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Use of natural material (flask) of the Taskalinsky deposit of the West Kazakhstan region to obtain thermal insulation material

Abstract. Modern construction market is experiencing a shortage of highly efficient thermal insulation materials. Alkali-silicate raw mixtures in combination with high-performance fillers currently make it possible to create porous heat-insulating materials with unique properties: rigid cellular structure, specified geometric dimensions and shape, low thermal conductivity, incombustibility, high processability, environmental friendliness, etc. at a relatively low cost. The use of such heat-insulating materials in construction allows solving the problems of energy saving, accessibility and cost-effectiveness. The article considers possibility of obtaining heat-insulating material based on sodium silicate (silicate glue "Polipax") and natural material – flasks from Taskalinsky deposit of West Kazakhstan region. Technical characteristics of Polypax glue are given. Using a scanning electron microscope, elemental, chemical, and oxide compositions of the flask were studied. A recipe for a heat-insulating composite material (HCM) has been compiled.To assess the quality of the obtained HCM, its physical and mechanical characteristics were determined: density, water resistance, thermal conductivity, strength. Samples I-II in terms of density and strength showed the best results, and samples III-IV differ slightly from the technical conditions in terms of the studied indicators. It has been determined that the obtained HCM using flask as filler has a positive effect on the performance properties of the heat-insulating material, and is also economically viable, because local raw materials are used. Thus, it is possible to use flask from Taskalinsky deposit of West Kazakhstan region as filler for heat-insulating material.
Key words: flask, liquid glass, heat-insulating material, water absorption, strength, thermal conductivity coefficient.

Introduction

It is economically unprofitable to use materials such as traditional brick, lightweight concrete for thermal protection of enclosing structures. In the manufacture of building structures, the use of indestructible highly efficient heat-insulating materials is required.

To compensate for heat losses, it is necessary to increase the heating of building or use more efficient heat-insulating materials. The last case is advantageous, because in this case, 17% of fuel is saved. In addition, the use of highly efficient thermal insulation materials reduces construction costs and material consumption.

The introduction of resource-saving technologies is an important direction in the development of building materials industry. In various regions of the country, resource conservation is facilitated by the involvement of industrial waste and by-products in the production [1-4]. At the same time, raw materials of technogenic origin with a high degree of technological readiness are the most effective in terms of resource saving.

The use of two-layer heat-insulating elements with a dense finished structure will make it possible to complete the construction of buildings in less time and increase the degree of industrialization. Science has accumulated a real potential for creating new effective materials based on the improvement of processes and equipment.

So, for example, in [5] the results of studies on the production of heat-insulating, heat-insulating-structural and heat-resistant building materials based on filled liquid glass compositions using low-energy foaming technologies are presented. As a raw material, ultrafine microsilica was used, a waste of a ferroalloy plant. Regularities of structure formation were determined, which provide strength, heat-insulating and heat-resistant characteristics of the building material. The advantages of technological solutions that ensure the stability of technical characteristics of materials were noted, which is important when using foaming technologies.

The authors [6] studied composite material liquid glass–graphite microparticles with increased thermal stability and thermal insulation properties. A composition consisting of graphite (42% by mass), liquid glass $Na_2O(SiO_2)_n$ (50% by mass) and hardener – sodium fluorosilicone Na_2SiF_6 (8% by mass) was proposed.Values of limit loads, nature of discontinuous surface, numerical values of specific heat capacity and coefficient of thermal conductivity were determined. Studies have confirmed the increased thermal insulation properties of the proposed composition.

No less interesting is the work [7], which presents an overview of the world experience in the production of foam glass materials using various raw materials, and also describes the results of research into the technology of foam glass foaming based on various types of silicate raw materials.The properties of synthesized samples and their microstructure have been studied. The conclusion is made about the applicability of silicate raw materials in the production of porous materials.

The paper [8] considers a method for manufacturing foam glass using float glass waste and sodium hydroxide. Titanium dioxide TiO_2 was introduced as hardening additive. The compositions consisted of, % (by mass): titanium dioxide – 20, sodium hydroxide – 3-17, ground glass – the rest. It is shown that samples containing 11% (by mass) NaOH and 20% (by mass) TiO_2, and without it, have the following strength values, respectively 3.40 and 0.48 MPa.

