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MINERAL FOAM AND METHOD FOR ITS PRODUCTION

Description

[0001] The invention relates to a formulation for producing a flame-retardant mineral foam comprising a calcium sulphate aluminate cement, a sulfate component, an aluminium silicate and a calcium oxide-providing component, a porous mineral foam comprising a hydraulic setting component and a foam component, a structural element with a having a structural element body, and a method for the production of a self-curing mineral foam, according to which, in order to produce a formulation powdered components are mixed together in a first mixing section to form a batch, and water is added to this batch to form a slurry.

[0002] Structural elements made of mineral foams for various uses are known from the prior art. For example, mineral foams are used in the thermal insulation of buildings. Many thermal insulation approaches *per se* are known in an enormous variety of forms from the prior art. Essentially, a distinction can be made between inorganically based and organically based insulation materials. A common feature of both types is that essentially an attempt is made to reduce the conduction of heat through the insulation material by creating the greatest possible pore volume. Organically based insulation materials have the advantage over inorganically based insulating materials in that they generally have a much lower density and are easier to manufacture in process engineering terms.

[0003] However, mineral insulating materials with low density are also already known from the prior art. Thus, for example a method for producing a heat insulating material made of quartz flour with a specific surface according to BET of at least about 3 m^2/g, calcium hydroxide, water, foam and a reactive fast-setting cement containing aluminates, in which the thermal insulation material has a bulk density less than 250 kg/m^3 is known from EP 0 628 523 A1. In this process, a pourable crude batch is produced from the raw materials and poured into moulds. The crude batch is produced with a weight ratio of water/solid (without foam) of at least about 1.25 to about 1.85 depending on the total surface area of the solids, and an essentially stoichiometric amount of calcium hydroxide with a surface area of at least

about 15 m^2/g according to BET based on the practically complete conversion of the quartz powder and the reactive aluminates. The blanks are poured into moulds, and after sufficient solidification they are demoulded apart from a mould bottom and are autoclaved on the mould base. A surfactant or protein foam is used as the foam.

[0004] But besides density, the fire retardant properties of an insulation material are also important regarding its suitability for use as an insulating material in the building industry.

[0005] A method for producing lightweight foam concrete bodies is known from DE 26 17 153 B1. In this method, two different masses, of which one consists of a hydraulic, quick-setting cement mass in the form of a fine dry powder and the other consists of a propellant and aqueous foamed liquid containing a setting inhibitor, are introduced separately and continuously at defined flow speeds into a continuously stirred vessel, the foamed cement slurry formed thereby is continuously discharged from the vessel before the foamed cement slurry begins to set, and the foamed slurry is then poured into a mould to produce castings. A binder mixture consisting of 100 parts Portland cement, 25 parts alumina cement, 42 parts silica and 5 parts of calcium hydroxide may be used.

[0006] The object of the present invention is to provide a mineral insulating material, which has low tare weight and good fire retardant properties.

[0007] This object of the invention is solved, independently in each case, with the formulation between described in the introduction, in which the calcium-sulfate-aluminate cement is present in a proportion chosen from a range between 55 parts by weight and 85 parts by weight, the sulfate component is present in a proportion with a sulfate content between 5 parts by weight between and 15 parts by weight, the aluminium silicate is present in a proportion with an Al_2O_3 content between 3 parts by weight and 30 parts by weight, and the calcium oxide-providing component is present in a proportion with a CaO content between 0.5 parts by weight and 2 parts by weight, with a mineral foam that is produced from said formulation, with a structural element containing the mineral foam, and with the method described

previously, according to which the formulation is mixed in the composition according to the invention and added to the slurry in a second mixing section, and the mineral foam is then hardened.

[0008] With the new formulation, a mineral foam with flame-retardant effect and fire prevention properties up to at least 1000 °C can be produced with the method. Moreover, it allows a possible further advantage in that the mineral foam can be produced without the need for autoclaving, so that the method may be simplified and costs reduced. The use of the calcium-sulfate-aluminate cement yields a further advantage to the effect that the mineral foam does not shrink significantly, if at all, during hardening. Consequently, the mineral foam and/or structural elements including or consisting thereof are more easily producible since a shrinkage factor does not have to be taken into account.

