Abstract: The system of granulated foam glass production has been suggested. The following invention falls into the category of production of light bulk construction material based on glass, in particular, the means of production of foam glass or foam silicate commercially marked e.g. as PENOSTEK, that are also heat-insulating and fire-resistant materials and can be used, for example, for thermal insulation and fire protection of vehicles, buildings, and equipment, as an aggregate added into concrete constructions and in other areas of technology. Production of foam glass is also related to the issues of glass waste utilization and aimed at solving environmental issues. The system for granulated foam glass production is a processing line of functional devices and equipment that includes cullet storage, crushers and mills for refinement and fine grinding to produce glass powder, containers and mixers for storing and mixing the glass powder, liquid glass, water, and ingredients of foaming agent; batchers, granulator for foam glass batch granule production, drum dryer for cullet drying. The processing line also consists of connecting pipes, conveyors and pumps for connecting functional devices, feeding materials and ingredients. The system is different for its processing line parts being located at least four container modules; the system also contains batch planetary screw mixer successively connected to the plate granulator, various sieves, granule separator, granule powdering machine, granule foaming and sintering furnace, closed system of reverse water supply with pumps, containers for water, filters for its refinement and washing devices. At the same time, new relations between functional devices and equipment have been established. The equipment is distributed across separate modules according to new features and possibilities of module structure. Thus, all the modules have solid bases and sealed sloping floor in the form of perforated baths for drainage, interconnected with the reverse water supply system. Connecting pipelines between the containers are installed with the possibility of overlapping and separation from each other e.g. during transportation. The suggested version of the system presents closed system of reverse water supply consisting of two loops, with each of them having at least one storage container for drainage water and at least one storage container for industrial water, washing device with settling tank and filter, the clean water outlet of which is connected via pipe to the storage container of industrial water and washing device. This allows re-using water and bath waste that accumulate from the production, cleaning and washing equipment and facilities faster.
At least the third module of the system should be the shape of parallelepiped and bath formed by sealed floor and two adjacent side walls with the drainage holes between them. This allows using the module as one-level, multi-level, rotated at the angle of 90 degrees construction, which is both technologically, and economically more effective. The distinctiveness of the system is also related to the granule foaming and sintering furnace construction that is located in a separate extended module supported by movable supports of, for example, lifting jack types, which allows lifting, lowering, inclining, and fixing of the module. This provides the system not only with the mobility, but also a range of such new features as fast changing of line configuration for introduction of new technologies, changing production or its volumes, production areas. The mentioned new features present significant difference between the suggested new system and the already established ones (claim 5).
Description

Title of Invention: GRANULATED FOAM GLASS PRODUCTION SYSTEM

Technical Field

Technical Field

[1] The following invention related to the production of light bulk construction material based on glass, in particular, the means of production of foam glass or foam silicate commercially marked e.g. as PENOSTEK, that are also heat-insulating and fire-resistant materials and can be used, for example, for thermal insulation and fire protection of vehicles, buildings, and equipment, as an aggregate added into concrete constructions and in other areas of technology. Production of foam glass is also related to the issues of glass waste utilization and aimed at solving environmental issues.

Background Art

Background Art

[2] Positive features of foam glass, areas of its application, its production technology have been widely acknowledged. This foam glass heat-insulating porous material is known to be produced mainly by the means of sintering fine glass powder with gasifier and usually comes in a form of small-sized granules used e.g. as aggregate. There are various granulated foam glass production methods, such as crushing and grinding of utilizable glass or glass products to form granulated fine disperse glass powder for further production of foam glass batch by adding foaming agent. It is known that production of foam glass from waste simultaneously solves both the issues of waste utilization, and environmental issues.

[3] Most common type of glass among household, tare and construction glass is inorganic silicate glass produced on the basis of silicon dioxide; therefore, silicone glass that can be recycled and used in granulated foam silicate production constitutes the major part of the utilized household and construction waste. General issues of foam glass production are deeply covered in the related literature (see i.e. (for example, see Demidovich B.K. Production and Application of Foam Glass. Ed. Nauka i Technika, Minsk, 1972; Shil F. Foam Glass. Ed. Construction Literature Publishing House, Moscow, 1965, pages 6-18; The Great Soviet Encyclopedia 'Sovetskaya Enciklopedya' volume 24-1, Moscow,1976, pages 470-473; Concise Encyclopedia of Chemistry 'Sovetskaya Enciklopedya', Moscow, 1965, volume 4, pages 1033-1034 ).

