Produce foam Glass Crystalline Insulating Material Based on Anthropogenic Raw Materials in Kazakhstan According China's Experience

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***Abstract*—In cold regions of Kazakhstan and China, the use of thermal insulation materials in the designing of buildings is one of the most important issues. In China is a quality use of environmentally friendly materials. China has experience of using green materials are in the processing of secondary materials blast furnace slag, gypsum, slag, ash and the steel slag, ash and other low environmental load. To improve the properties of chemical building materials used to optimize production, the introduction of new technologies. The total CO_2 emissions could reduce by 30% to 40%. This study proposes a method for improving the thermal insulation foam glass-material and provides a method a considerable reduction of energy consumption and hence the cost can be achieved using a two-stage low-temperature glass synthesis technology and process waste granulates using as a main component. The case study shows, the resulting foam glass crystalline insulating material is environmentally friendly because it complements the original components are non-toxic and non-corrosive substances; the resulting material has a high chemical stability and biological refractory. The proposed method, by the core process of architectural design, uses an approach focused on efficiency, to find solutions that meet the requirements. The use of foamed glass solves practical optimization problems in the construction.**

***Index Terms*—glass granulate, viscous modulus, glass synthesis, CO_2 emissions, crystalline**

I. Introduction

Green building is better able to make environmental concerns a comprehensive response to the building. Its aim is to provide mankind with a healthy, comfortable, efficient work, living space as much as possible to save energy and resources and reduce the impact of natural and ecological environment. The consensus on the formation of environmental awareness in the field of architectural design is an important prerequisite for the formation of a green environment and green building. Government agencies, businesses, people are obliged to implement in their work and life processes in this awareness. Green design building materials must meet the following five principles: the choice of construction materials must consider the possibility free of environmental pollution in their production process; the energy expended in the manufacture of materials; excessive use of natural resources; re-use of recycled materials used in the manufacture of building materials.

The industry of building materials in the construction based on research. In Kazakhstan, there is a problem in the production of green building materials, related mainly based on the cost of energy, excessive resource consumption, and environmental pollution. Thus, it is very harmful for sustainable economic development of Kazakhstan in the 21st century. Therefore, the develop green building materials are to change the industry of construction materials fundamentally in Kazakhstan, which has long been a high level of investment. High-level pollution and low efficiency of the extended mode of production, select the resource, contamination of the lowest type, quality and effectiveness, technology-oriented approach to development, with the development of industry and protect the ecological environment, pollution control. This is the only way of development of Kazakhstan building materials industry in the new century

II. Literature Review

Ying Pan, Xiao Gang Zhao, Juan Li [1] discussed the domestic and international status of green building materials research the concept of green building materials; achieving green building materials status assessment of ecological building materials and renewable energy sources, the use of composite materials. The authors describes the way of use and development of green building materials

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The purpose of the study to establish the fundamental possibility of producing foamed glass crystalline material of the low-temperature technology on the basis of local technological waste, as well as to consider possible solutions, based on China experience construction should be noted that in the architecture, the housing structure has a large heat loss, and the walls constitute a large part of the body structure. This is the main aspect of the reform and development of energy-saving technologies [2].

Wall Materials: An amount of green material wall in China to replace some or all of the natural resources of wall materials using industrial waste. It currently has a broad range of applications, including the new Thai cypress boards, third light wallboard, concrete block board, expanded clay article gap autoclave reinforced floor slabs and calcium silicate.

According to the China revealed a higher level of use of environmentally friendly materials that will further allow analysing the methods and apply it. According to the research Jie Li, Fang Wang [3] comparison between the simulations of energy saving and the corresponding data from the engineering applications are also shown in this paper, a passive building in China by the German energy conservation codes to use the external walls. For some characteristics, the passive house requires a proper thickness of the insulating layer to obtain the optimum balance between performance and cost. The first passive house in China, that is, the so-called Langshi Passive House authorized the Deutsche Energie-Agentur, scholarly from the Chinese Academy of Building Research (CaBr), conducted energy-saving analysis received the optimal thickness of the heat-resistant insulating layer, taking into account production through layers of different thickness and the average annual output. The total aggregate value of wall heat transfer indexin average power at the expense of production is in EPS-square meter with a thickness of 25-200mm [4], [5].