[0009] The proportion of calcium-sulfate-aluminate cement in the formulation is preferably at least 60 parts by weight, particularly at least 70 parts by weight, thus making it possible to improve the mechanical and insulating properties still further.

[0010] The sulfate component is preferably chosen from a group comprising calcium sulfate, α- or β- hemihydrate or dihydrate of calcium sulfate, anhydrite, sodium sulfate, iron (II) sulfate, magnesium sulfate and mixtures and derivatives thereof. Consequently, hydrate phases are produced while the insulation material is hardening, and these undergo a phase transformation over time which render the material harder still.

[0011] Das aluminium silicate is preferably an alkali-activatable aluminium silicate, particularly an igneous aluminium silicate, preferably basalt, pitchstone, obsidian, phonolite, and/or metakaolin, and mixtures and derivatives thereof. This makes it possible to positively influence the solidification behaviour and setting time. For example, it may be used to adjust the setting time of the slurry in order to reduce the risk that the foam added will collapse and so lower the porosity of the insulation material. In this way, therefore, processing may be made easier.

[0012] With a view to further improvement, a basalt is preferably used that contains zeolite and/or a pozzolan. In this context, the zeolite and/or pozzolan content may be up to 40% by wgt., particularly up to 30% by wgt.. This serves to render the aluminium silicate more readily alkali-activatable. In addition, particularly the zeolite has an enhancing effect with regard to the fire-resistant properties of the mineral foam.

[0013] In a preferred variant thereof, the aluminium silicate is used in calcined form, which helps to improve its reactivity and thus also the setting behaviour of the slurry/foam mixture.

[0014] The calcium oxide-providing component is preferably chosen from a group comprising calcium oxide, calcium carbonate and calcium hydroxide, and mixtures thereof, in which case calcium hydroxide is particularly preferred due to its deacidifying effect. This enables the swelling behaviour of the formulation to be improved.

[0015] The formulation may further include at least one high-performance plasticiser in order to influence the rheological behaviour of the slurry produced from the formulation, wherein the proportion is limited to a maximum of 3 parts by weight. The high-performance plasticiser is a polycarboxylate ether or derivative thereof, to enable the water content in the slurry to be reduced, since water from the foam component that is added to the slurry is also introduced into the system that is available for setting the mineral foam.

[0016] It is further possible that at least one thickening agent may be added to the formulation in a proportion not exceeding 0.5 parts by weight to stabilised the slurry and thus improve the processability of the slurry. The thickening agent is preferably added in a proportion not exceeding 0.25 parts by weight, particularly not exceeding 0.02 between parts by weight. The thickening agent is chosen from a group comprising hydroxymethylpropylcellulose, methylhydroxyethylcellulose and mixtures and derivatives thereof, because it was found during the tests conducted in association with the invention that these thickening agents offer im-

proved propties for processing purposes, such as rheology, dispersion of solids or water requirement and water retention capacity

[0017] With regard to the processability of the slurry, it was also fund that improvements are achieved if the thickening agent content is not more than 70% of the high-performance plasticiser content.

[0018] It is advantageous if the formulation (and thus also the mineral foam) contains no fibres, since this enables construction of more homogeneous foam bodies and helps to prevent any directional dependency of the mineral foam properties more effectively. A side effect of this is that production of the mineral foam is also simplified since no environmentally related restrictions are encountered during production of the mineral foam due to fibres. In theory, however, it is possible for fibres to be added.

[0019] At least one substance from a group comprising alkali carbonates, alkali sulfates, fruit acids may be added to the formulation as retarder, for example, to improve its rheology.

[0020] In order to reduce the proportion of sorption moisture in the finished mineral foam and thus also improve heat insulation (λ value), it may be provided that at least one hydrophobing agent is added, particularly for the purpose of mass hydrophobing the formulation. The proportion of hydrophobing agent in the formulation may be as much as 3 parts by weight, preferably up to 1 part by weight.

[0021] According to another variant of the formulation, it may be provided that it is free from between aggregates, i.e. free from fillers, that is say it contains no non-reactive components, which helps to lower the density of the mineral foam further.

[0022] The foam component is preferably formed by a protein foam and/or a surfactant foam for producing the mineral foam. This makes it easier to control the foaming behaviour than in the direct foaming method with a propellant. It may be used in particular to influence

the pore size and pore distribution, making it possible to adjust the thermal conductivity value and sound absorption capability of the mineral foam as well as the flame retardant behaviour more effectively.