[4] There are various additions, compositions, mixtures, and components used for production of batch that serves as the basis of the end-product, i.e. foam glass. Two mainstreams of such technologies and methods can be mentioned as an example: the
first - specific founding of glass of the required chemical composition; the second -
using composition based on the glass powder which is the product of cullet (waste
glass) of heterogeneous or homogenous chemical composition, and selection of
gasifier with the subsequent foaming while heating the complete mass of glass. Glass
powder is produced either by the means of grinding, or by using melted glass masses
(for example, see patents RU2023982, C03C 11/00, 30.04.1995; US4192664, class
C03B 19/08, 1980; US3403990, class 65-22, 1968), or crushed window, container
glass etc. (e.g. RU2149146, C03C 11/00, 20.05.2000; RU2051869, C03C 11/00,
10.01.1996; US4198224, class C03B 19/08, 1980). In certain cases, finely crushed
melted glass is used for foam glass production (RU2361829, C03C 11/00, 27.11.2008;
DE2010263, C03C 11/00, 1979). Among the analogues of the suggested invention of
production technology and composition of granulated batch for foam glass production,
batch that contains ground glass and carbonate gasifier (patent RU2266874, C03C
11/00, 10.11.2003) or batch based on the mixture of glass forming component and
powder additives including carbon gasifier that contains water alkaline solution of
sodium and/or potassium (liquid glass) silicate as the glass forming agent, and fine
crushed glass as the powder additive (patent RU2255058, C03C 11/00, 27.06.2005)
can be distinguished.

The use (choice) of certain methods and compositions for foam glass production are
determined by a range of independent features and local conditions, for example,
availability of the required raw materials, ecological issues, composition and nature of
the utilized waste, cost of energy resources, demand and efficiency of using foam glass
for certain purposes, and set characteristics. This, accordingly, suggests a wide range
of production systems, technological equipment and machinery for certain production
technology of various types of foam glass that possess certain features, technological
and economic characteristics of the production. However, this is not an obstacle for
rational use of standard common hardware in these specialized production systems.

For example, there are various systems and equipment for production of granulated
batch and foam glass of various types, including mixers and granulators that can be
considered identical to the ones used in the present development (for example, see
patents RU2291126, C 03 C 11/00, 2007; RU2209662, B 01 J 2/14, 2003-08-10;

This shows that though, on one hand, there are multiple technologies and methods of
quality foam glass, including granulated foam glass, production. On the other hand,
known technologies and equipment are insufficiently fit, and sometimes even inapp-
plicable, for solving issues of waste utilizations and heterogeneous glass waste
recycling. For example, glass of different composition and its secondary raw materials
may significantly differ in their physicochemical and technological characteristics,
whereas, established technologies of foam glass production have been developed and, in most cases, are designed for using raw materials of stable characteristics.

[8] Using heterogeneous glass waste and random glass waste for mass production of foam glass may result in a wide range of compositions and characteristics of the produced glass powder, drop of the quality of end-product, more possibilities of defects and need of utilization of the product as foam glass waste. This may also cause additional pollution of environment, violate labor protection requirements.


[10] Based on the considered issue, the set technological outcome, and all the essential features of the inventions present in the closest analogue-prototype of the suggested equipment, the system of foam silicate gravel raw material production based on the well-known system described in the patent with 67 references to technology level and analogues (see patent RU2307097, C03C 11/00, 20.04.2007) can be presented.

[11] The above mentioned system for granulated foam glass production is a processing line of functional devices and equipment that includes cullet and ground glass storage, crushers and mills for refinement and fine grinding, containers and mixers for storing and mixing the ingredients, batchers, granulator for foam glass batch granule production, driers for cullet and granule drying. The processing line also consists of connecting pipes, conveyors and pumps for feeding materials and ingredients. The production equipment and functional devices connected with pipes and conveyors form a processing line that ensures implementation of the set technological process. The process involves primary production and storage of cullet; it's crushing, drying, and fine grinding to form fractions of less than 40 microns, simultaneous production of powder mixture of quartz, chalk, and carbon of component fractions of less than 40-60 microns by fine re-grinding. The mixture is further mixed with glass powder and liquid glass water solution. The acquired mixture is fed to the mixers and granulator, where raw granules are formed. The granules are dried and fed further for thermal treatment.

