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RESEARCH ON CREATING DECORATIVE OBJECTS FROM GLASS WASTE THROUGH THERMOFORMING

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ABSTRACT

The paper presents a research study on the production of decorative glass objects using the thermoforming process. For this purpose, glass waste was used, aiming at the recovery and reuse of various glass scraps for the production of ornamental objects. The thermoforming process was applied to various combinations of white and coloured glass with inserts from different materials to achieve the most pleasant visual impact, producing different shapes and geometries.

KEYWORDS: glass, thermoforming, decorative objects, waste

1. Introduction

Decorative glass elements have become a symbol of elegance and sophistication in modern interior design. The role of decorative glass elements in luxury design is significant. Glass adds a modern look, reflecting light and creating a feeling of open space. It can be used to highlight design elements, such as furniture or works of art.

Each type of glass has its own unique characteristics, which can be exploited to create a special interior design, both by using decorative art objects and by incorporating glass into lighting fixtures or building elements, such as decorative walls, windows, and doors [1, 3].

Decorative objects can be made from glass waste through various methods, transforming used glass into unique and attractive pieces. Recycling glass is a sustainable option, and the process can be customized to create various decorative objects.

There are numerous possibilities to transform glass waste into decorative objects, contributing to environmental protection and the creation of unique and valuable pieces.

Every time we produce new bottles, we need materials from coastal areas, where soil erosion is a real problem. The more we produce new items, the more sand we take from these areas. Therefore, one way we can contribute to protecting the environment is to reuse the materials, through "upcycling" and by creating personalized decorative objects [2].

2. Experimental research

To obtain ornamental pieces by thermoforming, I made several attempts, on different combinations of glass waste with different inserts. I used refractory brick as a template, on the surface of which I placed different pebbles to ensure, through them, convex deformations of various shapes and sizes.

Between the pebbles and the refractory brick, I placed a ceramic separator, and over the pebbles, a coloured glass plate. For this study, I used glass waste.

We followed the behavior of the glass during the thermoforming cycle. In addition to the uneven heating provided by the oven, there were also sudden temperature variations, as a result of repeated openings of the oven door, which ultimately led to the appearance of stresses inside the glass sheet and, subsequently, to the appearance of cracks and fissures.

Figure 1 shows the assembly, sheet-pattern, fixed on the refractory brick, which was inserted into the oven.

The refractory support ensured, when the assembly was introduced into the furnace, the preservation of the chosen design and reduced the temperature variations that usually occur along the height of the furnace.

Figure 2 shows the ornamental object obtained after thermoforming.

You can see the cracks that appeared in the glass sheet - specifically, the cracks at the level of the bulge, in the upper part of the deformed glass (Figure 3), as well as the cracks that led to the delimitation of fragments of smaller or larger sizes; practically, pieces detached (broken off) from the glass sheet.

The pebbles with variable sizes and large differences in height, together with the temperature variations caused by the oven and those "introduced" due to the door opening, led to the compromise of the first "thermoformed" decorative object.

The convexity of the glass, its varied height and its asymmetrical positioning - all influenced by the pebbles - proved that the method can lead to the creation of interesting decorative objects.

An important problem with this piece is the imprints of the pattern left on the piece (Figure 4.). The texture given by the separator is also visible on the edge of the sample.

