International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

https://ijpsat.org/

Vol. 50 No. 2 May 2025, pp. 296-299

Extraction And Study Of Foam Glass From Volcanic Rock - Obsidian

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Abstract: Foam Glass was obtained artificially almost a century ago and is still a widely used and it is a universal, environmentally and hygienically safe, lightweight thermal insulation material. Foam Glass, in addition to low thermal conductivity and moisture absorption, is non-flammable, resistant to water and chemical reagents, etc. This allows it to be widely used in construction, energy, chemical industry and other areas. Foam Glass is used to produce many types and areas of products - tiles and blocks, shaped thermal insulation, individual materials (grit, granules) and much more.

The technology of manufacturing Foam Glass and Foam glass products is complex, as it requires a specific raw material base, as well as careful adherence to technological processes for the manufacture of porous glass and products from it.

The economics of Foam glass making is largely determined by the availability and cost of raw materials, as well as costs incurred in obtaining charge. It becomes important to take into account issues such as the stability of the composition of raw materials and the minimization of the number and types of technological processes required for its preparation. In this regard, modern approaches to Foam Glass production are irrational.

As an alternative raw material base for Foam Glass, we have chosen glass-obsidian of volcanic origin, mined in Georgia (Samtskhe-Javakheti region). Its deposit is a volcanic, entirely obsidian (glass) mountain, and its deposits were formed as a result of erosional processes, which are represented by a large number of detrital products.

The results of the conducted research show that obsidian mono charge from the selected deposit can be used as a suitable raw material for Foam Glass production. Foam Glass is obtained by heat treatment of obsidian at a temperature of 1200± 20°C for 20-25 minutes, which ensures the production of a material with a bulk density of 180-200 kg/m^3. Water absorption, sorption capacity, compressive strength and other properties of the resulting Foam glass fully comply with the requirements of the current glass standard.

Keywords: Obsidian, Heat Treatment, Foam Glass, Technological Parameters, Properties.

1. Introduction

Energy efficiency remains a pressing issue to this day, and targeted work is being carried out in many areas in the world's leading countries to achieve it. Among them, the production of inorganic porous materials, which are widely used in industry and construction, is relevant. Among such materials, one stands out, characterized by lightness and high porosity (more than 90%) – Foam Glass [1, 2].

Currently, Foam Glass and Foam Glass products are produced mainly from two types of raw materials: secondary/collected, practically smashed glass and fritted granules obtained from specially welded glass. Primary processing of these smashed glass

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requires sorting, washing and crushing, which increases labor intensity and energy costs and does not ensure the production of high-quality Foam Glass products. Obtaining granules from specially welded glass requires additional glass melting in a material holding furnace, which leads to a sharp increase in the cost of Foam Glass.

The technology for preparing glass-receiving charge from shards of glass and granules is identical and consists of pure grinding of shards of glass or granules. Together with the foaming material (1 - 5 wt. %) and foaming the resulting mixture with high-temperature (800 - 1000^{0}C) heat treatment [3-5].

The technological process of Foam Glass production from both “traditional” types of raw materials is characterized by high energy and material intensity, which leads to an increase in the cost of Foam Glass and a decrease in its competitiveness. This circumstance has led to the search for new raw materials for Foam Glass, and in this direction, many countries are actively conducting research into the production of Foam Glass using natural rocks and technogenic waste [6].

We have conducted research aimed at expanding the available raw material base for Foam Glass and reducing material consumption by simplifying its production technology. For this purpose, volcanic glass – obsidian from a specific location (Georgia, Samtskhe-Javakheti region) was selected and studied.

2. Experimental approaches

The possibility of obtaining Foam Glass from obsidian taken for research in laboratory conditions was determined by conducting the following research works: grinding of raw materials, averaging of composition, heat treatment, determination of optimal foaming parameters and properties of the resulting porous material.

The object of study – obsidian – is a black material – glass, which does not contain visible crystalline inclusions. Chemical composition of the raw material sample taken for the study (wt.%): 73,81 SiO_2; 14,79 Al_2O_3; 1,25 Fe_2O_3; 1,02 CaO; 0,39 MgO; 2,88 $Na_2$0; 0,30 MnO; 0,47 LOI and is an aluminosilicate glass containing a small amount of alkali (2.88%) and alkaline earth metal oxides (2.41 RO). It contains up to 0.5% volatile matter, presumably in the form of water molecules.

