Exploration of Glass Bottle Wasteinto Functional Products Using a Combustion Furnace as Flameworking Technique

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ABSTRACT
The waste problem is increasingly becoming a problem in Yogyakarta because the Piyungan landfill is considered not to fulfill the waste capacity of Yogyakarta and its surroundings. The plan to close the Piyungan landfill for revitalization and the issue of “zero inorganic waste” is the rationale for developing an inorganic waste processing technique, especially glass bottle waste. Glass bottle waste is one of the inorganic waste that is difficult to process; therefore this study chose to focus on glass bottle waste. There are several factories in West Java and East Java that process glass crumbling, but none in the Yogyakarta area. One of the many potentials in Yogyakarta is the clay processing into pottery or ceramics.

This is one of the reasons for trying to develop glass waste processing techniques utilizing similar technology to clay processing, namely using a kiln. The long-term goal of this research is to provide an alternative to processing glass bottle waste locally by the local potential in Yogyakarta. Glass bottle waste will be tested by burning it with a pottery kiln widely used by craftsmen in DIY. The experimental method based on goal formulation will be used as a strategic design development to achieve this goal. The experiment will start with cutting the glass bottles and then continue transforming the shape into functional products using the heat (flameworking) of the furnace with the setting of the burning time and cooling time adjusted. The experiment will look for the efficiency of the burn time related to the amount of fuel used in the realization of the product and the calculation of cooling time in making disposable products from glass bottle waste.

Keywords: Glass Bottle Waste, Functional Product, Flameworking Technique, Combustion Furnace

INTRODUCTION
Waste management is one of the problems that exist in Yogyakarta. From 2017 to 2023, the waste problem has become one of the things that need to be resolved

in Yogyakarta News about waste on the website of the Yogyakarta Environmental Agency (BLH) (https://lingkunganhidup.jogjakota.go.id) can be seen that the accumulation of waste is one of the sources of disease; therefore, the improvement of TPS has been carried out in 2017 at several points.

BLH Yogyakarta has also sought training in recycling processing, sorting, procurement of waste banks, clean waste movements, recycling galleries, waste bank clinics, and waste reduction is also carried out from year to year. The goal in this experiment is to solve the problem of glass waste by finding the technique in processing the glass bottle. Thus, the strategic design development will focus on solving this problem.

LITERATURE REVIEW

Waste

The increasing amount of waste today is due to population levels and lifestyle standards, i.e., the higher and wealthier people live, the greater the amount of waste generated (El Haggar, 2007). The Piyungan landfill will reportedly be temporarily closed from 2023 to 2026 for revitalization. This will undoubtedly be a problem that must be faced, considering that the temporary closure of the Piyungan landfill in October 2022 alone has caused an accumulation of 260 tons of waste, of which 43 percent is inorganic.

The latest movement announced by the Yogyakarta Environmental Agency in November 2022 is “Zero Inorganic Waste.” This is evident in that TPSs in Yogyakarta no longer accept inorganic waste. One inorganic waste that is quite difficult to process is glass waste, where the immense majority is in the form of glass bottles, both from drinks, soy sauce, syrup, and others.

Waste is something that is not used, not liked, or something that is discarded from human activities and does not occur by itself (Chandra, 2006). Waste is an unavoidable problem that people in big cities will always face. Waste that can damage the environment is waste that cannot be decomposed by nature (Supiatun, 2021). The high level of consumption and the increasing population lead to a rising amount of waste accumulation. One way that can be applied in an attempt to minimize garbage glass bottles is to reuse the material into different products or called by recycling (Nursakti, 2016).

Waste can come from various sources, such as households, offices, markets, and industries. Waste is the solid residue of daily human activities. The owner does not want waste and is solid (Soemirat, 1994). Public health experts in America limit waste as something that is not used, not used, not like, or something that is discarded, which comes from human activities and does not occur by itself.
Based on the above limitations, several points can be made that:

1. Waste is a solid object.
2. Waste has a relationship resulting from human activities
3. Waste has the nature of no longer being used

Processing of Glass Materials

Processing of glass materials can be done with cold and hot techniques; in this research, we will use hot techniques (flameworking) utilizing a kiln widely used by pottery and ceramic craftsmen in Yogyakarta. According to Palupi (2019), this flameworking technique still needs to be widely known by the Indonesian people because, in Indonesia itself, there are only a few craftsmen who use this technique to make works/products from glass materials called glass art.