Over the past decades, composites have actively entered practice and replaced traditional materials in energy, transport, electronics and other fields of activity. The difference between most composite materials and traditional ones is that the process of their manufacture can be combined with the process of manufacturing the product [9]. There is also world experience in the use of composite technologies based on carbon fibers [10-15].

Liquid soda glass, powdered mineral fillers and special additives are used as raw materials for foamed liquid glass materials. Foam production consists of special processes (fig. 1):

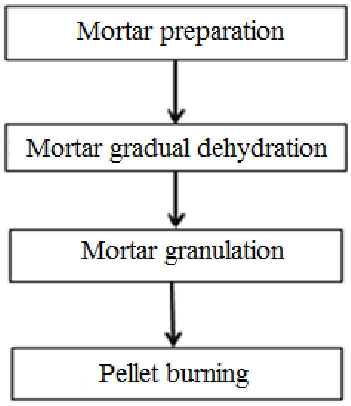

Figure 1 – Foam materials production scheme

In connection with the foregoing, the purpose of this work is to obtain composite heat-insulating materials based on liquid glass using flasks (local raw materials) from Taskalinsky deposit of West Kazakhstan region as filler.

Materials and methods

The main raw material for the production of the proposed materials is the flask from Taskalinsky deposit of West Kazakhstan region, which is a homogeneous mixture of light green color (Fig. 2), consisting of opal silica (60-80%), clay (10-40%) and soil-aleurite (up to 10%) material. A feature of the flask is the mesocompatibility of the structure, mechanical strength, high dispersion, and, as a result, high water absorption capacity. Physical and mechanical properties of the flask: bulk density – 1.49-1.59 (1.54) g/cm^3, natural moisture content -14.3-23.83 (17.88)%, activity – 17.81-44, 5 (37.1)%. Chemical composition of the flask is represented mainly by silicon dioxide SiO_2. These properties of the flask make it possible to use it as filler for the manufacture of heat-insulating materials.

The binder in the work is the liquid silicate glue Polypax, the basis of which is sodium silicate. Features of Polypax glue: when foaming, it ceases to conduct heat, therefore it is used to create heat-saving materials; withstands heating to very high temperatures, for some brands the limit is more than + 1000 degrees.The table 1 shows the technical characteristics of the glue.

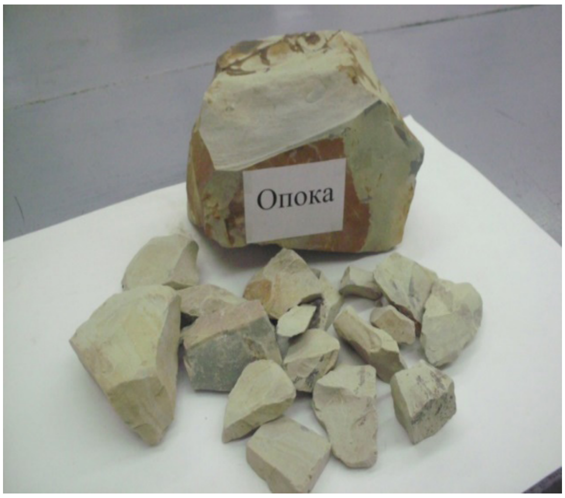

Figure 2 – Flask from Taskalinsky deposit of West Kazakhstan region

Table 1 – Technical characteristics of Polypax glue

Appearance	Thick yellowish or slightly greenish liquid
Density	1.36-1.45 g/cm^3
Mass fraction of insoluble substances	0.2 %
Shelf life in closed containers	2 years
Freeze/Defrostpossibility	allowed
Operating temperature of insulating layer	1300 ^{0}C

The flask has a strengthening effect when introduced as filler into liquid glass, which is an inorganic polymer. This action depends on the binding properties of liquid glass.

Results and discussion

Physico-mechanical properties of the flask have been determined. Experimental data are shown in Table 2.

Table 2 – Physical and mechanical properties of flask

Fraction sizes, mm	Bulk density, g/cm^3	Water absorption, %	Splitting up, %	Thermal conductivity, W/m K
5-10	561	44.50	28.29	0.08
10-20	553	46.60	28.57	0.08
20-40	528	45.20	28.16	0.07

Chemical composition of the flask was studied by physicochemical methods using X-ray phase (X-600, France) and differential thermal analyzes (DTG-60, Japan), as well as using a scanning electron microscope (Hitachi SU8220, Japan). Figure 3 shows the flask radiography.