[12] The shortcoming of the line-prototype could be the following:

[13] 1. lack of equipment mobility in the case of quick dismantling, transportation, and installation at a new facility;

[14] 1. difficulties of using in the case of utilization of glass waste that contains heterogeneous cullet, including contaminated cullet;

[15] 1. difficulties of washing and cleaning of the system and the equipment from harmful and dangerous additives, such as glass dust and cullet; waste from batch and finely crushed glass, water or other solutions of foaming agent that accumulate on the equipment and in the facilities, thus worsening work conditions;
1. significant volume and emission of waste by the production itself.

**Disclosure of Invention**

**Technical Solution**

The suggested invention and its technological result are aimed at removing the above mentioned shortcomings and, first of all, solving environmental problems related to utilization of heterogeneous glass waste, including waste varying in its composition and form. The invention has also been designed to ensure cost-effectiveness of utilization and to create conditions for producing foam glass from non-standard glass of varying composition and, at the same time, to improve the quality of end-product (construction materials that contain foam glass). The suggested invention is also aimed at improving the mobility of the system, simplifying its dismantling, transportation, installation at new facilities, and reducing the cost on these operations. The invention also addresses the issue of harmful emissions and waste of the in-house fabrication, ensures clean equipment and improves work and environmental conditions, provides wider technological range of equipment for recycling glass waste and helps build clean production of granulated foam glass from this waste.

In order to solve the set issues, the following composition for granulated batch and foam glass production has been elaborated as the result of tests and cost parameters (weight percent):

- Liquid glass - 5-15;
- Carbonate foaming agent, including glycerin - 1-2;
- Water - 5-15;
- Ground glass (sieved) - the rest.
- \( \text{CaCO}_3 \) or \( \text{MgCO}_3 \) or \( \text{BaCO}_3 \) or \( \text{SrCO}_3 \) of maximum 1% by weight are used as the carbonate foaming agent.

The choice of batch composition has determined suitable technological means necessary and sufficient to solve the set issues.

The suggested system of granulated foam glass production represents a processing line of functional devices and equipment that includes cullet storage, crushers and mills for refinement and production of fine glass powder, containers and mixers for storing and mixing the glass powder, liquid glass, water, and foaming agent ingredients; batchers, granulator for foam glass batch granule production, drum drier for granule drying. The processing line also consists of connecting pipes, conveyors and pumps for connecting functional devices, feeding materials, and ingredients, which is already known from the prototype. The given system is different for its processing line being designed out of several, minimum four, container-type modules and incorporating batch planetary-screw mixer successively connected with the plate granulator;
sieves, including vibrating sieves; a machine for powdering the granules; furnace for foaming and annealing the granules; closed reverse water supply system with pumps, water containers, filters, and washing equipment. The first module incorporates cullet washing equipment with drainage system and filter; and coarse crusher for the fractions of maximum 1 mm. The second module incorporates refill containers for storing and mixing water, liquid glass, and ingredients of the foaming agent; their pumps, batchers, and mixers interconnected by pipelines, and general mixing outlet. The third module contains containers for cullet and water interconnected by pipelines and fixed for 90 degrees moving ability; fine grinders for glass powder fractions with maximum 0.005 mm particles; planetary-screw mixer and plate granulator with outlet for raw granules; drum drier; separator for prepared raw granules in the form of e.g. sieve. The fourth module contains a device for powdering granules, foaming furnace for sintering foam glass, separator for ready foamed granules in the form of sieve. The basis of the modules is solid with sealed sloping floor in the form of perforated baths for drainage, interconnected with the reverse water supply system. Connecting pipelines between the containers are installed with the possibility of overlapping and separation from each other e.g. during transportation.

Moreover, the suggested system allows the possibility of creating closed system of reverse water supply that can consist of two loops, each of them incorporating at least one storage container for drainage water and at least one storage container for industrial water; containing own clarifier device with settling tank and filter, filtered water outlet of which is connected to the storage container of industrial water and washing equipment through the pump. The system may also incorporate the third module in the form of parallelepiped or rectangular prism. The bath of the third module is formed by sealed floor and adjacent side walls with the drainage holes between them. In the fourth module, foaming furnace is suggested to incorporate heat-isolating cylinder pipe with several separate areas of heating along its length. The pipe contains rotation drive and is installed for pivot rotation and inclination of up to 5 degrees horizontally. The furnace can be equipped with pipe cooler that should be e.g. in the form of heat-insulated cylinder, the inner diameter of which would exceed the external diameter of the foaming furnace. The cylinder is fixed to allow pivot rotation and limited telescopic movement along the axis of the foaming furnace.