Ceramics and glass have a connection because glass material is used as a glaze in ceramic products. Glass materials have different melting points according to the content of the type of glass material. Boro silicate glass has a high melting point compared to pottery, while glass bottles have a melting point that is not much different from pottery. According to Sylvia (2018), this flameworking technique is based on fire, skill, and design accuracy; this process requires the most experience and flying hours. After the product formation process is complete, the following process is to cool the glass product to room temperature so that the product can immediately adapt to the ambient temperature.

This melting point issue is influenced by the ability to achieve melting temperature in the furnace. Furnaces for pottery (with gas fuel) certainly have different melting temperatures from special glass furnaces (usually using electric energy sources). This research chose the flameworking technique using a pottery kiln because the melting point of glass bottles is close to the melting point of pottery, and the shape change that will be carried out on glass bottle waste can be achieved with a pottery kiln.

The experiments conducted will look for the right burning temperature for glass bottle waste along with the length of time for burning and cooling to transform glass bottle waste into functional products. Experiments on cutting glass bottle waste are also conducted in search of the best shape modification to realize functional products.

METHODOLOGY

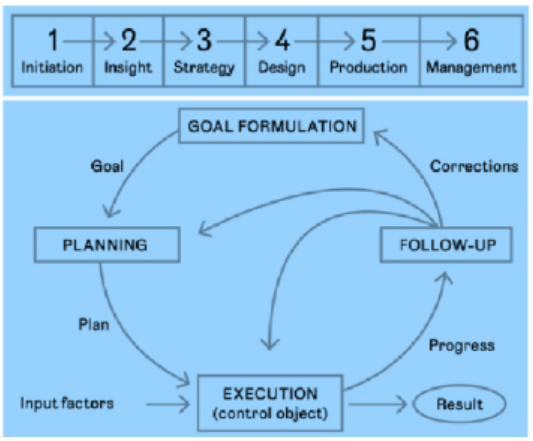
The method used is the experimental research method. Experimental research, according to Amat Jaedun (2011), is “laboratory” research such as in biological or physical sciences; research is carried out by comparing “research subjects” who are given treatment with those who are not given treatment to examine the consequences that arise. Amat Jaedun (2011) states that “experimentation is research to determine the effect of the treatment variable (independent variable) on the impact variable (dependent variable)”.

This study will use glass bottle waste without treatment as a reference for the initial conditions, then use the cut treatment variable and the burn treatment variable, where the cut size and burn time will be compared to the impact that appears on glass bottle waste.

The stages of the assessment are as follows:

1. Collecting glass bottle waste
2. Determining the glass bottle as a reference for the initial condition
3. Cutting the glass bottle with a specific size into three experimental parts, namely the base of the bottle, the bottle body, and the bottle neck.
4. Burning glass bottles with different reference times of 60, 70, and 75 minutes.
5. Cutting and arranging the glass bottle pieces (repetition) to form a sheet arrangement and then burning.
6. Calculating the cooling time required in units of time (hours).
7. Looking at the cooling results from burning glass bottle waste that has been burned to determine the product's function.
8. Conclude the best cutting size, arrangement of pieces, firing time, and cooling.
9. Retest the conclusion in the final experiment.
10. Write down the formulas for cutting, stacking, burning, and cooling.
11. Determine the product's function from the experimental results of processing glass bottle waste with the flameworking technique using an earthenware (ceramic) kiln.

Strategic design development in this project focuses on solving the problems and opening a new opportunities (Wanda Grimsgaard, 2023). The reasearch stages diagram below:



Step-by Step of the Research:
1. Initiation: Collect Reference
2. Insight: Local Technique
3. Strategy: Experimental
4. Design: Functional Product
5. Production: Burning the Glass Bottle
6. Management: Determine the Product

Formulation
Goal: Processing to Transform the Bottle
Plan: Cutting-Stacking-Burning-Cooling
Input Factors: Time-Size-Arrangement
Execution: Implementation
Follow-Up: Manage Goal-Plan-Execution
Result: New Form of the Glass Bottle Waste

Image 1 Diagram of Research Stages based on Wanda Grimsgaard. (Researcher, 2023)

RESULT & DISCUSSION

Initiation: Collect Reference

Glass as we know it today is a shiny, multicolored object, easy to break, and has the potential to be molded into a craft. Glass crafts nowadays we often encounter everywhere both indoors and outdoors.crafts at this time has also begun to be used in home furnishings. Glass can be applied to doors, windows, living room, even the garden. For some people who have an artistic spirit, glass can be utilized as an important part of the exterior and interior, according to Ferdian (2017).