Energy uses buildings in China divide into three stages, today uses the second stage of the standards and requirements for energy saving, as it enters the third phase. In developed countries are at the same latitude observed heat flow per unit area of 2 ~ 3 times less. The main reason for deteriorating insulation characteristics are conversion of buildings, two-thirds of the energy used in a random order. In the development of energy efficiency standards implementation the practical of the third stage, there are three common practices of external insulation of walls: exterior wall internal insulation of exterior wall system External insulation, exterior insulation system of walls

Kitaigorodsky I. I, *et al*. 1961, Gorshkovs V. S., 1988, Kazmina O.V., 2010, O.V. Kazmina, 2009 showed that the choice of the furnace burden composition for liquids a foal glass material is has carried out taking into account the following conditions [6]: the quantity of glass former and oxides of alkaline metals, the amount of fusion is to be not less than 70%, the liquid phase is to have optimum viscosity (103-106 Pa·s) in the temperature interval of foaming, the temperature of the liquid phase formation (fusion) should not exceed 950℃ that reduces energy consumption. The presence of crystalline phase has a positive effect on physical and mechanical properties of the finished foam, while according to the size of the crystalline phase of the particles and some its certain conditions.

Kazakhstan is proses of foam glass will increase value if using competitiveness reduces to compare with other types of insulation. Therefore, a practical development has interested of technology for foam glass materials based on various available technogenic raw materials at low-temperature synthesis technology of glass granulate. The glass granulates an intermediate product, which readies by the foaming mixture to produce the foam glass. Synthesis of granulate glasses carry out at relatively low temperatures not exceeding 950℃; conventional glass melting was compared temperatures of 1300 - 1400℃, which takes place it. In the synthesis of the glass granulate under low temperatures; the product is a glass crystalline material.

III. Methodology

Conventional optimization of building materials primarily oriented insulating properties of the building, use energy-saving technologies. This problem is particularly noticeable in the cold regions. Often a significant amount of energy, that must be used, which leads to minimizing consumption of material.

A. *Theoretical Approach*

In accordance with the development of green building materials abroad, combined with practice, the author believes that the development of green building materials will follow these trends.

Saving energy in the production of building materials, improvement of properties due to the introduction of new methods. Minimum consumption of resources and minerals, energy-saving building materials are characterized not only by the properties of energy saving, but also to optimize the production process. Environmentally sound uses only pure materials, as well as the use of secondary materials and waste in the production of green building materials.

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In the China passive building codes use the heat-insulating materials, that apply in cold winter area contain vacuum insulation panel, inorganic heat insulating mortar, polyurethane rubber sheet, wool plate, extruded polystyrene board, loam glass plate, mineral expanded polystyrene mortar, foamed cement plate, B-EPS, phenolic foam board, common molding of polystyrene. According to analysis in Kazakhstan raw materials and process to produce the possible way to produce will be producing foamed glass crystalline materials in the two-stage technology without glass melting the schematic of flow sheet producing foam glass crystal materials for a two-step technology is shown Fig. 1.

A two-stage technique is based on a powder method and involves three main stages. The first steps in obtaining the glass granulate under low temperature (not more than 950 ℃) synthesis.

In this verification process is carried out on a standard for the industry of building materials equipment, without the use of high-cost and energy-intensive glass furnaces. The second step of the preparation of the foaming mixture of glass powder granulates with the gasifier, the foaming process to produce finished foam.

