Determination of Best Refractories Suitable for Glass Forming Molds by Manual Blowing

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Introduction:

Glass represents the fourth state of matter, and it consists of a group of oxides such as silicon oxide, sodium, calcium, potassium, magnesium, aluminum and some colored and non-colored oxides. There are many methods for glass production, such as automatic, semi-automatic and manual, as well as re-formation inside closed ovens, and the formation of glass by manual blowing into a mould.

Manual blow molding methods are one of the methods that have attracted attention due to their ability to form artistic glass products in limited quantities, at low cost and in a short time. Also, everything that can be machined and manufactured can be produced and assorted manually, while machines are unable to implement and form some handmade products. With artistic and aesthetic formations with subtle and complex details that cannot be produced automatically.

Thermal materials are suitable for forming a thermal mold for blowing glass, and there are two types of them, formed refractories and non-problem refractories, and it is considered the last target and the subject of the study, because of its ability to form in the form of unformed refractories and its ability to show the smallest details of the technical formations of the glass product, after pouring it on a model glass product.

Research problem:

The need to find alternatives of refractory materials that are suitable in their physical and chemical properties to the requirements of designing manual blown glass molds.

Research importance:

- Contributes to the application of advanced technology for the manufacture of thermal molds to form glass by hand blowing.
- From the interdisciplinary research of the Glass Department, Faculty of Applied Arts, Helwan University, and Metals Research and Development Center.

Research objectives:

Reaching the installation of new refractory materials with physical and chemical properties that fit the chemical and physical properties and requirements of glass forming molds in terms of density, mechanical endurance, non-friction, cracking, non-adhesion to the thermal mold, low

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expansion and contraction, numerical achievement in production, and glass conformity to design specifications.

Implementation of the research:
By identifying the best alternatives of thermal materials for manual blowing glass molds, it leads to achieving the efficiency of the thermal mold in forming and operating, and thus matching the mold outputs to the product specifications.

Research Methodology:
Inductive – experimental

Methods and procedures:
The thermal composition properties of the mold (physical and chemical) must meet the following mold specifications:
1- Show the details form, Render Details.
2- Resistance to abrasion, flaking and refraction at the mold contact areas.
3- Density.
4- Working temperature
5- The coefficient of expansion and contraction
6- Adequate production method (inflating with rotation - inflating with pressure), appropriate production method,
(resistance to friction during inflation with rotation. - resistance to pressures during inflation with pressure)
7- The number of products produced, productivity
8- The percentage of conforming to the specifications of the glass product, match ratio.
The search was carried out through the following:
1- Parametric Experiments
2- Practical Experiments

First: Scientific Studies.
1- Equipment, tools and devices used to carry out laboratory experiments.
2- Conditions that must be met when conducting thermal experiments to determine the best one.
3- Laboratory thermo-settings for manual blowing glass molds.
4- Criteria for evaluating thermal experiments to determine the best ones.
5- The best refractory materials are suitable in their properties for the manufacture of hand blown glass molds.

6- Results.
7- Recommendations.
8- Arab and foreign references.
1- Equipment, tools and devices used to carry out laboratory experiments.
1-1 Scale for weighing materials.
1-2 Sets of mixing bowls.
1-3 Multi-speed electric mixer.

1-4 Set of sample molds 5 x 5 x 5 cm & 23 x 5 x 5 cm
1-5 Dryer
1-6 Muffle Furnace
1-7 Electric saw for thermal materials.
1-8 Vernier
1-9 Cold Crushing Strength Mechanical Strength Meter.