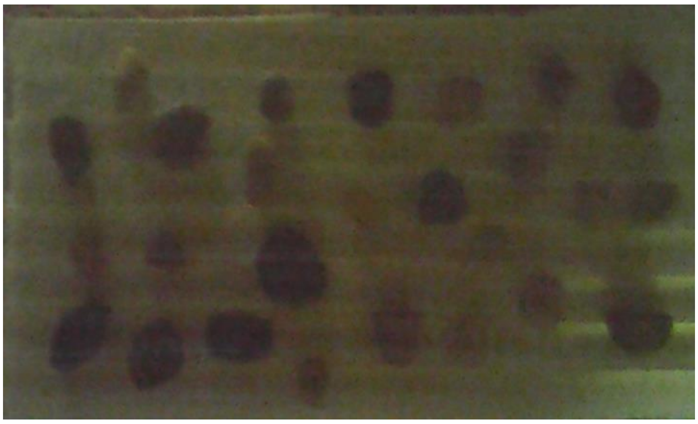

Fig. 1. *Model assembly, glass sheet-pebbles*

Fig. 2. *Thermoformed ornamental object*

Fig. 3. *Superficial cracks on the surface of the part*

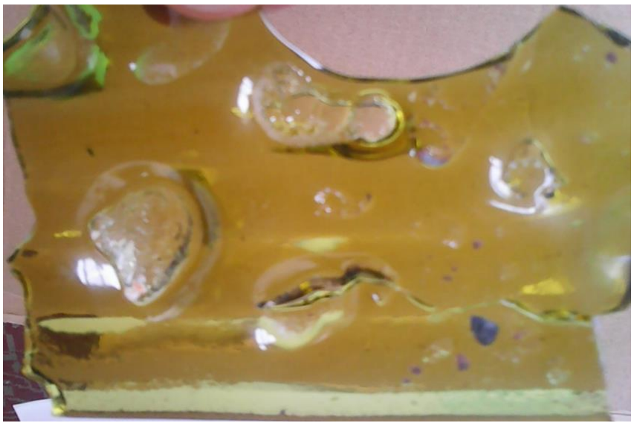

Fig. 4. *Imprinting of pebbles on the surface of the piece*

In the next sample taken into the study (Figure 5), we used smaller, more uniform pebbles, without too many temperature variations in the working space of the furnace induced by the outside, and better results were obtained.

Fig. 5. *Decorative ensemble made of brown glass (ornament) and thermoformed pebbles*

Fig. 6. *Texture of the thermoformed sample, due to the shape of the pebbles*

When removed from the oven, the transformed plate, with the protuberance given by the pebbles used as a model, presented a slight transverse crack, which over time propagated, transforming into a much larger one. Due to the shape of the pebbles with inclinations in both directions, some of them remained trapped in the piece, and their final detachment from the respective areas damaged the object.

It is worth mentioning that the crack appeared in approximately the same area, observed in all samples taken, located in an area with greater temperature variations, recorded along the length of the furnace.

Another test consisted of combining two types of glass, with different colours, which we assumed could have the same expansion coefficient, being the case of window glass with a printed pattern from the factory.

To create the assembly (Figure 7), in addition to the two types of coloured glass, out of the desire to print a more unique pattern on the support glass, we also placed some wires, with a diameter of 3 mm, between it and the ceramic separator.

Fig. 7. *The combination of the two types of glass, with different colours, placed on steel wires*

The plate obtained (Figure 8) confirmed the assumption that the two types of glass have the same or a similar coefficient of expansion, as there was good compatibility between them. And in this case, in the area with temperature variations, a slight crack appeared which over time led to cracking and breaking.

Here, as in the previous case, some pieces of wire, like pebbles, remained embedded in the plate, but they could be extracted. A possible cause of the crack can also be considered the lack of compatibility between the glass and the metals used to obtain the ornamental motif.

Fig. 8. *Thermoformed assembly, made of brown glass, green glass, wire strands*

To see the behavior of the two types of factory-decorated glass and transparent window glass, we created an assembly consisting of three different layers: a transparent glass plate as the background support, brown decorative glass (wavy type) in the middle, and on top, green decorative glass with a geometric ornament.

However, some defects were also observed, but these cannot be attributed to the existence of several types of glass and their different thermal expansion coefficients.

As can be seen from Figure 9, due to the dimensions of the base glass plate, which exceeded those of the refractory brick, when the glass softened, it flowed past the edges of the brick, giving rise to several fringes, almost perpendicular to the support plate.

Fig. 9. *Ornamental shape made of three types of glass (brown, green, transparent) thermoformed*

The missing portion at one of the ends is explained by the fact that it was located in the area of the highest temperatures, at the back of the furnace. At the working temperature, 800 ºC, the thermoforming temperature, the glass became less viscous, and the oversized portions, softening, took the shape of the brick, molded on the edge and elongated, and under their own weight, they broke. The missing portion was formed, according to the drawing, of two layers of glass, therefore slightly heavier.

No cracks were recorded, so the three types of glass may have had equal expansion coefficients or only small variations between them.

Based on these results, I also wanted to create some decorative objects, slightly more special, made of overlapping coloured glass bars.

The first of them (Figure 10) was made only of glass bars of a single colour (brown), compatible with each other.