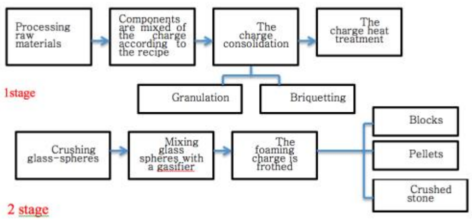

Figure 1. Schematic flow sheet producing foam glass crystal materials for a two-step technology

A two-stage technology for producing foam glass crystalline material (hereinafter FGCM) stages allows optimizing the structure and properties of the material, depending on its destination. At the first stage the synthesis problem is solved glass granulate with the desired properties, which can be controlled by prescription and technological factors. At the second stage, the management of the main indicators of macro- and microstructure of the material

Temperature batches for low-temperature processing window glass granulate should meet the charge phase transition from solid to viscous flow (with the formation of the melt in an amount not less than 75%), which is determined by the composition of the charge and the nature of its main component. Heat treatment mode is selected individually for each form of the prosecution.

As a result of the heat treatment charges at temperatures not less than 0.8 times is not reached the equilibrium temperature of the system and the crystal phase is retained. It should not exceed 25% in granulate. After foaming crystalline phase content is reduced to 15 to 4% values.

The resulting granulate is milled, mixed with the gasifier and produce foam. Gasifier must be the requirements: the gas phase by heating should be allocated only after sintering; gradual pressure increase of degradation products in the temperature range of sintering. Foaming, depending on the type of product, there is a conveyor or a rotary kiln.

B. Experimental Procedure

The main components of the first furnace burden are natural and anthropogenic materials. Depend on the type of raw materials is corrected the furnace charge composition by various additives. The basis of the furnace charge and made by three components: silicic (waste), alkaline (calcinated soda) and carbonate (dolomite). The main requirements for the initial silicic material are its fine dispersibility (the average size of particles less than 100 microns) and chemical composition, to the furnace burden it is resistance to glass forming, quantity, formed fusion, and its rheological properties.

In the work, there were used the tails of enrichment of copper-zinc ore of Kazgidromed LLP, which chemical composition is determined by the X-ray- fluorescent analysis data (Fig. 1). The waste was crushed previously on a planetary mill to a particular surface of the powder, according to the results of measurement on Tovarov's device, 5000 cm2/g.

By its chemical composition, the considered waste does not conform to the requirements of standard 22551-77 of silicic raw materials for glassmaking as it differs in the lowered content of the primary glass formed (SiO_2) and raised in comparison with glass sand, the content of such impurity oxides as Al_2O_3, Fe_2O_3, and CaO. In the phase composition, the material is presented by quartz and albite.

For glass forming from the furnace burden by waste in the composition, there were additionally introduced oxides of alkaline metals in the shape of calcinate soda, the chemical composition of an average test of the studied materials.

Considering that the studied waste contains, except silicon dioxide (to 80% of SiO_2), rather a high amount of aluminum oxide (to 10% of Al_2O_3). For the preliminary selection of the phase composition of the furnace burden there is carried out the analysis of the chart of the three-component system $Na_2O–Al_2O_3–SiO_2$.

The concentration zone of the compositions are having at temperatures below 950 ℃ not less than 70 % of fusion. In the Figure it is seen that the area is limited according to the content of containing SiO_2 (60-75 %), Al_2O_3 (5-15%) and Na_2O (13-20%). Almost all compositions get into the same elementary phase triangle $Na_2O \cdot 2SiO_2$ – $Na_2O \cdot Al_2O_3 \ 6SiO_2$ (albite)-SiO_2 and cover the zone of tridimite crystallization. Material characteristics were explained in Fig. 2. The most fusible eutectic of the system is between disilicate, albite and silicon dioxide with the temperature of melting 740 ℃. The composition of glass granulates suitable for obtaining FGCM by the low-temperature technology is to correspond to particular values of criteria. Such criteria are the Module of Viscosity (MV), the factor of connectivity (Y), the coefficient of the anion structure (CAS). The calculation the module of viscosity was performed by the principle of oxide impact, in the numerator, there are the components increasing viscosity, in the denominator the lowering ones (1). The different implications of the glass components on viscosity are considered by the use of multipliers connected with the size of the ionic radius of the cation. The higher is the multiplier at the component; the stronger is this element's impact on viscosity. The module of viscosity of silicate glasses used for foam glass changes in the range of 1.68…1.97. The borders of the module of viscosity of optimum structures for alumosilicate fusions are expanded to values 1.8 ÷ 2.2.