One of the modules may be provided with the supports in the form of lifting jack, and installed with the possibility of moving it up, down, inclining it, and fixing its position.

The suggested type of technological solution allows simultaneous solving of several set tasks, in particular, the task of creating cost-efficient production of the construction material under demand - granulated foam glass; the task of creating mobile production
that can be transported quickly in the containers to other areas with the ability of changing its efficiency by changing the number of modules based on the present raw material and market demand; the task of solving environmental issues related to glass waste and other waste utilization, environmental protection and labor protection issues by developing this kind of low-waste production.

After performing patent search and considering analogues, for example, those mentioned in the references to patents-analogues, it can be stated that the totality of essential features put forward in the claims, necessary and sufficient for solving the set problems is original and does not originate directly from the technology level, which proves the novelty of the technological solution and its level of invention. The implemented test models have proved the industrial applicability of the suggested system and have solved the set issues, i.e. the models fully comply with the criteria of invention and prove the need of patenting.

**Description of Drawings**

The invention is represented by schemes and drawings.

Figure 1 shows schematic functional flowchart of the main version of the module system, interconnection of functional devices and sequence of implementation of the technological process. Figure 2 represents schematic version of binding of a module (container) of system 1. Figure 3 shows schematic version of binding of a module (container) of system 2. Figure 4 shows schematic version of binding of a module (container) of system 3 in a vertical operating (for the given version) position. Figure 5 shows schematic version of binding of a module (container) of system 4; Figure 6 shows schematic version of installation of modules during assembly of the system. Figure 7 shows schematic scheme of the reverse water supply system. Figure 8 represents schematic version of the batch planetary-screw mixer.

**Best Mode**

The analyzed version of technological process represents the system consisting of a range of functional devices, the major part of which can be located in modules-containers 1, 2, 3, 4 made according to the or based on the freight containers for carriage by sea and other. The area of the floor of the containers amounts to 15.22 or 30 square meters with the length of 6.9 or 12 meters.

Standard rectangular parallelepiped modules are used; however, modules of other prism forms, for example, simple parallelepiped with inclined walls are also acceptable. In order to enter and work inside the containers, the containers may have side openings 5, and their outside perimeter equipped with work stations 6 (not indicated schematically). The floor of at least module 1 has the shape of sealed bath 7 with the height of the welt of at least 0.1 meter. At least module 3 should be inclined at the
angle of 90 degrees in its working state and mounted on one of the side surfaces. Each bath contains drainage perforations (spillways) 9 that are located in the lower point of the floor, along the edge of the intersection of the surfaces in module 1. The floor of baths 7 or the system of modules is mounted with certain inclination to ensure proper drainage. It is advisable to mount the modules in 2-3 levels (floors), for example, to reduce the used area by increasing efficiency and the number of modules (at least 3-4) and for more convenient supply of materials (to the upstairs), for example, to module 3.

[34] The composition of the equipment of the system depends on the composition of the batch. The given example considers granulated batch of the following proportions (mass percent): ground glass - 70-88 %, liquid glass - 5-15 %, water - 5-15 %; carbonate foaming agent (CaCO₃ or MaCO₃ or BaCO₃ or SrCO₃) - maximum 1 %, and glycerin - maximum 1 %.

[35] Accordingly, the suggested example of the system focuses on the given composition. Module 1 (or the area next to it) contains storage (container) 10 for cullet (glass waste), equipment 11 for washing cullet e.g. in the form of high-pressure water fluid oscillators, drainage system 9 and filters 12 for water filtering, and connected container 13 for industrial water. Module 1 also contains driers 14 for glass (after washing), primaries 15 and fine grinders 16 for glass (for example, of orbicular type) with vibrating or other sieves 17 for glass powder fractions with particles of maximum 1 mm, and connected containers 18 for storage. Module 1 also contains grinding equipment and containers 19 for temporary storage of ground glass of other fractions; the containers are connected with pipes in the same principle as vacuum-cleaner, aspiration systems or other product conveyers.