The initial stage of the exploration was to collect glass bottles, wash them, and clean the labels on the bottles.

The bottle used in the experiment in the initial stage was a green glass bottle from Bintang beer. The bottle chosen is a bottle with intact condition and not cracked. The following process is to clean the bottle from all residues and dirt attached to the glass bottle. Some types of cleaned dirt are label stickers, dust, and other dirt. The cleaning process is done by immersing the bottle in water to remove all the dirt attached. Then, the label-cleaning process is done using a knife. The following process carried out after the glass bottle becomes clean is to cut the bottle into three parts with relatively the same size in each bottle (image 2). One whole bottle is separated into the neck part, body part, and butt part of the bottle.

Image 2 Three Cut Parts of the Bottle and The Arrangement of Glass Pieces Resembling Square Weaving. (Researcher, 2023)

Insight: Local Technique

The following experiment is to cut the bottle body into a rectangular shape with a slight curve, following the original cylindrical shape of the bottle. The resulting rectangular pieces have varying sizes and are different. The next step is to group the rectangular glass pieces into several groups of similar sizes. Several pieces of glass almost the same size are then arranged to resemble a one-level woven shape, which will then be burned in a furnace.

After going through the process of cutting and arranging the glass bottle pieces, the preparation of the firing exploration is followed by preparing the firing mold. The firing mold uses an earthenware-based container. The mold used is 13cm in diameter, with a thickness of approximately 5-8mm. The following process is to coat the pottery with a layer of separator (graphite). Giving the separator layer is done using a brush tool. The molded pottery is coated using the separator evenly and relatively thickly.

Image 3 Process of Coating the Mold with Separators. (Researcher, 2023)

Strategy: Experimental

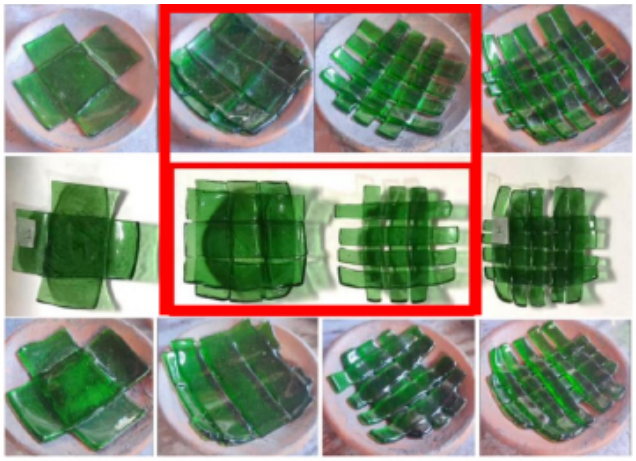
The glass bottle pieces cut and arranged in the previous stage are then placed on the pottery smeared with a separator. The process of placing the glass pieces is done carefully so as not to erode the separator layer applied to the mold. The risk that will occur if the separator layer peels off or is not spread evenly is that the melted glass will stick to the mold. Later, the mold must be destroyed to get glass molds. The glass bottle is then inserted into the furnace for the combustion process about 800-1000^{0}C.

The variation of sintering holding time has a directly proportional and significant effect on the hardness value. The longer the sintering holding time, the greater the hardness value of the composite, according to Alit (2022). The combustion process will be carried out for 60 minutes, 70 minutes, and 75 minutes, then the fire in the furnace will be turned off. The next step is to cool the combustion results naturally. The cooling process is carried out without opening the combustion door so the glass structure does not crack.

Image 4 Arranging the Mold in the Kiln. (Researcher, 2023)

Design, Production, Management: Platter

The cooling process is carried out for a relatively long time so that it is ensured that the temperature of the experimental results is entirely by room temperature. The experimental results are considered successful if the burnt results melt following the shape of the pottery mold, and the glass can be released from the pottery mold. The mold results are considered to have followed the form of the pottery mold used.



