of Sholokhov street and S. Tulenin street. This market is specialized in the sale of auto parts. The location is convenient for residents of the city, but it is 10-12 km away from the Central part of the city. It was estimated that 30% of the total number of glass containers was delivered at this point.

The collection of glass containers in the area of the El Irisi market Uralsk

The market El Irisi located on the street of Syrym Datov, is the food market. All wholesalers of natural markets of the city moved the market El Irisi. This market is located 15 km from the Central part of the city. It was estimated that 20% of the total number of glass containers was delivered at this point.

The number of glass containers by category in the study areas is shown in table 1. bottles of alcoholic beverages (57.23%), soft drinks (21.5%) and milk, fermented milk drinks (8.5%) were, respectively, the most common category. Sauce products (5.5%) were the fourth most common glass container, followed by baby food (3.9%) and cosmetics (3.1%).

Table 1. Collection of glass containers by category for 6 months

№	Categories of glass containers, pieces						
	Alcoholic beverages	Soft drink	Milk and lactic acid milk drinks	Sauce products	Baby food	Cosmetic product	Other
Central market	750045	40650	14900	10350	6800	5645	570
Aigul market	527956	33276	12920	8360	5928	4712	456
El Irisi market	346550	26500	11600	6800	4235	3800	360
The mean value of the markets, pieces	541517	33475	13140	8503	5654	4719	462
Average of the total volume, %	57,2	21,5	8,5	5,5	3,9	3,1	0,3

The composition, abundance, and distribution of the glass container category varied between the study sites. Most of the bottles and cans were recycled, while the other categories of glass containers were used using fusing technology. To use this technology, you need a mini-furnace for fusing and glass containers (table 2, picture 1,2).

Table 2. Processing of glass containers using fusing technology

Category of glass containers	Getting failure of glass, kg	Getting new exclusive dishes, pieces
Milk and lactic acid milk drinks	263	2-3
Sauce products	170	1-2
Baby food	255	2-3
Cosmetic product	165	1-2
Other	9	1

Picture 1 – Furnace for fusing technology

Picture 2 – Ware retrieved from the failure of glass containers

Picture 3 – Ready-made exclusive glassware

Undoubtedly, an important property of the glass obtained by this technology is its strength, which exceeds the strength of ordinary glass products by four times. This effect is achieved by heating the glass to high temperatures, which is actually hardening. And if such glass is still broken, it will break up into very small fragments that can not cause dangerous wounds. As a result, we get a safer design in every sense (picture 3).

In total, during the study (from January to June 2020), 1075 thousand items of glass were collected. The abundance of all glass containers varied between and within the 3 sites surveyed. At the time of this study, the main categories of glass waste were glass containers for alcoholic beverages, soft drinks, milk and lactic acid drinks, sauce products, baby food, cosmetics, and others.

Conclusions

1. In the context of this research, we tend to believe that new technologies for recycling waste, in particular, glass containers, are effective and in demand. Urban residents are quite willing to hand over glassware at glass container collection points, which also helps to reduce environmental pollution.
2. We also came to the conclusion that glass container collection points are preliminary reasonable indicators of the most frequently used categories of glass containers.
3. The results of the study showed that the problem of recycling glass containers can be solved, and the use of preventive measures, accompanied by awareness-raising activities and investments in the processing of glass containers will further improve and maintain the current state of environmental cleanliness.

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