Composite materials based on liquid-glass binder for thermal insulation

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Abstract

The relevance of the work is due to the fact that thermal insulation currently plays a significant role in various sectors of the economy. It helps to solve important issues of life support, organization of technological processes, and energy saving. The construction industry, heat power engineering, metallurgy, shipbuilding, housing and communal services are in need of modern effective thermal insulation materials. The market offers a wide range of effective, in terms of thermal protection properties, thermal insulation materials of an organic nature. However, they have significant disadvantages — combustibility and release of asphyxiating gases during combustion, low corrosion resistance, short-lived, as well as low mechanical properties and resistance to high temperatures, which significantly limits their application. In this regard, the development of compositions and technologies for obtaining absolutely non-flammable, fire-safe products with high thermal protection properties and capable of withstanding long-term exposure to high (up to 1000ºC) temperatures without loss of properties based on mineral fillers and inorganic binders is an urgent problem. The use of hydration-hardening binders for this purpose does not allow achieving this goal, since they are actively dehydrated and subjected to destruction under the action of high temperatures. All these requirements are met by thermal insulation materials based on additionally foamed chemically cured liquid glass and various light fillers. In addition, these materials can be produced using a fairly simple, from the hardware point of view, technology on affordable and cheap raw materials, so their cost is not high. At the same time, unlike organic polymer insulation, they are absolutely non-flammable, as well as foam concrete on Portland cement.

The purpose of this work is to develop methods for obtaining and composing thermal insulation materials based on mechanically foamed, volumetrically cured liquid glass and mineral fillers.

Scientific novelty

1. The relationship between the composition of sodium liquid glass and the polymer structure of silicon-oxygen anions, as well as between the average degree of polymerization of KKA (N_{av}) and the surface tension (σ) of the sodium silicate solution, which play a leading role in the foaming of the binder, is established and quantitatively described. It was found that N_{av} increases with increasing of silicate concentration and increasing of modulus of liquid glass. The effect of N_{av} on σ becomes significant only when the proportion of the polymer fraction increases to 70% or higher.
2. The dependences of the values of surface tension (σ) and the foaming coefficient on the liquid glass and the concentration of the foaming agent are established. It was found that the foaming is mainly determined by the concentration of foaming agent and the density of the liquid glass, while the modulus in the range of its values from 2.3-3.0 does not significantly affect the foaming.
3. The possibility of bulk solidification of liquid glass using various hardeners is investigated. In terms of setting and hardening rates, molding properties and strength of hardened foams, the optimal hardener is Na_2SiF_6.
4. The possibility of using various foaming agents for liquid glass and their concentrations, allowing to obtain stable foams, is investigated, and the dependence of foaming coefficient from silicate module, the density of liquid glass, its surface tension and foaming conditions is established. The

optimal foaming agent is PB-Lux at its concentration of 4-6% of the mass of liquid glass, the optimal foaming coefficient is 4-5.

5. The possibility of using light and needle-like mineral fillers in combination with a foamed liquid glass binder for the production of thermal insulation materials is investigated and the optimal areas of compositions are determined for each. It is established that the proposed technology on the basis of different fillers can produce a wide range of materials with the complex of characteristics that are determined by the requirements for thermal insulation and their service conditions.
6. The type and quantity of additives that modify the liquid glass and do not interfere for foaming are selected, which allow to increase the strength and prevent cracking of the final material, while not reducing its thermal protection properties. The most effective additive is PMS-50 polymethyl siloxane in an amount of 1-1.5%, which provides increasing of strength on different fillers by an average of 8-10 times.

Practical significance of the work

The developed technological methods for obtaining porous materials based on the established optimal compositions containing volumetrically cured foamed liquid glass binder, as well as various natural and artificial light and needle fillers can be used to develop a technology for the production of effective mineral thermal insulation products that are non-combustible, fire resistance up to 900°C, corrosion resistance, water-resistant and biostability, and due to the availability of raw materials and low energy and material costs that can successfully compete with the available materials of this class on the market.