[36] Module 2 may incorporate a laboratory; a changing room; refillable drinking water container 20 and container with for industrial water 21 with batchers; replaceable container 22 for liquid glass with batcher; replaceable containers 23, 24, 25 with batchers for several possible carbonate ingredients of the foaming agent (for example, CaCO₃ or MaCO₃ or BaCO₃); replaceable container 26 with a batcher for glycerin. Batchers of containers 21 and 22 are connected to the mixer 27 via pipes, where is prepared liquid glass water solution in the set proportions. Identically, containers 23 or 24 or 25 with the required carbonate; container 26 with glycerin; water container 21 are connected via their respective batchers and pipes to mixer 28, where foaming agent mixture of, for example, glycerin, CaCO₃ (optional) and water, is prepared. The complete mixture of foaming agent, water, and liquid glass is prepared in mixer 29 that is connected via pipes with regulatory valves to discharges of mixers 27 and 28, and to container 21 e.g. for cleaning water. It is possible to disconnect mixers 27 and 28, and to directly mix ingredients in mixer 29.
[37] Modules 1, 2, 3, and 4 may contain various devices of the closed reverse water supply system 30 with pumps 31, containers 32 and 33 for wastewater, devices 34 and 35 for cleaning wastewater with filters and settling tanks (not indicated), washing devices 36, 37, 38, 39 and containers 13, 21, 40 and 41 for industrial water for modules 1, 2, 3, 4 respectively. System 30 is also provided with mobile electric water heaters 42 (for modules 1 and 2) for heating water, or with cooling devices (for modules 3 and 4). At the same time, system 30 is divided into two loops. The main function of the first loop is washing cullet that may contain any type of occasional dirt, in module 1, and for the possible cleaning of module 2. The main function of the second loop is recycling and re-use of batch waste in modules 3 and 4. For module 2, minor contamination and discharge of water during washing into container 30 of module 1 are anticipated. System 30 has been designed to connect discharge pipes 9 of the first and the second loops of system 30 to containers 32 and 33 respectively.

[38] Module 3 with the ability to turn it 90 degrees contains its own container 40 for industrial water, storage container 43 for glass powder, fine grinder 44 (attritor type) producing glass powder particles of maximum 0.005 mm, mixer 45 for planetary-screw mixer with the plate granulator 46 installed (successively connected) on the outlet, drum drier 47, separator 48 for granules e.g. vibrating sieve. The distinctive feature of module 3 in the given version of system is the ability to turn it 90 degrees, to change from horizontal to vertical position, by maintaining the same efficiency. In the given example, it is recommended to install module 3 under module 2, and mixer 45 above granulator 46, but under water container 40 and storage container 43 for convenience. Such placement is more compact and reduces the area required for the system; allows gravity feeding of batch and its ingredients down the pipes, which improves the possibilities of management and control of the process by the operator. At the same time, module 3 is suitable for horizontal transportation and operation with single-level system, for example, at replacing simple connecting pipelines with aspiration, auger pipes or conveyors with separate drives for material handling. It is also worth noting that dimensions of batch granules and foam glass at the outlet of the system are mostly determined by the dimensions of mixer 45, for example, diameter and pitch of auger 49, and the parameters of the rotary motion of its device 50 and granulator 46 that are set and determined by tests.

[39] Module 4 is longer than modules 1-3 with its length of e.g. 12 meters, and contains (or holds) machine 51 for powdering the granules and container 52 for powdering materials i.e. kaolin or kaolinite, raw granules container 53, heat-insulated pipe furnace 54 for foaming and sintering of foam glass with its rotation drive 55 and inclination drive 56, and pipe cooler 57 for cooling granules after sintering with its separate rotation and inclination drive 58, and computer device for automatic operation of the
mentioned pieces of equipment (not indicated).