➲60 minutes

ANALYSIS OF FURNACE RESULTS	
Edges	Soft curved
Adhesive	Stick together
Shape	Stable deformation

➲70 minutes

ANALYSIS OF FURNACE RESULTS	
Edges	Soft curved
Adhesive	Stick together
Shape	Stable deformation

➲75 minutes

ANALYSIS OF FURNACE RESULTS	
Edges	Edges Soft curved
Adhesive	Adhesive Stick together
Shape	Shape Unstable deformation

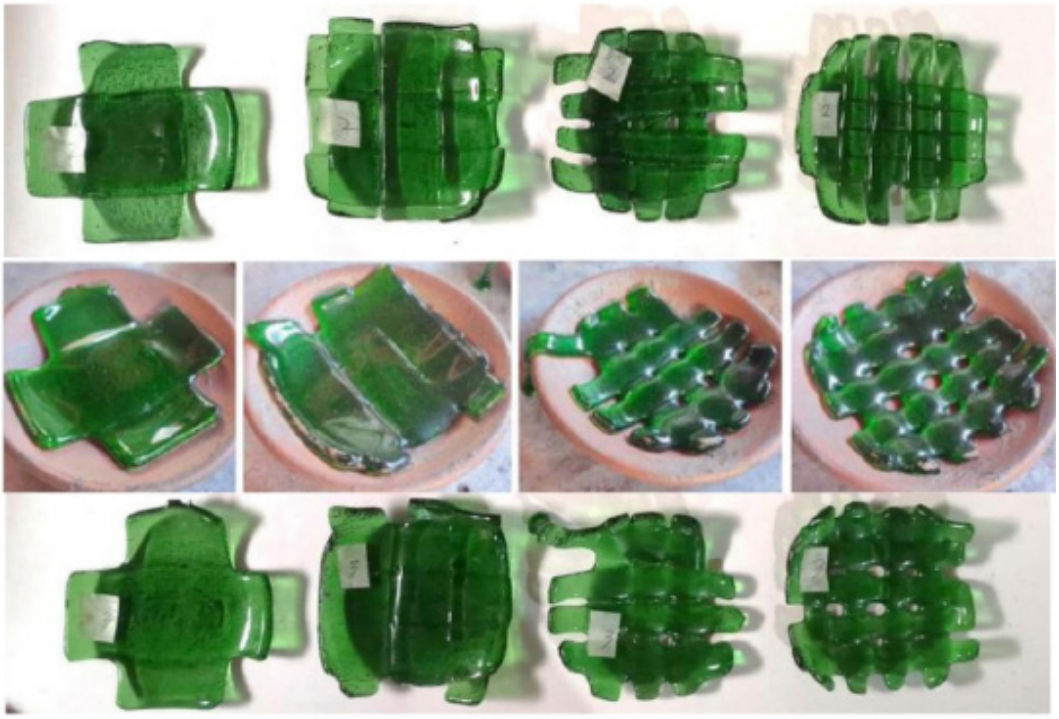


Image 5 The Result of the Arrangement of Melted Glass Following the Shape of the Mold. (Researcher, 2023)

CONCLUSION

There are several types of glass waste processing, both technically and by the type of character of the glass being processed. There are cold techniques and hot techniques, as well as cut/sheet glass and cullets (crushed glass). Both processing using hot techniques and cold techniques have been widely carried out, such as making glass bead crafts in Jombang using hot techniques and glass crafts using resin using cold techniques. Processing using flameworking heat techniques needs to be adjusted to the local potential of an area. Yogyakarta, which has pottery centers in Bayat and Kasongan, can burn with a kiln to process glass waste.

Even though the glass firing kiln should have an electrical temperature gauge to regulate the temperature drop during the annealing process, glass processing using a gas-fired pottery kiln can still be carried out by monitoring the baking and cooling time within 1 x 24 hours (of course adjusted to the ambient air temperature during firing).Processing glass waste using flameworking techniques can be done using pottery molds, which Bayat and Kasongan pottery artisans widely produce. Pottery molds need to be provided with a separator so that the melted glass can be separated from the glass. Without a separator, glass will stick to the pottery because of the nature of glass as a glaze on earthenware (ceramic) products.

The product that can be produced from changing the shape of glass bottle waste in this research is a tableware that functions as a serving platter because the results are aesthetic. This product was chosen because it meets safety standards,

namely that it has no combustion products sharp corners on the edges of the glass pieces, the burnt products can be washed and cleaned of dirt, and the burnt results from the arrangement of several pieces of glass can stick together well. The best formulation is 60 minutes burning, 6 arrangements of 2cm wide pieces and 7 arrangements pieces 1cm wide (image 6 in the red square). The longer of the combustion process, the higher of the melting glass amount, the shape deformation become more unstable, and the cost more expensive.

The development of this research can still be carried out by further experiments regarding the size of glass bottle pieces and developing the size and shape of pottery molds, because research about the molds hasn't been done in this research. The burning time can also be reconsidered at certain time intervals. The size of the results of burning glass bottle waste can also be enlarged so that its serving function can increase in volume.

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