[0023] Preferably between 30 and 60 parts foam component, particularly between 40 and 50 parts foam component are contained for each part formulation, so that greater porosity of the mineral foam can be achieved, and in turn the density of the mineral foam can be lowered without loss of the good flame resistance properties.

[0024] In order to stabilise the foam while the formulation with water is being mixed into the slurry, at least one surface-active (boundary surface-active) agent may be added to the foam component, wherein the surface-active agent is chosen from a group comprising fatty acids and alkyl sulfonates as well as derivatives and mixtures thereof, since an improvement in stabilisation of the foam was observed with these substances.

[0025] It is also possible for the foam component to contain a vegetable protein as a crosslinking agent, said crosslinking agent preferably being in a proportion between 1% and 3%, particularly in a proportion between 1.2% and 2.3% of the weight of the hydraulic setting component contained on the mineral foam. In this way, formation of the mineral foam may be improved, particularly accelerated, wherein the stability of the foam formed may be improved during the setting of the hydraulic binder.

[0026] According to a preferred variant, the mineral foam has porosity of at least 70%, particularly between 80% and 95%. This high proportion of pores not only serves to improve the insulation behaviour *per se*, but also makes it possible obtain a lower density of the mineral foam.

[0027] The pores preferably have a diameter of 0.5 mm at most, particular 0.25 mm at most and 0.1 mm at most, firstly in order to achieve positive insulating behaviour and secondly to

improve the mechanical stability of the finished mineral foam. In particular, heat loss due to thremal condictivity can be minimised by keeping the pores as small as possible.

[0028] EiA further improvement in the thermal properties of the mineral foam may be achieved if IR-opacifying agents, e.g., infrared-active oxides or carbides such as SiC, or C are added to the foam. The proportion of IR-opacifying agents may be up to 5 parts by weight. This also hleps to reduce heat loss due to heat radiation.

[0029] Air-entraining agents such as alkylpolyglycol ethers, alkyl sulfates or -sulfonates, may also be added to the foam component to improve the stability of foam, as well as other functions.

[0030] It may be provided that the foam component is reacted with water and optionally with processing agents in a foam generator before it is added to the slurry, thereby improving the its processability, particularly the stability of the foam while it is being mixed with the slurry. For this purpose, a foam generator may be arranged inside the apparatus in order to foam the foam component, in which a protein reacted with water is foamed with a gas, particularly air.

[0031] For the purposes of better understanding, the invention will now be explained in greater detail with reference to the following figure.

[0032] The figure shows, in diagramatically simplified form:

Fig. 1 a device for producing a self-hardening mineral foam.

[0033] At the outset, it should be noted that the positional indications in the description, e.g. top, bottom, side etc relate to the figure that is specificlly shown and described, and if the position is changed they must be transferred accordingly to the new position.

[0034] Fig. 1 shows a preferred apparatus 1 for producing a self-curing, fire-retarding mineral foam 2.

[0035] The term mineral foam 2 is understood to mean a porous construction material that is produced with a hydraulisch setting binder. It preferably contains mainly mineral components, although processing additives may also be organic in nature.

[0036] One of the most important advantages of the invention consists in that mineral foam 2 does not have to be autoclaved, as is known from the prior art. For this purpose, at the heart of the invention, device 1 has a first mixing section 3, and a second mixing section 4 arranged downstream therefrom in the direction of production. In first mixing section 3, a formulation for the production of mineral foam 2 made from powdered components which can be stockpiled in storage containers 5 for example, is transported via a conveyor 6, a screw conveyer for example, to first mixing section 3, with the addition of water in the direction of arrow 7 to make a slurry, that is to say a mixture of the solid components and water. Normal tap water is usually used as the water, although of course also distilled or deionised or purified water may also be used. Optionally, other additives may als be introduced into the first mixing section 3 for blending with the powdered ingredients, as indicated by a dashed arrow 8 in Fig. 1, wherein at least some of the additives may also be added in liquid or dispersed form.

[0037] It is possible for the powdered components to be blended before the water is added as indicated with arrow 7, which is to say that these additives and excipients are added to the main components of the formulation for the production of mineral foam 2 before the water is added and these powdered components of the formulation may optionally be mixed in advance.

