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COMPOSITION, SYNTHESIS AND PROPERTIES OF INSULATION FOAM GLASS OBTAINED FROM PACKING GLASS WASTE

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ABSTRACT

So far, the starting compositions for obtaining foam glass have been developed based on glasses pre-synthesized for the purpose. From the point of view of such important issues as increasing the energy efficiency and utilization of municipal and industrial waste, the possibility for production of foam glass insulation out of packing glass waste is a very good alternative.

The present study to suggest a decision for utilization of waste glass and serves as a basis for developing the technology for production of continuous strip of foam glass material. This technology will be implemented in vertical production installation, which is currently under construction.

Keywords: foam glass, powder method, insulations, waste glass, foaming agent.

INTRODUCTION

Industrial and municipal waste glass is still not sufficiently utilized. There is a paradox: on one hand, glass is one of the most robust and clean inorganic materials and on the other hand, it is used as disposable product although its period of decay is infinite. Therefore the issue for utilization of glass waste is very important [1, 2]. In this direction introduction of waste glass in the production of the foam glass is very perspective. For the preparation of the foam glass were developed several methods: introducing compounds into the starting batches that produce abundant foaming during the process of manufacture of glass; saturation of the liquid with air or another gas in various methods; foaming of the softened glass in vacuum; foaming of finely grinded glass with foaming agent in cold and subsequent fixing the structure through sintering the glass particles; heat treatment of fine glass powder and gas generating agent [3, 4].

The powder method finds the widest practical application [3]. The method allows the easiest control of the operation parameters for production of high quality foam glass and is therefore the most used in world practice. Besides, the powder method has found wider application and has been established in industrial practice since it is the only method enabling to obtain foam glass with particular properties defined in advance. Moreover, its workflow is comparatively easily feasible and yields to changes. The method consists in preparation of starting batches through precise mixing of finely grinded glass particles with a definite size with foaming agent and subsequent heating to a set temperature. In the last years new directions for the development and applications of foam glass are registered [5-9].

The aim of this study is to suggest a decision for utilization of waste glass and to serve as a basis for developing the technology for production of continuous strip of foam glass material.

Table 1. Chemical composition of collected waste glass.

Oxides	Content, mass %	Oxides	Content, mass %
Al_2O_3	1.77	P_2O_5	0.05
CaO	8.67	SiO_2	72.31
Fe_2O_3	0.27	TiO_2	0.06
K_2O	0.48	SO_3	<0.03
MgO	2.77	Moisture	0.11
MnO	<0.01	3X	0.026
Na_2O	13.26	-	-

EXPERIMENTAL

The chemical composition of waste glass collected is very important for the chemical processes taking place during foaming. In the containers of ECOPACK and ECOBULPACK mainly glass packing from food industry are disposed, e.g. white bottles and jars, green or brown bottles.

Chemical composition of the collected waste glass was determined out in a certified laboratory. The content of the oxides is shown in Table 1. It is seen, that the glass composition corresponds to a typical industrial silicate glass.

There are also dirt and various plastic or paper items, e.g. labels, taps, etc. These items must be removed before utilization and the glass must be cleaned both mechanically and chemically using some detergents. The final mechanical cleaning before grinding is carried out through crushing in water. The washed water is treated in accordance with the environmental requirements and is used again. All mechanical impurities are finally removed from the crushed glass through repeated running through magnet separators and subsequent sieving. There is not technology that guarantees the full cleaning of the waste glass but the impurities can be minimized for the purpose of the technology we propose.

To foam glasses with various chemical composition particular foaming agents and temperature conditions are necessary to manufacture high quality foam glass [3,4]. It is found that the final product contains pores 0.5 - 2 mm. Depending on the foaming agent, particular interactions proceed during foaming.

The foaming in the powder method takes place at considerably higher viscosities of the glass mass. The increased contents of Na_2O, MgO, Al_2O_3 and Fe_2O_3 in the glass composition and decreased SiO_2 content results in alteration of the viscosity. The decreasing of the viscosity through increasing the temperature of the foaming in the glasses at the same chemical composition results in increasing the degree of foaming. This leads to small bulk density and increasing the diameter of the pores at the same time. Another important requirement that the glass has to meet is the low ability to crystallization because the crystals have negative impact. In industrial manufacture of foam glass, the operation temperature in the furnace plays important role too. The requirement for the operation temperature is to be 830-860^{o}C.