$$M_B=(M_{SiO_2}+2M_{Al_2O_3})/(2M_{Fe_2O_3}+M_{CaO}+M_{MgO}+2M_{K_2O}+2M_{Na_2O}) \quad (1)$$

where $M_{Rm\ On}$ is some corresponding oxides, mass. %.

The factor of connectivity of the structure is determined as an average number of mastic oxygen of structural polyhedrons by the formula

$$Y = (\Sigma\ mi\ xi\ z - \Sigma\ mk\ xk)/\ \Sigma\ mi\ xi \quad (2)$$

where x - is the molar content of oxide, %; m - is the number of cations in oxide; i and k - are oxides containing cations with the number of bonds larger than one and equal to one, respectively; z - is valency (coordination number).

The optimum factor of connectivity of the fusion structure for obtaining foam glass crystalline materials there are accepted values 3.30…3.36 that coincides with the data characteristic of industrial silicate glasses.

The coefficient of the anion structure is determined by the ratio of the number of oxygen atoms to the sum of the number of silicon and aluminum atoms by the formula

$$CAS = O/(Si + 0,75\ Al) \quad (3)$$

At a value of CAS from 2.2 to 3.0 the anion structure of fusion is presented by discrete anions from the polymerized rings of Si3O96- or Si4O128-. In crystallizing glasses, such a structural dependence remains before crystallization, and in non-crystallizing glasses to the value of viscosity 102 – 102,5 Pa·S (O.V. Kazmina., 2010)[7]. The ability of glasses to crystallize increases with the growth of the coefficient, at values of CAS > 3 fusions inclined to spontaneous crystallization, with a decrease of the coefficient owing to the complication of the anion structure crystallization ability falls. Fusions with CAS < 2.4 are poorly boiled and clarified because of high viscosity (O. V. Kazmina., 2010), [8].

The component composition of furnace burdens is calculated proceeding from the chemical composition of the raw materials entering the furnace burden and the chosen basic composition of glass by solving the system of equations. For basic compositions of glass structures in which oxides were making its basis change in the following limits, mass. %: SiO_2 62–73; Al_2O_3 5–15; Na_2O 22-23. The furnace burden chosen for the experiment has the following structure, mass.%: 80 – waste; 20 - calcinated soda [9]. The calculated composition of glass granulate and the composition of the reduced to the three-component granulate which the presented data conforms to the requirements imposed to low-temperature glass granulate.

C. Glass Granulate Synthesis

Glass granulate represents a mainly amorphous product of low-temperature processing of the furnace burden with the present residual crystal phase which contents influences the ready material durability, [10].

Before heat treatment, the furnace burden was compacted that provides faster, uniform warming up and growth of chemical activity of the furnace burden in comparison with powdery one. For this purpose, the powdery furnace burden was moistened previously with 15% solution of liquid glass to 5…7 mass. % and pressed in the form of tiles of 1010 mm in size. Heat treatment of the furnace burden was preliminarily carried out on samples in the form of cylinders of 1020 mm in size which was heated in the muffle furnace at temperatures 900 and 1000 ℃. After thirty minutes of keeping the cylinders of the furnace burden at the maximum temperature the samples completely vitrified show Fig. 2.