[0038] Mixing section 3 is designed as a paddle mixer or plough blade mixer, although other mixer types, such as free-fall mixers, may be used. However, the advantage of the mixer

types mentioned first is that less water has to be added to them – the aim is to use as little water as possible - and that the energy consumption per m^3 slurry is relatively low. Moreover, the risk that the mixer may be clogged by these rounded shapes may be reduced. In particular, this mixing section 3 may have three mixing apparatuses 9, which are arranged on a mixing section shaft 10 with radial distance therebetween. In this context, between 3 and 30 mixiing apparatuses 9 may be arranged in mixing section 3. In particular, mixing section shaft 10 is driven at a different speed from that of conveyor 6.

[0039] Subsequently, a protein foam and/or surfactant foam which is produced in a foam generator 11 is added to this slurry as the foaming component. Thus, mineral foam 2, i.e., the formulation for mineral foam 2, is not foamed directly according to the invention, instead pores are formed in mineral foam 2 by adding an own foam. For this purpose, a protein foam and/or a surfactant foam is used as the foam component. 12 as a protein, which can be kept in stock in a corresponding reservoir 13, is an animal or a vegetable protein or batchs thereof may be used. In particular, as a keratin protein 12, preferably a hydrolyzed keratin, are used, which is preferably resistant to alkali. The protein can be used in an amount of up to 15 parts by weight, especially up to 10 parts by weight.

[0040] In turn, water, particularly distilled or purified water, is added to this protein 12 as indicated by arrow 14, and the protein foam is created in the foam generator 11 by blowing in air in the direction indicated by arrow 15.

[0041] Is is shown by the hatched area of foam generator 11 in Fig. 1, processing additives may also be added to said foam component, for example from a storage container 16, in which case it is also possible for these additives to be mixed in advance if multiple processing additives are to be added at this point.

[0042] In general, it should be noted that these processing additives can be added as additives to the foam component as a powder or in dissolved or dispersed form.

[0043] The finished foam component is then added as indicated by arrow 17 to the slurry emerging from first mixing section 3 as indicated by arrow 18, wherein the addition takes place in second mixing section 4 or preferably before the second mixing section 4. For this purpose this mixing section 4 may be preceded by a conveyor 19 such as a screw conveyor, although in this case it is possible for the foam to be introduced into conveyor 19 first, so that it is at least approximately completely filled therewith, and the slurry is added to the foam afterwards, particularly in increments, wherein a plurality of feed openings for the slurry into conveyor 19 may be present. Alternatively or additionally, however, it is also possible for the slurry only to be mixed with the foam once it is in second mixing section.

[0044] Second mixing section 4 is particularly realised as a paddle, screw, helix agitator or static mixer, or in the form of a combination of one or more of these mixer types.

[0045] In the context of the invention, is it possible for the two mixing sections 3, 4 to be combined into a single mixer, in which case they are still separated from each other, i.e. configured one after the other in this mixer.

[0046] The further option exists according to which the first and/or second mixing sections 3, 4 consists of a separate conveyor device 6 and 19 and a separate mixer, wherein the separation may also be configured such at they have separate drive systems to enable different rotating speeds and therewith improved mixing result for minimal energy consumption.

[0047] Next, the finished mixture of slurry and foam component is transported out of second mixing section 4 via a corresponding conveyor device 20 and can be poured into a corresponding to allow self-curing of the mineral foam 2 as the corresponding chemical reactions take their course.

[0048] It should be noted that the mineral foam 2 according to the invention may be produced in panel form for example, for subsequent mounting on structural elements such as walls, but it is equally possible for building elements such as hollow chamber bricks for example to be at least partially filled with the mixture, so that in this way structural elements which are insulated in and of themselves, for example bricks or stones provided with a thermal insulation may be prepared. But there are also other possible forms of the mineral foam 2, such as stones, plumbing elements, elements in the floor area, in floor heating systems for example. In particular, mineral foam 2 is used as a fire-retardant building material, which also has appropriate thermal insulation properties. Stones for chimney building may be manufactured with it. Likewise, filling materials for structural elements whose primary purpose is not thermal insulation but rather flame resistance are also possible.

[0049] Although not shown in Fig. 1 provision is still made within the scope of the invention for ensuring the presence of corresponding regulation and/or control instrumentation and/or measuring equipment inside device 1, and operating said regulation and/or control instrumentation and/or measuring equipment, also with computerised support, of course.