Using a scanning electron microscope, the elemental and oxide compositions of powdered, chipped and thin sections of the flask were determined.As an example, in fig. 4 shows the elemental composition of the flask in the form of a chip.

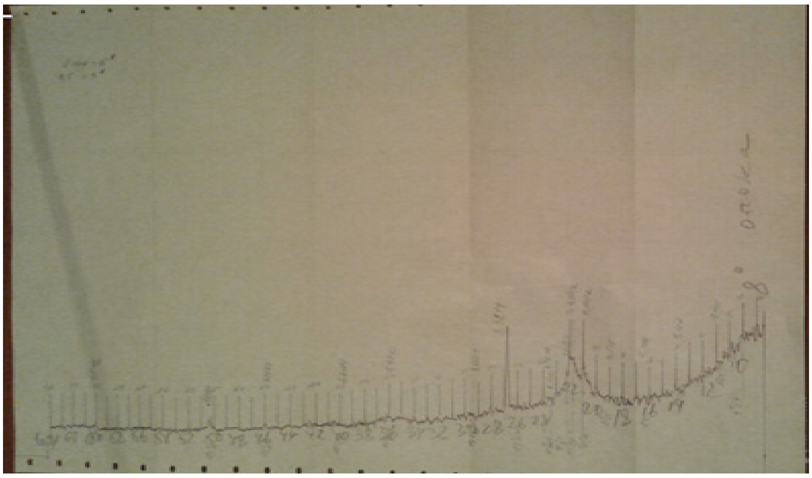

Figure 3 – X-ray of the flask

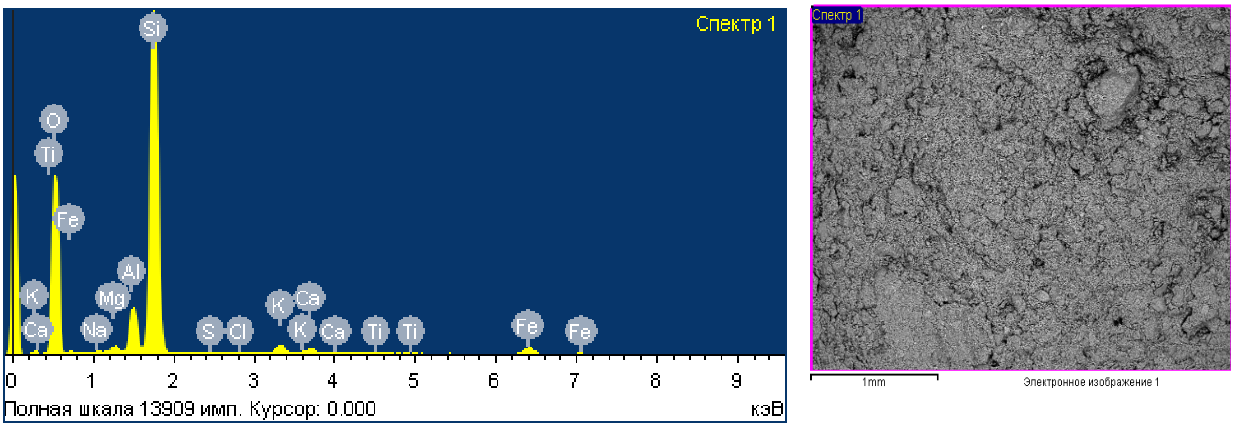

Figure 4 – Elemental composition of flask in the form of chip

Figure 5 shows the oxide composition of the studied raw material (flask).

To prepare composite material samples, the flask was crushed using a ball mill. The crushed flask was removed every 15 minutes in the amount of 250 g. Physical parameters of the crushed flask were determined using PSKh-K device (Table 3).

Effective composition of heat-insulating material based on liquid glass and flask has been developed. 4 composite material compositions were made. Mass ratios of the components are presented in table 4.

Composite materialpreparation method: the components were placed in glass beakers and stirred for 10-20 minutes until a paste-like mass was formed. Then the masses were transferred into porcelain crucibles and placed in a muffle furnace heated to 600 ^{0}C. And kept in the oven for 15 minutes.

Physical and mechanical properties of the obtained samples of composite material were studied (Table 5).