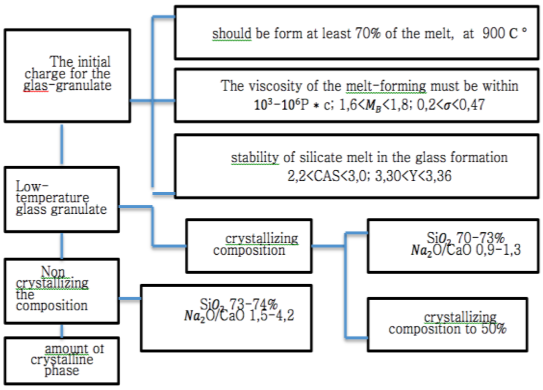

Figure 2. Criteria for assessing the suitability in the composition charge and granulate for FGCM

Interpretation of the e composition of the obtained glass granulate was carried out using the Crystallographic Search-Match program. According to the glass phase (70 mass.%), the obtained glass granulate meets the above requirements, show Fig. 3.

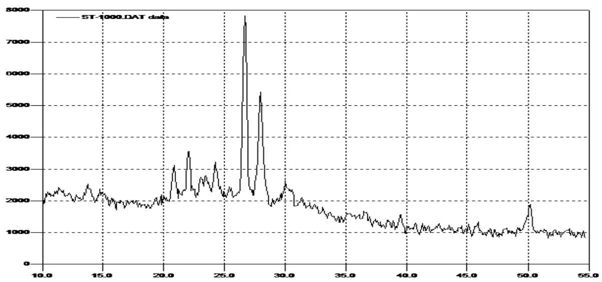

Figure 3. Glass granulate radiograph obtained at 1000 ℃

Thus, the select option for obtaining FGCM by the low-temperature technology is the synthesis of glass granulates at the temperature 900 ℃ from the two-component furnace burden containing 80 masses. % of waste and 20% of calcinated soda.

IV. CONCLUSION

The perspective trend directed both to the solution of the environmental problem of utilization of anthropogenic waste and to obtaining foam glass crystalline materials as a useful production is the development of a technology of obtaining foam glass crystals based on anthropogenic waste containing high siliceous and alumosilicate components.

Despite a significant number of the works connected with the use of anthropogenic waste as raw materials for the production of foam glass crystalline materials, it is necessary to consider in each case the composition and properties of the available anthropogenic waste for obtaining high-quality production.

The carried out assessment experiments showed that local anthropogenic waste could use for getting foam glass in a single-stage process. However, this technology is very energy-intensive as it proceeds at high temperatures (not less than 850 ℃) and long time (not less than 3 hours).

The use of the two-stage process permits to obtain foam glass crystalline materials when using local anthropogenic waste. At this elimination of the process of glass melting in the two-stage process promotes decreasing the process temperature (to 850 ℃), reduces the time of forming the needed amount of the glass phase (30…40min.) that leads to a considerable decrease in energy consumption.

In recent years, through a series of wall reform, China's energy-saving thermal insulation walls have seen significant development, but our gap with the developed countries persists. Therefore, it needs to continue to intensify research and development of energy saving thermal insulation wall to have a new upsurge of building energy saving in the country.

Currently, the exterior wall thermal insulation materials in China and Kazakhstan’s FGCM need further research and development. The following recommendations:

- Evaluation experiments carried out have shown that local manmade waste can use for the one-step process for foam glass. However, this technology is very energy intensive, as occurs at high temperatures (not less than 850 ℃) and long time (at least 3 hours)
- Study of physic-mechanical properties, thermal characteristics, weather resistant properties and the structure, function, and application of the foam glass materials technology is energy efficient.
- Implement a breakthrough foam glass materials energy-saving technologies to improve the energy-efficient production and use of wall material technology to achieve 65% ~ 80% energy saving goals, and improve the energy-saving effect.
- Develop energy-saving foam glass materials, which combines security, energy efficiency, soundproofing, and supporting green building materials together.

In this paper, the optimization of foam concrete in severe cold areas needs to achieve the best material properties: cost reduction in manufacturing, energy saving features, environmental friendliness.

The proposed method demonstrates the feasibility a case study is conducted to optimize the production of foam. Compared with conventional production, this approach to use glass granulates typical high thermal insulation and reduced costs. The results show that the use of glass granulates has a much higher performance and heat gain coefficient values.

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