[0050] EThe further option exists to use other gases such as N_2, CO_2, etc. instead of air to produce the foam. And yet another option exists, according to which a particularly alkaline propellent is added to the protein so that a separate gas does not need to be added in order to foam the protein, or the amount of gas may be reduced.

[0051] The foam component preferably also comprises at least one crosslinking agent, which in particular is formed by a vegetable protein, such as transglutaminase, when the foam component is formed by a protein foam.

[0052] It should be noted at this point that the chosen number of mixing apparatuses 9 in the first mixing section 3 with the design as described previously offers advantages with regard to the product properties of mineral foam 2. It is true that a mineral foam 2, that is to say a slurry, can also be prepared with a smaller or larger number of mixing rods 9, but

during the testing associated with the invention it was found that the product properties of mineral foam 2 are improved with a number of mixing apparatuses 9 from the specified range. In this context it should further be noted that the number of mixing apparatuses 9 is related to a certain size of device 1, that is to say a certain volume discharge rate of mineral foam 2, which may be as much as 50 m^3/h. It is therefore possible, though not tested, that a number of mixing apparatuses 9 differing from the specified number may be advantageous in a different configuration of system 1.

[0053] It was also found within the scope of the invention that a circumferential speed chosen from a range with a lower limit of 4 m/s, particularly 5.5 m/s, and an upper limit of 12 m/s, particularly 11 m/s, at which the mixing section shaft 10 of mixing section 3 is driven, also offers advantages with regard to the product properties of mineral foam 2 for the specified production volume. In particular, it is advantageous if a number of 16 mixing apparatuses 9 are connected for a circumferential speed of 6 m/s and a number of 4 mixing apparatuses 9 are connected for a circumferential speed of 10 m/s of mixing section shaft 10, wherein these values are to be understood to represent the lower and upper limits of a range of the number of mixing apparatuses 9 with regard to the circumferential speed of mixing section shaft 10.

[0054] In this context, it should be noted again that particularly for the first mixing section 3, but for the second a mixing section 4 as well, combinations of various types of mixing apparatuses 9 may be used, for example five stator rods and four paddle bars as the rotor. In general, a combination of stator and rotor bars is used in mixing sections 3, 4.

[0055] For a product stream between 5 kg/min, particularly 15 kg/min, and 50 kg/min, particularly 35 kg/min, of the powder components for production of the slurry, a volume of water between 150 l/h, particularly 300 l/h and 1000 l/h, particularly 500 l/h, is fed to the first mixing section 3. In this context, a correlation was again observed between the number of mixing apparatuses 9 in first mixing section 3 regarding the product properties of mineral foam 2. It is particularly advantageous if a volume flow of 250 l/h water is added to the powdered com-

components of the formulation for producing the slurry when 6 mixing apparatuses 9 are used, and volume flow of 800 l/h water is added when 18 mixing apparatuses 9 are used, wherein these values are also to be treated as the lower and upper limits of a range for the number of mixing apparatuses with reference to the volume flow of water.

[0056] It is advantageous for the addition of water to the powdered components in the first mixing section 3 if the water is supplied in distributed manner, via multiple areas of mixing section 3, in particular via spray jets. For example, spray jets may be arranged around the periphery of the first section 3 between 2 and 10, especially between 3 and 6.

[0057] Preferably between 30 and 60 percent by volume of the foam component, particularly between 40 and 50 percent by volume of the foam component per quantity share of the powder formulaton is delivered from foam generator 11 to the second mixing section 4. For 100 g powder formulaton, 5 g to 10 g foam component is added.

[0058] The foam component preferably has a density selected from a range with lower limit of 35 kg/m^3 and an upper limit of 60 kg/m^3.

[0059] The peripheral speed at which the second mixing section 4 is operated is preferably in the above-specified production volume is lower than that of the first mixing section 3 with regard to the volume flow of added foam component . The mixing apparatuses of the second mixing section 4 are arranged such that the slurry and the foam component are mixed homogeneous in mixing section 4, and the foam component is gently mixed with the slurry.

[0060] With the aid of device 1 according to the invention and using the method according to the invention it is possile to produce a mineral foam 2 that has a density of max. 300 kg/m^3, particularly a density between 100 kg/m^3 and 250 kg/m^3. In this context, this value refers to the completely dried mineral foam 2. The density may also be adjusted for example via the densities of the slurry and the foam component.