Based on the above remarks, it is seen that there are entirely definite but unfortunately sometimes conflicting requirements. For this reason it is necessary to make experiments for the selection of the appropriate compositions, special furnaces and selection of foaming

Table 2. Content of foaming agents in different batch and regimes of heat treatment.

Stock No	Sample No	Content of foaming agent		Temperature	Time
		%	%	^{o}C	min
1	1 - 12	1 % glycerin	3 % water-glass	800; 830; 840; 850	5; 10; 15
2	13-21	1 % glycerin	2 % water-glass	830; 840; 850	5; 10; 15
3	22 - 24	1 % glycerin	5 % water-glass	850	12; 15; 10
4	25 - 27	1 % glycerin	4 % water-glass	850	12; 15; 10
5	28 - 30	1,5 % glycerin	5 % water-glass	850	12; 15; 10

Table 3. Data from experiments carried out with variable stock content, time and temperature at initial temperature 20°C.

Sample No	Composition	Temperature	Time	Heating rate	Size of pores
		°C	min	°C/min	mm
1	3% water-glass, 1% glycerin	800	15	52	0.25
2	3% water-glass, 1% glycerin	800	20	39	0.50
3	3% water-glass, 1% glycerin	800	30	26	0.75
4	3% water-glass, 1% glycerin	830	5	162	0.25
5	3% water-glass, 1% glycerin	830	10	81	0.50
6	3% water-glass, 1% glycerin	830	15	54	1.00
7	3% water-glass, 1% glycerin	840	5	164	0.25
8	3% water-glass, 1% glycerin	840	10	82	0.50
9	3% water-glass, 1% glycerin	840	15	55	1.00
10	3% water-glass, 1% glycerin	850	5	166	0.25
11	3% water-glass, 1% glycerin	850	10	83	0.50
12	3% water-glass, 1% glycerin	850	15	56	1.00
13	2% water-glass, 1% glycerin	830	5	162	0.25
14	2% water-glass, 1% glycerin	830	10	81	0.50
15	2% water-glass, 1% glycerin	830	15	54	1.00
16	2% water-glass, 1% glycerin	840	5	164	0.25
17	2% water-glass, 1% glycerin	840	10	82	0.50
18	2% water-glass, 1% glycerin	840	15	55	1.00
19	2% water-glass, 1% glycerin	850	5	166	0.25
20	2% water-glass, 1% glycerin	850	10	83	0.50
21	2% water-glass, 1% glycerin	850	15	56	0.25
22	5% water-glass, 1% glycerin	850	12	69	0.50
23	5% water-glass, 1% glycerin	850	15	56	1.00
24	5% water-glass, 1% glycerin	850	10	83	0.50
25	4% water-glass, 1% glycerin	850	12	69	1.00
26	4% water-glass, 1% glycerin	850	15	56	1.50
27	4% water-glass, 1% glycerin	850	10	83	1.50
28	5% water-glass, 1,5% glycerin	850	12	69	1.00
29	5% water-glass, 1,5% glycerin	850	15	56	0.50
30	5% water-glass, 1,5% glycerin	850	10	83	2.00

agents.

The examinations were carried out with different foam glass batches, based on the same starting waste glass with a specific surfaces about 6000 cm^2/g but with different content of foaming agent glycerin and water glass and different regimes of heat treatment (Table 2). They are selected taking into account the previous investigation of Veleva at all. [10].

RESULTS AND DISCUSSION

The main results are shown in Table 3. It is worth noting that the size of pores varies from 0.25 to 1.5-2 mm depending on the time and temperature of burning, the rate of heating.