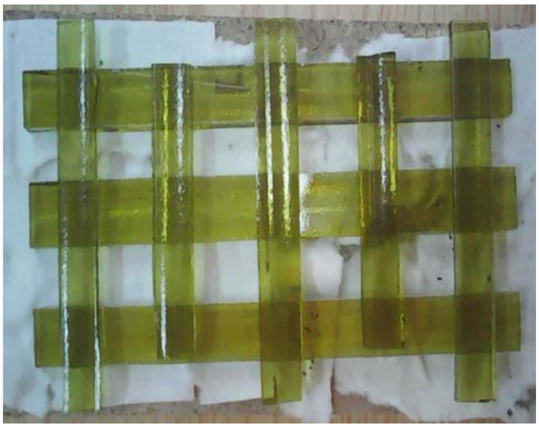

Fig. 10. *Decorative object made of overlapping glass bars*

Maintaining the piece for a longer time at the final temperature of 800 ºC led to the perfect joining of the bars and to the creation of a decorative object without cracks (Figure 11a). The texture, given by the ceramic separator and the non-uniformities of the brick, can be observed in Figure 11b.

In the second decorative object made, difficulties arose in preserving its design, not through the alternation of colours, but through the dimensions, the spaces between the bars and their positioning. The great weight of the entire assembly, formed by the brown and green glass strips and the brick, its cumbersome handling (pushing it onto the hearth of the oven until it touched the back wall), combined with the gloss of the glass and the reduced space of the oven enclosure, led to the displacement of the strips, resulting in the deterioration of the geometry.

Following the same conditions as in the previous case, we obtained a second decorative object, two-coloured (Figures 12a and b), without cracks or thermoforming defects.

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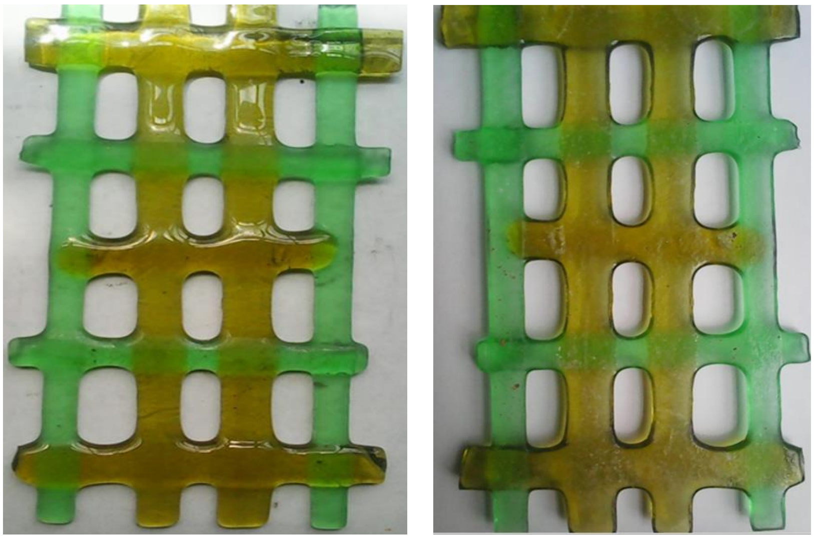
The small irregularities that appear on the back of the pieces or certain sharper corners or curves that appear at the edges can be explained by the fact that the strips exceed the refractory brick surface in some areas, which caused the appearance of deviations from the general shape of the strips at some edges [4, 6].

a) b)

Fig. 11. *Decorative object made of thermoformed glass bars: a) thermoformed object; b) its texture*

It is also worth mentioning that on the back of the object created, such as compact plates or lattice plates, the texture of the support used as a separator was imprinted, to prevent the glass from sticking to the refractory material (Figure 12).

As objects of comparison, I took a similar one, obtained in two different workshops: a workshop in Brăila (Figure 13b), and another obtained in a workshop abroad (Figure 13c), next to which I placed one of the decorative objects created by me (Figure 13a).



