UTILIZATION OF WASTES

PRODUCTION OF FOAM GLASS WITH GRANITE SIFTINGS FROM THE MIKASHEVICH DEPOSIT

N. M. Bobkova,1 S. E. Barantseva,1 and E. E. Trusova1


The possibility of using granite siftings from the Mikashevichi Deposit in the Republic of Belarus for production of porous heat-insulating materials was investigated. The initial glasses were synthesized with from 50 to 70% (by weight) granitoids and additional incorporation of quartz sand, chalk, and soda. The region of compositions with the necessary viscosity at foaming temperatures of 800 and 830°C was determined. Foam glass with a bulk density of 180 – 190 kg/m³, compressive strength of 0.72 – 0.78 MPa, and heat conduction of 0.091 W/(m·K) was fabricated with these compositions. The possibility of manufacturing foam glass by adding up to 60% of inexpensive natural raw material to the batch was demonstrated.

The market for heat-insulating materials is now practically limited to four types: foam plastic (primarily polystyrene foam), gas concrete, mineral wool, and foam glass.

The use of foam plastics in construction not only causes serious problems related to the high fire hazard, environmental toxicity, and adhesive incompatibility with cement and ceramic structures, but also and especially due to the fact that safety structures will not ensure the required heat resistance after 7 – 10 years [1, 2].

Mineral wool articles create important environmental problems during production and have yet another important drawback — a short lifetime, especially in a humid atmosphere.

Gas concrete, widely used in construction, is the most reliable and lasting, but it also has some drawbacks such as low strength and moisture and cold resistance.

One of the most promising heat-insulating materials is foam glass, which has a number of advantages over other heat-insulating materials: it is durable, incombustible, impermeable to moisture and steam, chemically stable, and is characterized by the stability of the physical characteristics in time and low density, is environmentally safe, and is not subject to degradation [3].

In the mid-1950s, there were important process difficulties in fabricating quality industrial foam glass. To solve them, Gomel’sk Glass Works was selected in the USSR as the enterprise for introducing the latest scientific advances in foam glass production. A science and technology school on foam glass production problems was created in Belorusia. The well-known Belorussian scientist, Dr. B. K. Demidovich, who made important efforts to optimize chemical and physical processes in foam glass production, headed the school [4, 5]. Sector scientific sections were involved in solving these problems. This became one of the main factors that allowed such unique production of foam glass in Belarus to survive in the 1990s. At the end of the 20th century, Germany, the Czech Republic, and Poland lost their own production. At present, there are Pittsburgh-Corning foam glass works in Germany and the Czech Republic; Pittsburgh-Corning is the largest manufacturer of foam glass in the world.

In most cases, foam glass production is based on the use of bottle (most common), container, or sheet glass cullet. Table 1 reports the compositions of container glass suitable for manufacturing foam glass [6].

The generalized compositions of glasses for production of foam glass can thus be represented as (%): 67 – 72 SiO₂, 1 – 6 Al₂O₃, 7 – 11 CaO, 1 – 7 MgO, 14 – 15 Na₂O, 2

However, cullet is used to a significant degree in basic production as reusable, so that supplying foam glass shops with cullet significantly limits the production volumes. In organizing high-capacity foam glass production, the glass melt is cooked in special bath furnaces followed by granulation.

1 Belarus State Technology University, Minsk, Belarus.

2 Here and below: mass content.
For this reason, there was such a furnace for cooking glass and obtaining glass granulate to supply the raw material for operation of the foam glass shop at Gomel’ Glass Works. Traditional glass production materials were used as the raw material.

Since the granulate obtained was more expensive than cullet, the question of using cheaper raw materials in production of granulate always arose. One way of answering this question was to obtain initial glass granulate from cheap natural raw material or industrial wastes. The promise of using sludge from Achinsk Alumina Combine and other associated wastes was demonstrated in [7]. The authors proposed a batch composition containing 25% nepheline sludge, 55% sand, and 20% soda for production of heat-insulating material with closed pores and a uniform structure. A feature of nepheline sludge is a significant CaO content (up to 53%), which gives glass high chemical stability and is simultaneously a good flux.

RF Patent No. 21292397 proposes a method of obtaining porous glass materials from zinc production slags. The invention concerns the area of processing zinc production slags into porous heat-insulating materials for construction with associated production of zinc vapors. The method of obtaining porous glass materials from the slags consists of the following. Up to 3% carbon is added to slag of the composition (%): 42.0 – 47.0 SiO₂, 17.0 – 20.0 Al₂O₃, 6.0 – 8.0 Fe₂O₃, 24.0 – 30.0 CaO, 4.0 – 6.0 MgO, 2.0 – 3.0 ZnO, 1.0 – 1.8 Na₂O. Melting is conducted in a reducing medium, and the melt is cooled by pouring in water. Glass material with low thermal conduction is obtained with this method, and this allows using it as heat-insulating material, but such material contains hydrogen sulfide, which worsens its heat-insulating properties.

A method of obtaining porous glass materials from non-metalliferous raw material is described in RF Patent No. 221181. The technical result of the invention is expansion of the range of foamed compositions from melts of non-metalliferous raw material and fabrication of porous glass materials with a bulk density of 30 – 100 kg/m³.

The use of natural raw materials for production of foam glass is of great interest. The use of readily sintering rocks with a high content of alkalis — trachyte, syenite, nepheline, obsidian, volcanic tuff, etc., is currently being widely studied. A composition of production of foam glass containing nepheline syenite, volcanic glass, and container glass cullet in the following ratio of components (%), is proposed in RF Patent No. 2164898: 5 – 15 nepheline syenite, 45 – 55 container glass cullet, 7 – 9 sodium oxide hydrate, remainder — volcanic glass. Addition of nepheline syenite to the batch complicates the composition and increases the thermal stability of the glass due to aluminum oxide. A heat-insulating material is obtained — foam glass with improved properties (structure and density).

Use of compositions with different ratios of tripoli and soluble sodium silicate is proposed in [8]. The proportion of tripoli is 25, 37.5, and 50%.

To reduce the volume mass and foaming temperature of foam glass, RF patent No. 1821452 reports the following batch composition (%): 99.2 – 99.5 zeolite-containing tuff, 0.5 – 0.8 silicon carbide. Tuff contains calcites as impurities, and in decomposing, they yield calcium oxide, a strong flux that reduces the melting point of the batch. CaO also decreases the viscosity of the aluminosilicate melt, which allows manufacturing light foam glass since the ability of the melt films to stretch increases. The pore structure of foam glass becomes more developed and the volume mass de-