The mycrostructure of the samples in the cross

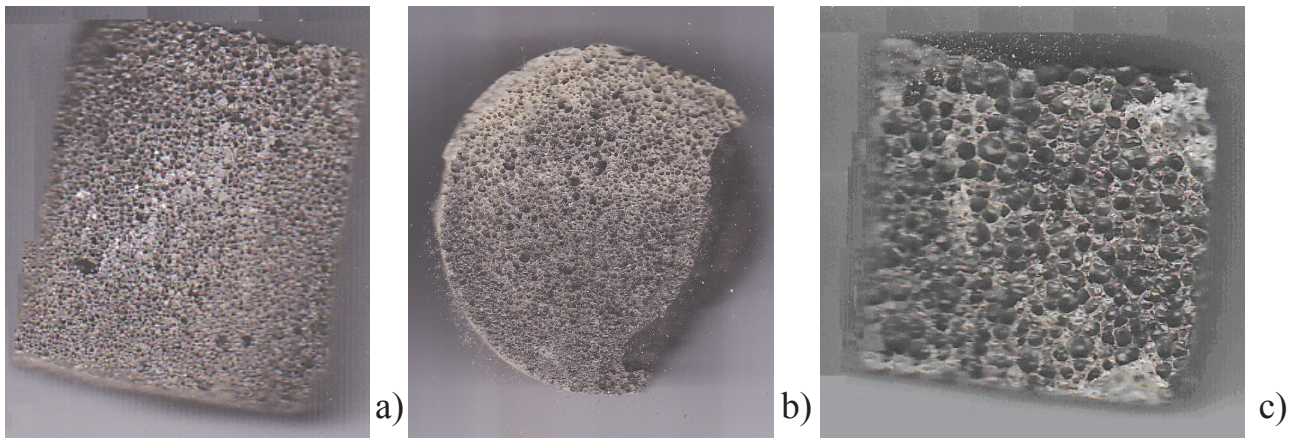

Fig. 1. General view of the foam glass samples obtained using foaming agent 1,5 mass % glycerin + 5 mass % water glass at different experimental conditions: a) at 850°C for 10 min (average 0,25 mm 60 %); b) at 850°C for 10 min (average 0.5 mm 80 %); c) 850°C for 15 min (average 1.5 mm 100 %).

section and on the surface are shown in Fig. 1. Most of the pore are closed and depending of the heating conditions they varied between 0.25 and 1.5 mm. With increasing of the temperature up to 850°C and duration 10-15 min the dimension of the pores increases. They are compared with the industrially manufactured foam glass (Fig. 2).

The coefficient of heat conductivity λ [W/(m K)] of selected foam glasses is determined in steady heat flux by measuring the temperatures on two opposite surfaces of the sample. The measurements were made using C-Therm TCI ™, which is a flexible, prompt and highly precise tool that can measure directly the heat conductivity of the sample.

The obtained results are shown below:

1. Sample No 29: pellets of content 5 % mass water glass + 1.5 % mass glycerin, temperature 850°C, time 15 min; r = 200 kg/m^3, λ = 0.05 W/(m K).

2. Sample No 30: powder of content 5 % water glass + 1.5 % glycerin, temperature 850°C, time 10 min; r = 260 kg/m^3, λ=0.083 W/(m K).

3. Sample No 28: powder of content 5 % mass water glass + 1.5 % mass glycerin, temperature 850°C, time 12 min; r = 130 kg/m^3, λ=0.02 W/(m K).

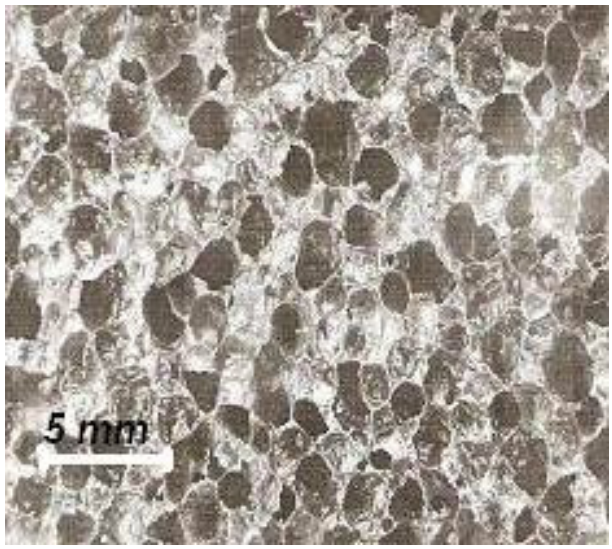

Fig. 2. Mycrostructure of industrial foam glass (Vedi Trade Co.) with size of the pores with the average size of the pores 1.5 mm (more than 80 %).

CONCLUSIONS

Several regimes for manufacture of foam glass based on waste glass and using mixture of water glass and glycerin as foaming agent are studied.

It is established that the best results (size of the pores - 1,5-2 mm) are achieved at 850°C for 10-15 min duration and heating rate 50-80 °C/min. The appropriate content of the foam agents is 1,5 % glycerin and 5 % water glass. The coefficient of the heat conductivity is compatible with the data for industrial foam glasses [11].

Aknowledgements

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