[0061] The formulation from which the slurry is produded in the first mixing section 3 consists in its simplest form of a calcium-sulfate-aluminate cement (CAS, sulfoaluminate cement, $4CaO.3Al_2O_3.SO_3$), a sulfate component, an aluminium silicate and a calcium oxide-providing component. The calcium-sulfate-aluminate cement is contained in the formulation in a proportion selected in a range from 55 parts by weight to 85 parts by weight. The proportion of the calcium-sulfate-aluminate cement is preferably at least 60 parts by weight, particularly at least 70 parts by weight. The sulfate component, that is to say the sulfate carrier, is contained in the formulation in a proportion in which a free sulfate proportion of the formulation is between 5 parts by weight and 15 parts by weight, particularly between 7 parts by weight and 12 parts by weight. The aluminium silicate iis contained in the formulation in a proportion in which the Al_2O_3 - proportion is between 3 parts by weight and 30 parts by weight, particularly between 4 parts by weight and 20 parts by weight. The calcium oxide-providing component, that is to say the calcium carrier, is contained in a proportion in which the free CaO proportion is between 0.5 parts by weight and 2 parts by weight, particularly between 0.7 parts by weight and 1.2 parts by weight.

[0062] The phrases "free sulfate proportion", "free Al_2O_3 proportion" and "free CaO proportion" are used to indicate that the respective proportions from the calcium-sulfate-aluminate cement are not under consideration, but instead these proportions originate from the other substances contained in the formulation.

[0063] Calcium sulfate, preferably in the anhydrite, dihydrate and/or α-hemihydrate forms is used as the sulfate, but other sulfates can also be used, for example a β-hemihydrate of calcium sulfate as well as magnesium sulfate or sodium sulfate. Optionally, mixtures and derivatives of the above substances may also be used. The added sulfate also functions as a grinding agent for the formulation, particularly if it ground before being introduced into the first mixing section 3, and as an accelerant during setting. It also improves the green strength of the slurry/foam mixture.

[0064] The aluminium silicate is preferably an alkali-activatable aluminium silicate, particularly an igneous aluminium silicate, preferably basalt, pitchstone, obsidian, phonolite, and/or metakaolin, and mixtures and derivatives thereof. For further improvement, a basalt is used, preferably with a zeolite and/or pozzolan content. The zeolite and/or pozzolan content may then be as much as 40% by wgt. particularly up to 30% by wgt.

[0065] The powdery components of the formulation, that is to say the sulfate-aluminate cement, the sulfate component, the aluminium silicate and the calcium oxide-providing compponent, preferably have a particle size up to 40 µm, particularly up to 25 µm, and not more than 17% larger particles in the main quantity. When this degree of grinding of the powdered main components of the formulation is maintained, the production of the slurry can be improved, in particular it is also possible to positively affect the porosity and volume proportion of the pores in mineral foam 2.

[0066] Besides these main components of the formulation, namely the sulfate-aluminate cement, the sulfate component, the aluminium silicate and the calcium oxide.providing component, the option exists within the scope of the invention for urther additives and excipients to be added to said formulation, particularly in powder form, although in the preferred variant of this formulation, it contains no non-reactive fillers, that is to say all components are reactive.

[0067] The formulation may also contain at least one high-performance plasticiser in a proportion not exceeding 1 percent by weight to reduce the proportional water content, wherein said high-performance plasticiser is preferably a polycarboxylate ether.

[0068] Moreover, at least one thickening agent may be added to the formulation in a proportion by weight not exceeding 0.5 parts by weight, wherein this thickening agent is preferably selected from a group including hydroxymethylpropylcellulose, methylhydroxyethylcellulose, and mixtures and derivatives thereof.

[0069] According to a preferred variant, the proportion of thickening agent does not exceed 70% of the proportion of the high-performance plasticiser.

[0070] Moreover, the additives for improving the rheology, e.g., viscosity reducing substances, may be added to prevent the quantity of solid components in the slurry from diminishing.

[0071] In order to avoid repetition, it should be noted at this point that in general the previous notes regarding the individual components of the formulation and the slurry, the foam component or the slurry/foam compnent also still apply.