Table 5 shows that using siliceous rock (flask) it is possible to obtain heat-insulating materials with different pore sizes. Heat insulators obtained on the basis of liquid glass and flask in terms of density, water resistance, thermal conductivity coefficient and strength meet technical requirements.

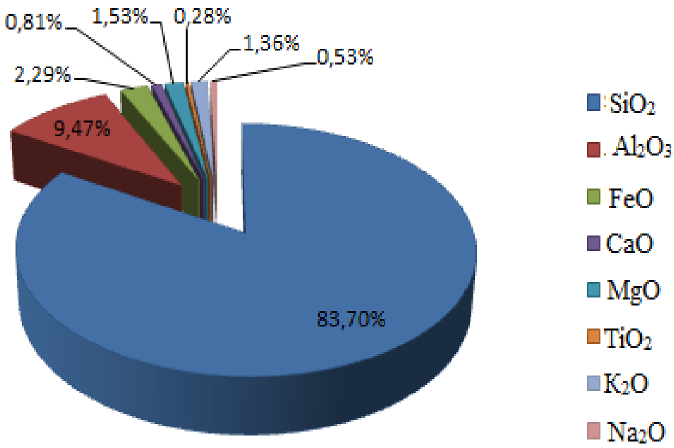

Figure 5 – Oxide composition of flask

Table 3 – Physical indicators of the crushed flask

Specific surface, cm^2/g	Average particle size, microns	Density, g/cm^3
3891	9.6	1.61
5458	6.8	1.61
6130	6.1	1.61
6390	5.8	1.61

Table 4 – Component composition of composite material

Sample No.	Component, wt. %	
	Flask (average particle size, µm)	Liquid glass (Polypax glue) (ρ=0.9 g/cm^3)
I	50 (9.6)	50
II	50 (6.8)	50
III	50 (6.1)	50
IV	50 (5.8)	50

Table 5 – Physical and mechanical characteristics of the manufactured samples of composite material

Sample No.	Density, ρ, kg/m^3	Water resistance, K_p	Coefficient of thermal conductivity, λ, W/mK	Strength, Rc, MPa
I	610.0	0.900	0.116	4.34
II	594.5	0.870	0.113	4.20
III	574.0	0.859	0.109	4.00
IV	563.0	0.847	0.107	3.90
GOST 7076-99	400-600	1.000	0.100-0.140	1.20-4.00

The main problem of the widespread use of foam glass materials is their high price relative to other heat-insulating materials. In the world practice, the production of heat-insulating foam-glass materials based on cheap natural and technogenic silica raw materials is being studied. In this article, samples of heat-insulating material are made, obtained on the basis of sodium silicate and local natural raw materials – flask. 4 samples of composite material were made in a percentage ratio of 1:1 (50% – flask, 50% – sodium silicate), but with different particle sizes of flask. The best result was shown by the 1st sample with a particle diameter of 9.6 µm, which exceeds the values according to GOST in terms of density and strength. Good results were shown by the second sample with strength of 0.2 MPa more than the maximum permissible norms (MPN), the density and thermal conductivity values correspond to the technical conditions. The results of analyzes for samples III and IV are satisfactory. However, it should be noted that all 4 composite materialsamples slightly differ from MPN in terms of water resistance values. It has been determined that, in general, it is possible to use flask from Taskalinsky deposit of West Kazakhstan region as filler for liquid glasses.

Conclusion

The paper synthesized heat-insulating materials that are most widely used in construction, studied their properties and selected the most effective heat-insulating material – foam glass, which has good thermal properties and has the best environmental performance, as well as resistance to aggressive factors.The resulting heat-insulating material is a silicate material with evenly spaced pores separated by thin vitreous partitions, has the necessary properties and, due to the foregoing, can be accepted for research aimed at its improvement (modification). The research results can be applied in the production of foam glass, which is used for thermal insulation of buildings and structures, equipment, pipelines.

Thus, according to the results of the conducted studies, it was proved that flask from Taskalinsky deposit of West Kazakhstan region can be used as filler for the production of heat-insulating materials. The possibility of obtaining building materials based on local raw materials (flasks) is shown, which contributes to saving material and energy costs in the production of multi-purpose building materials. The use of flask will expand the mineral resource base of plants for the production of thermal insulation materials.

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