2 - Conditions that must be met when conducting laboratory experiments
2-1 Prepare the refractory materials separately (1).
2-2 The weight of the refractory materials according to the percentage of each substance in the refractory composition.
2-3 These ingredients are mixed together through the electric mixer on dry mode for five minutes and then water is gradually added until we get a homogeneous mixture that takes the form of a ball, and the percentage of water does not exceed 7-15%.
2-4 The mixture is poured into molds to form it in the form of cubes of size 5 x 5 x 5 cm or it is poured into the form of 20 x 20 x 5 cm tiles, then it is cut without adding water during cutting so as not to affect its mechanical strength.
2-5 Cover with a piece of cloth so that the water does not evaporate from the surface layer of the sample.
2-6 It is left for 24 hours for primary drying and then taken from the molds it was formed in.
2-7 The samples are placed in the dryer at a temperature of 60°C for 12 hours, then we raise the temperature to 110°C and leave for 24 hours to ensure the initial drying of the water.
2-8 The samples are placed in a closed electric oven Kiln Furnace at a heating rate of 170 °C / hour until we reach 1100 °C, then the temperature is stabilized for five hours and then left to cool inside the oven or cool down through a cooling rate of 100 °C / hour, till reach room temperature.

3 - Laboratory thermoforms for hand blown glass molds (7:2):
The refractory experiment consists of at least 25% (2) of refractory materials, preferably about 15%, of a binder with a particle size of less than 5 microns, preferably including between 1.2 microns and containing a high percentage of alumina, with a grain size of less than 20 microns, preferably in the range (20:1) microns in successive proportions of (7:3) approximately microns, which are the appropriate proportions for obtaining refractory concrete.
Samples are measured according to the following standard specifications:
1- Density of samples is measured at 110°C according to American Standard Testing Measurements (ASTM) 134-95.
2- The mechanical strength density is measured at 110°C according to ASTM 133-97.
3- The density of expansion and contraction is measured at 110°C according to ASTM 133-02.
Thermal experiments included (16) experiments.
4 - Criteria for evaluating thermal experiments to determine the best ones.
4-1 It should have a high density of 1.9: 2.6 g/cm^3 so that there are no cracks in the mold body.
4-2 Its mechanical strength should be greater than 120 kg / cm^2 in order to avoid cracks in the body of the thermal mold.

4-3 It should have a low shrinkage coefficient of ± 0.05 mm in order to ensure conformity with the specifications of the glass product.

4-4 The percentage of water should not exceed 15%. The absence of pores in the mold body affects the details of the outer shape of the glass product, and the percentage of water affects the mechanical strength of the thermal mold and affects the rate of heat diffusion inside the mold.

4-5 The thermal endurance range should be 1500:1300^{o} C, so that the mold can tolerate it during production by blowing with rotation and blowing with pressure.

4-6 It should contain a fine particle size, preferably 5:20 microns, to show fine and smooth textures and to ensure matching between the thermal mold and the model.

These criteria have been applied to select the best thermal installations.

Secondly, practical experiments

The obtained refractory material was applied in the glass forming mold, and the glass was formed in two applications as follows:

The first application: The thermal material was successfully applied and the glass was blown into the thermal mold with pressure, and the conformity rate was 95% of the design, (glass product height 33 cm) as shown in Fig. (1)

Fig. (1) First application

The second application: The thermal material was successfully applied and the glass was blown into the thermal mold with rotation, and the matching ratio was 98% of the design, (the height of the glass product is 17 cm) as shown in Fig. (2).

Fig. (2) Second application

Results:

1- The glass designer has a pivotal role in designing molds for forming glass from refractory materials.

2- Thermal materials have proven to be completely valid in the implementation of thermal molds and glass formation.

3- Refractory formulations containing 50% alumina are suitable for glass blow molding with rotation, as shown in the second application.

4- Thermal installations containing alumina with a percentage greater than 80% are suitable for the implementation of glass blow moldings with pressure and have recessed and prominent formations, which is clear in the first application.

5- The best thermal installations are number (5) in terms of density, resistance to cracks, thermal endurance, resistance to fragmentation, low shrinkage coefficient, and conforming to the technical specifications of the design of the thermal mold.

6- Using thermal molds to produce the first sample of the glass product.

7- Production and formation of artistic glass products, which cannot be produced automatically in some products.

Recommendations:

1- Activating the role of the glass designer in designing thermoforming glass molds in products of an aesthetic nature and one-piece products.

2- Using clean energy resources, as it is the best solution to preserve the environment and human health, instead of the traditional energy that causes severe damage.

3- Production of the first sample of the glass product through the thermal mold.

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