Table 1. Dependence of the fermentation coefficient (K_α)of obsidian on the temperature (t) and time (τ)of heat treatment

Heat treatment parameters		Bulk density	K_α	Heat treatment parameters		Bulk density	K_α
t, ^{0}C	τ, min	γ', kg/m^3		γ', kg/m^3	τ, min	γ', kg/m^3	
25	–	1420(1)	–	25	–	1420(1)	–
900	15	1420(4)	1,0	1100	5	1420(4)	1,0
1000	„	1270	1,1	„	10	940	1,7
1100	„	505	2,8	„	15	505	2,8
1150	„	305	4,7	„	20	**275(2)**	**5,4(3)**
1200	„	**200**	**7,1(3)**	„	25	**260(2)**	**5,5(3)**
1250	„	360	3,9	„	30	260	5,5
1300	15	630	2,3	1100	35	260	5,5

(1) - For dried material (γ_0=1420 kg/m^3)
(2) – Optimal parameters
(3) -K_α Maximum value
(4) --For heat treated material (γ', kg/m^3)

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Table 2. Properties of Foam glass obtained from obsidian and required by standards(1)

N	Demanding (characteristic) feature	Unit of measurement	The meaning of properties	
			Foam glass (GOST 33949-2016)	Foam Glass from obsidian
1	Specific density	d, kg/m^3	8 ≤ d ≤ 200	180 -200
2	Compression strength	P, Mpa	0,3 ≤ P ≤ 3.0	0,810 ± 0,1
3	Water absorption (2)	W, %	< 0,5	0,43 ± 0,02
4	Sorption capacity	S, %	< 0,7	0,420 ± 0,3
5	Thermal conductivity coefficient	λ_{25^0C}, W/(m.K)	≤ 0.065	0,055 ± 0,005

(1) - t = Heat treatment parameters: 1200 ± 20^{0}C; τ - 20 min.

(2) - After 24 hours in water

To determine the transformation of obsidian into Foam glass, heat treatment was carried out with two possible options: increasing temperature (t) and time (τ). The temperature range of heat treatment was 900-1300ºC (τ=15 min), and the duration of stay at a certain temperature (1100 ºC) was determined in the range from 5 to 35 min (obsidian grains 10-15 mm in size). The degree of Foam Glass transformation was estimated by the so-called fermentation coefficient: = $K_\alpha = \gamma' / \gamma_0$. (For definition and results, see Table 1).

Based on the evaluation of the obtained results, it was established that the optimal parameters for maximum fermentation of obsidian (as indicated by the maximum value of K_α) are the following: temperature 1200 ± 20^{0}C, and holding at this temperature is 20-25 minutes. Additional experiments showed that the recommended heat treatment regime ensures the production of Foam glass with a specific density of 180-200 kg/m^3 from obsidian (under laboratory conditions) (Table 2).

The assessment of the possibility and prospects of using obsidian-based glass was carried out by studying the characteristic properties regulated by the relevant standard GOST 33949-2016 [7] for glass (density, compressive strength, water absorption, sorption capacity, thermal conductivity). The experimental results obtained and regulatory requirements are presented in Table 2. Comparison of the data clearly shows that the Foam Glass obtained from obsidian meets the requirements of the standard, which confirms its suitability for use.

3. Conclusions

– The conducted research has established the possibility of obtaining Foam glass by high-temperature thermal treatment of natural volcanic rock – obsidian (mono charge) of a certain composition using simplified technology;

– An experiment conducted in laboratory conditions determined the temperature and optimal time for maximum fermentation of obsidian: temperature 1200 ± 20 ^{0}C; delay 20-25 minutes;

– The resulting Foam Glass has the characteristics required by the current standard, which fully complies with the requirements of the standard;

– From the raw material selected for the study – obsidian – it is possible to obtain a light inorganic porous material with a low specific density (up to 200 kg/m^3) – Foam Glass.

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