[40] Inlet flange of the furnace 54 is turned to (or connected to) the connecting pipe for feeding batch from drum drier 47 and granulator 46, while its outlet flange telescopically enters large-diameter pipe cooler 57 that allows limited telescopic movement along the furnace 54, for example, by using the guides (not indicated) with the possibility to compensate for linear displacement that may occur as a result of temperature expansion of the pipe of the furnace. Inclination of furnace 54 and cooler 57 may be ensured by lifting jack type movable supports 59 of module 4 that bear (at the corners) a module and provide the function of lifting, lowering, inclining (up to 5 degrees) and fixing, which is easier than separate inclination of the furnace and the cooler by using drives 56 and 58. Inclination of module 4 by lowering the part of outlet flanges of furnace 53 and cooler 57 is more preferable. In this case, position of module 3 and front part of module 4 with respect to drum drier 47 does not change. Independent drives 55 and 58 provide independent choice of speed of rotation of furnace 54 and cooler 57, which is comfortable during exploitation. Next to the outlet flange of the cooler, storage 59 for produced foam glass granules, fraction separator 60 of vibrating sieve type, containers 61 for storing produced materials are located. Movable loading arms (not indicated) can be used and fixed to furnace 54 and cooler 57 for transporting granules along the length of furnace and the cooler.

[41] The suggested system of the given version is assembled and launched in the following way.

[42] The system is delivered to the site of future production of granulated foam glass (for example, in the industrial areas of waste recycling plants) in four major transport module containers 1, 2, 3, and 4. Modules 1, 2 and 4 are installed to form (one of the options) T form, symmetrically with the junction of front edges of modules 1 and 2 to the side edges of module 4. Module 3 is installed vertically on module 4 and on the smaller front edge in the form of bath 7, i.e. turned 90 degrees from the transportation position and the granulator 46 being in the lower part. At the same time, modules or floors of all the modules are inclined up to 10 degrees towards drainage perforations 9.

[43] Each transport module ready for installation represents the prepared area of processing line with installed equipment. Module 1 has been designed for glass waste, glass tare, and cullet waste, which is delivered in the form of raw material, recycling into fine glass powder with maximum fraction of particles of 1 mm. The main function of module 2 is the production of a mixture made of various ingredients and used as a foaming additive. Module 3 is to be used for the production of raw granules, while module 4 incorporates furnace 54 for batch sintering and granulated foam glass production.

[44] Prior to launching of the system, the modules are connected to each other via
connecting pipes and ducts to form a single processing line according to the functional technological flowchart (Fig. 1). The system may also contain automatic control system (not indicated) that also includes automated control equipment that is usually installed into most functional equipment available on market. The equipment is connected to the major computer for control and management of the whole technological process by using a program that does not fall into the category of the given invention; therefore, is not discussed further.

Prior to launching of the system, availability and composition of ingredients, availability of water, condition of energy systems, functional devices, connecting pipes, batchers, storage containers and their cleanliness after washing are checked. Glass waste delivered to module 1 is, if possible, checked for the level of cleanliness and homogeneousness and lots of homogeneous cullet, for example, silicate glass based on silicon dioxide, is selected, technology of processing the given lot is defined according to preliminary test results, ingredients, their composition, proportions and modes of the process are determined. The selected waste lot of, for example, silicate glass tare i.e. bottles, are sent from storage 10 to one of the primaries 15, are further fed for wetting and spray washing to washing device 11 connected with water container 13, and to gas drier 14. After drying, the material undergoes visual rotary control for cleanliness, large fractions of possible waste are selected and, possibly, sent for re-crushing and re-washing and drying. When the necessary level of cleanliness has been reached, cullet is fed to the range of mills 16 and, further, to vibrating or other sieves to produce selected homogeneous lot of glass powder with the size of particles of maximum 1 mm. The glass powder is then stored into storage container 18. Larger glass fractions are sent to container 19 of module 1 for secondary processing at mills 16 or for exploitation for other purposes. Transportation of ground glass in module 1 and from the module is performed via i.e. pipes and hoses connected to the aspiration equipment or scooper devices (not indicated). Wastewater originating from washing is fed from equipment 11 to filters 12 (with settling tanks) via drainage system 9. Refined industrial water is stored in industrial water container 13, while waste accumulated in filters and settling tanks is fed for combustion. At the same time, ingredients are prepared in module 2.

According to the technological plan and set process parameters, required materials are prepared in module 2. Container 20 is filled with drinking water from e.g. water supply system; container 21 is filled with industrial water from e.g. container 13 of module 1. Replaceable liquid glass containers 22; insoluble calcium carbonate CaCO₃ (ground limestone) container 23; glycerin container 26 are placed. Depending on the single volume of the ground glass lot, the required batch of liquid glass water solution is prepared in mixer 27, and appropriate batches of CaCO₃ with glycerin and water are
prepared in mixer 28 by feeding the above ingredients from the batchers of the containers via pipes. The batch of the complete mixture of the foaming agent, water, and liquid glass is prepared in mixer 29. Several stages of dosing and mixing of components are necessary for equal distribution of small quantity of the foaming agent (0.5-2 % of the total batch volume). Preliminary mixing of the foaming agent with water and liquid glass allows higher quality of its distribution in the mixture. This also defines the requirements to the mixers that form a part of the system.