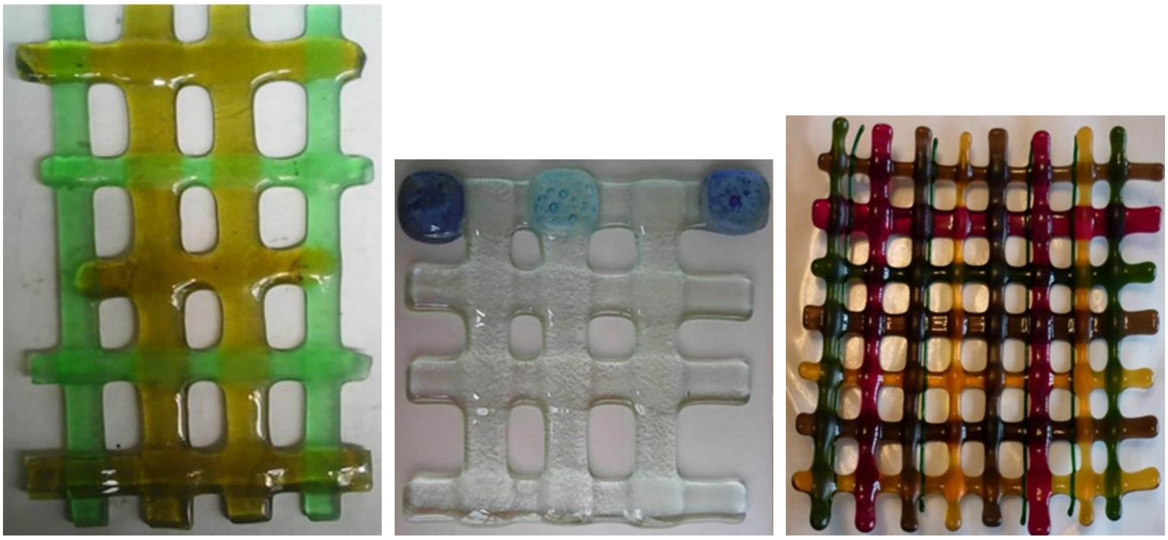
a) b)

Fig. 12. *Thermoformed objects from bicolour glass bars; a) thermoformed object; b) texture*

I also made an object, not necessarily decorative, but more useful, such as a small glass ashtray, obtained towards the end of the study, when I considered that I could improvise and control the thermoforming process.

I used a truncated metal cone, not too large (Figure 14), with which I obtained the hole in the glass sheet.

The glass plate was in the form of a circle, with a radius of approximately 120 mm, shaped according to the diameter of the bottom, the height of the walls, and the outer border. To prevent the glass from being imprinted by the metal mould and the refractory brick, we used a separator in the form of a powder of ceramic particles, with which, after soaking in water, we coated the parts that the glass was to come into contact during thermoforming. On the refractory brick and in the mould, we placed a ceramic separator [5].



a) b) c)

Fig. 13. *Decorative object, grille type, made: a) personal; b) workshop in Brăila; c) workshop abroad*

The final product, a small ashtray (Figure 15), exhibited the same defects caused by uneven heating and improper shapes:

- copying of shape defects;
- diametrically opposed areas of the walls of the inner cylinder of the ashtray with different heights;
- asymmetries in the marginal border.

Fig. 14. *Metal support for thermoforming the ashtray: a-cleaned metal support before thermoforming; b-metal support after thermoforming*

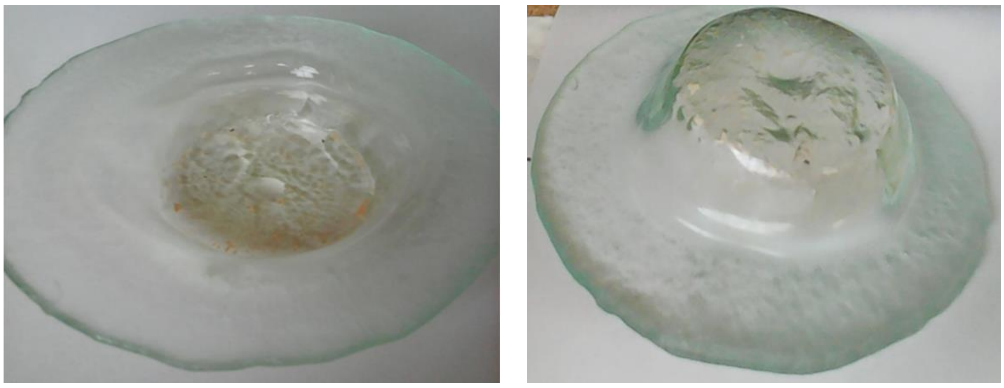


Fig. 15. Thermoformed glass ashtray

3. Conclusions

The study and research conducted led to the conclusion that glass waste can be transformed into unique and personalized decorative objects.

Research conducted on different samples, with various inserts and geometries, highlighted the importance of temperature and the thermal expansion coefficient on the viscosity of glass.

Through creative recycling, also known as creative reuse, new products of higher quality or value are created.

The advantages of using recycled glass to make decorative objects are: sustainability, creativity and originality. The objects created have a unique and personalized look.

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