[0072] Further processing additives include alkali carbonates, e.g., Li_2CO_3, alkali sulfates, fruit acids such as citric acid or tartaric acid, each of which may be included in a proportion of up to 2 parts by weight.

[0073] The formulation preferably also includes a hydrophobing agent in a proportion not exceeding 1 part by weight in ordfer to reduce the quantity of water taken up by the finished mineral foam 2, thereby enables a smaller reduction in thermal insulation behaviour, that is to say thermal conductivity, may be achieved by adjusting water uptake.

[0074] A surfactant, that is to say an agent that lowers surface tension may also be added to the foam component to improve its shelf life, in which case the proportion thereof in the foam component is preferably not more than 10 parts by weight.

[0075] Wetting agents known from the prior art may also be added to the foam component, particularly in a proportion up to 0.2 parts by weight, and high viscosity stabilisers, particularly in a proportion up to 0.02 parts by weight to improve mixing with the slurry.

[0076] The mineral foam 2 produced by the inventive method has pores which have a diameter not exedding 1 mm and may be present in 80% on the insulating material.

[0077] In the course of the tests conducted, the following exemplary compositions of the formulation according to the invention were prepared for the slurry according to Table 1. In this context, anhydrite was used as sulphate. The foam component was composed as indicated in Table 2, and hydrolysed keratin was used as the protein. The slurry/foam compositions were prepared in accordance with the preceding notes.

[0078] It should be noted that compositions were also produced with the other aforementioned substances within the scope of the invention.

Table 1: Slurry composition in parts by weight

No.	CAS clinker	Sulfate component	Basalt	$Ca(OH)_2$	Additives	Water
1	55	5	10	0.5	0.52	35
2	55	10	10	0.65	0.52	35
3	55	8	12	0.65	0.55	25
4	55	8	15	0.8	0.55	35
5	60	8	15	1.2	0.61	35
6	70	10	20	1	0.82	30
7	80	10	20	1.5	0.75	30
8	80	15	20	1.43	0.65	30
9	80	12	20	1.32	0.64	25
10	80	10	15	1.45	0.75	25

Table 2: Foam composition in parts by weight

No.	Protein	Water	Additives

No.	Protein	Water	Additives
1	1	60	0
2	1	55	0.2
3	1	50	0.2
4	1	45	0.2
5	1	40	0.2
6	2	60	0.2
7	2	40	0.5
8	2	20	0.5
9	3	60	0.5
10	3	50	0.5

[0079] A preferred composition of the formulation for the production of mineral foam 2 consists of 65 parts by weight to 75 parts by weight, particularly 70 parts by weight calcium-sulfate-aluminate cement clinker, 5 parts by weight to 15 parts by weight, particularly10 parts by weight anhydrite, 15 parts by weight to 25 parts by weight, particularly 20 parts by weight calcined aluminium silicate, particularly basalt, 0.5 parts by weight to 1.5 parts by weight, particularly 1 part by weight, calcium hydroxide, 0.25 parts by weight to 0.75 parts by weight, particularly 0.5 parts by weight lithium carbonate, 0.01 parts by weight to 0.03 parts by weight, particularly 0.01 parts by weight, 0,15 between parts by weight to 0.45 between parts by weight, particularly 0.3 between parts by weight polycarboxylate ether and 0.01 between parts by weight to 0.03 between parts by weight, particularly 0.02 between parts by weight methylcellulose.

[0080] Between 20 parts by weight and 40 parts by weight water are added to this formulation to form the slurry.

[0081] Between 40 parts by weight and 60 parts by weight foam componente are added to the prepared slurry. In addition to the foam, the foam component consists of a crosslinking agent, wherein the crosslinking agent is contained in a proportion between 1 part by weight and 3 parts by weight, particularly 1.5 parts by weight, relative to the content by weight of the hydraulic binder in the formulation. The foam component has a density between 40 kg/m^3 and 60 kg/m^3, particularly 50 kg/m^3.

[0082] Regarding the additives used, the reader is referred to the preceding notes.

[0083] Additionally, it should be noted that the foam component may also be added to the slurry in a discontinuous process as well as in the preferred continuous method described earlier.

[0084] For formal purposes, it should be noted finally that some components of device 1 have been represented not to scale and/or enlarge and/or reduced in size to enable a better understanding of the construction thereof.