[47] After glass powder has been prepared in module 1 and batches have been prepared in mixer 29 of module 2, container 43 is filled with glass powder, and container 40 of module 3 is filled with industrial water. Final grinding of glass powder to form particles of 0.005 mm is performed in the fine grinder (attritor type) 44. When ready, measured doses of glass powder from attritor batcher 44 and doses of components from mixer 29 (additives from mixers 27 and 28 are also possible) are fed to the planetary-screw mixer 45. Parameters of mixer 45, in particular, parameters of rectilinear auger 49 (diameter, pitch) and rotation drive 50 with planetary gear, as well as parameters of granulator 46 are determined by tests, according to the required size of granules (1-1.5 mm) and their density. Further rolling of raw granules and increasing their size, for example, up to 2-3 mm while increasing their density are performed by plate granulator 46.

[48] Gravity feeding (downwards) of the batch granules produced in the granulator 46 is performed via pipes from module 3 to e.g. concurrent drum drier 47 with gas or electric heat generator (not indicated) of module 4, where batch granules are dried at the temperature of approximately 300°C for partial removal of moisture. The granules can further be fed to the pipe furnace 54 for foaming and sintering. However, in order to improve the quality of the granules, it is recommended to powder them with kaolin or kaolinite. In the given example of the system, special powdering machine 51 is possible in module 4 with kaolin or kaolinite container 52 and raw granule container 53. Machine 51 is located in module 4 on the way of granules from drum drier 47 to the furnace. In order to improve the quality of powdering in the system, sieve separator 48 for separating fir dust can be installed. It is installed in the pipe on the way of the batch, between drier 47 and powdering machine 51.

[49] Thus, batch granules are free of undesirable dust after drier 47 and covered with a thin layer of kaolin by machine 51. Such processed batch granules are fed to the pipe furnace 54 for foaming and sintering to produce foamed granules of foam glass.

[50] Tunnel type pipe furnace 54 for foaming and sintering consists of the heat-insulated pipe of approximate diameter of 0.5 m with electric or other controllable heaters (not indicated), located along the pipe and allowing separate adjusting of temperature in several heating areas and reproduction of the set temperature curve inside the furnace.
along its length. During granule sintering, control system (not indicated) is introduced with the temperature simulation curve with the maximum temperature of 750-800°C. The indicated time of heating and keeping in the foaming temperature from 10 to 30 minutes depends on the mode and parameters of the batch. Certain mode is actuated and controlled automatically, for example, according to the data of the thermocouples (not indicated) that are located in furnace 54 and cooler 57.

[51] Cooler 57 also consists of large diameter pipe with separate rotation and inclination drive 58. The pipe is telescopically connected with furnace 54 and serves as its extension. During operation, the speed of rotation of the pipe of cooler 57 should be 1-10 % higher than the speed of rotation of furnace 54, which allows avoiding dead zones at the transfer of granules from the furnace to the cooler and has been tested. The cooler stabilizes the temperature, process of cooling foam glass granules, change of their features and size, allows increasing the quality of the produced material.

[52] Production is usually taken from furnace 54 and cooler 57 as soon as ready, depending on their rotation speed and inclination angle. When the devices stop, the production is taken by using the designed movable loading arms. At the outlet flange of cooler 57, produced foam glass granule storage 59 is usually located. At e.g. vibrating sieve fraction separator 60 granules are cleaned from dust and sorted by size and, possibly, put into containers 61 for end-product storage or into bags. For example, the test bulk density of the produced foam glass granules amounted to 100-200 kg/m³, compression strength of the filler (in the cylinder) amounted approximately 6 kg/cm², while thermal conductivity in the fill did not exceed 0.057 W/m°C.

[53] Using household and other waste might cause instability of the quality of the produced material. Therefore, the process should be stopped or slowed down in the case of such defect to find the cause of decreased quality and to perform the appropriate changes of, for example, foaming agent composition or temperature mode.

[54] In order to ensure high quality while using batch of varying composition and to comply with the requirements of labor protection, the issue of cleanliness of functional equipment, storage containers, pipelines, operation of reverse water supply system should be considered with special attention. Therefore, the equipment and modules are recommended to be regularly washed with industrial water by using washing devices with, for example, high-pressure pumps. Spray washing would remove all the waste from the equipment and floor of the modules into the storage containers. Afterwards, when the settling and filtration of wastewater is completed, refined industrial water would be sent for secondary use. Batch waste (in the second loop) should be fed as additives into new mixtures, while other waste from filters should be utilized as required. Such devices as vacuum cleaners and air aspiration systems can also be used for cleaning. Convenience and effectiveness of using the described mobile system have
been proved by tests.
Claims

1. The system for the production of granulated foam glass provided as a processing line of functional devices and equipment that includes cullet storage, crushers and mills for refinement and fine grinding to produce glass powder, containers and mixers for storing and mixing the glass powder, liquid glass, water, and ingredients of foaming agent; batchers, granulator for foam glass batch granule production, drum drier for cullet drying, consisting of connecting pipes, conveyors and pumps for connecting functional devices, feeding materials and ingredients, characterizing in that its functional devices and processing line parts are located in at least four container modules; the system also contains batch planetary-screw mixer successively connected to the plate granulator, sieves including vibrating sieves, granule separator, granule powdering machine, granule foaming and sintering furnace, closed system of reverse water supply with pumps, containers for water, filters for its refinement and washing devices, wherein first module contains cullet washing devices with drainage pipe and filter, crushers and mills for crushing glass with sieves to form glass powder fraction particles of maximum 1 mm, their storage containers, wherein the second module contains refill capacity for storing and mixing water, liquid glass and foaming agent ingredients, their pumps, batchers, and mixers interconnected with pipes with common mix outlet, wherein the third module contains glass powder, glass, and water storage containers that can be rotated up to 90 degrees, fine grinders for glass powder fraction particles of maximum 0.005 mm, planetary-screw mixer and plate granulator with an outlet for raw granules, drum drier, granule separator e.g. sieve, wherein the fourth module contains granule powdering machine, foam glass foaming and sintering furnace, where the system includes automatic process control devices, all modules have solid bases and sealed sloping floor in the form of perforated baths for drainage, interconnected with the reverse water supply system, wherein connecting pipelines between the containers are installed with the possibility of overlapping and separation from each other e.g. during transportation.

2. System according to claim 1, characterizing in that its closed system of reverse water supply consists of two loops, with each of them having at least one storage container for drainage water and at least one
storage container for industrial water, washing device with settling tank and filter, the clean water outlet of which is connected via pipe to the storage container of industrial water and washing device.

3. System according to claim 1, **characterizing in that** at least first module is in the form of parallelepiped and bath is formed by sealed floor and two adjacent side walls with the drainage holes between them.

4. System according to claim 1, **characterizing in that** its foaming furnace consisting of heat-insulated cylinder pipe with separate heating areas along its length is provided with its rotation device and installed to allow pivot rotation and horizontal inclination of up to 5 degrees.

5. System according to claim 1, **characterizing in that** pipe cooler is a heat-insulated cylinder, the inner diameter of which would exceed the external diameter of the foaming furnace, wherein the cylinder is fixed to allow pivot rotation and limited telescopic movement along the axis of the foaming furnace.

6. System according to claim 1, **characterizing in that** at least on module with solid base is installed with movable supports of lifting jack type, that allow lifting, lowering, inclining, and fixing of the module.

7. System according to claim 1, **characterizing by** the possibility of each module to operate independently, wherein at least module 1 and module 4 can be located further from each other, wherein module 1, for example, can be located closer to raw material, while module 4 can be installed closer to end-product consumer, which allows cutting the costs of raw material and end-product transportation.
Fig. 1
Fig. 7
A. CLASSIFICATION OF SUBJECT MATTER
INV. C03B19/08 C03C11/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC.

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
C03B C03C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Relevant to claim No.</th>
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[X] Further documents are listed in the continuation of Box C.  

[X] See patent family annex.

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Date of the actual completion of the international search
22 April 2010

Name and mailing address of the ISA/
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016

Date of mailing of the international search report
03/05/2010

Authorized officer
Deckwerth, Martin
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