Reference numerals

[0085]

1 Device
2 Mineral foam
3 Mixing section
4 Mixing section
5 Storage container
6 Conveyor
7 Arrow
8 Arrow
9 Mixing apparatus

10 Mixing section shaft
11 Foam generator
12 Protein
13 Storage container
14 Arrow
15 Arrow
16 Storage container
17 Arrow
18 Arrow
19 Conveyor
20 Conveyor

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ÁSVÁNYHAB ÉS ELJÁRÁS ELŐÁLLÍTÁSÁRA

Szabadalmi igénypontok

1. Készítmény tűzgátló ásványhab előállításához, amely tartalmaz kalcium-szulfát-aluminát-cementet, legalább egy szulfát-komponenst, legalább egy alumínium-szilikátot, valamint legalább egy, kalcium-oxidot biztosító komponenst, **azzal jellemezve, hogy** a kalcium-szulfát-aluminát-cementet 55 tömegrésztől 85 tömegrészig terjedő tartományból választott mennyiségben tartalmazza, a szulfát-komponenst olyan hányadban (részben) tartalmazza, hogy a szulfát-rész 5 tömegrész és 15 tömegrész közötti, az alumínium-szilikátot olyan hányadban tartalmazza, hogy az Al_2O_3-rész 3 tömegrész és 30 tömegrész közötti, és a kalcium-oxidot biztosító komponenst olyan hányadban tartalmazza, hogy a CaO-rész 0,5 tömegrész és 2 tömegrész közötti.

2. Az 1. igénypont szerinti készítmény, **azzal jellemezve, hogy** a szulfát-komponenst kalcium-szulfátot, kalcium-szulfát α- vagy β-hemihidrátját vagy dihidrátját, anhidritet, nátrium-szulfátot, vas(II)-szulfátot, magnézium-szulfátot, valamint ezek keverékeit és származékait tartalmazó csoportból választjuk.

3. Az 1. vagy 2. igénypont szerinti készítmény, **azzal jellemezve, hogy** az alumínium-szilikát alkálikusan aktiválható alumínium-szilikát, különösen vulkanikus alumínium-szilikát és/vagy metakaolin, illetve ezek keverékei és származékai.

4. Az 1 – 3. igénypontok bármelyike szerinti készítmény, **azzal jellemezve, hogy** az alumínium-szilikát kalcinált formában van.

5. Az 1 – 4. igénypontok bármelyike szerinti készítmény, **azzal jellemezve, hogy** a kalcium-oxidot biztosító komponenst kalcium-oxid, kalcium-karbonát és kalcium-hidroxid, valamint ezek keverékei által alkotott csoportból választjuk.

6. Az 1 – 5. igénypontok bármelyike szerinti készítmény, **azzal jellemezve, hogy** tartalmaz legalább egy polikarboxilát-étert vagy annak származékát nagyteljesítményű folyósítóként, legfeljebb 3 tömegrész mennyiségben.

7. Az 1 – 6. igénypontok bármelyike szerinti készítmény, **azzal jellemezve, hogy** legfeljebb 0,5 tömegrész mennyiségben tartalmaz legalább egy sűrítőszert, amelyet hidroximetil-propil-cellulózt, metil-hidroxietil-cellulózt, valamint ezek keverékeit és származékait tartalmazó csoportból választunk.

8. A 7. igénypont szerinti készítmény, **azzal jellemezve, hogy** a sűrítőszer hányada a nagyteljesítményű folyósító hányadának legfeljebb 70%-át teszi ki.

9. Az 1 – 8. igénypontok bármelyike szerinti készítmény, **azzal jellemezve, hogy** rostoktól mentes.

10. Az 1 – 9. igénypontok bármelyike szerinti készítmény, **azzal jellemezve, hogy** tartalmaz legalább egy olyan anyagot, amelye(ke)t alkáli-karbonátokat, alkáli-szulfátokat, gyümölcssavakat tartalmazó csoportból választunk.

11. Az 1 – 10. igénypontok bármelyike szerinti készítmény, **azzal jellemezve, hogy** töltőanyagtól mentes.

12. Porózus ásványhab (2), amely tartalmaz hidraulikusan megkötő komponenst és habkomponenst, **azzal jellemezve, hogy** a hidraulikusan megkötő komponens egy az előző igénypontok szerinti készítményből van kialakítva.

13. A 12. igénypont szerinti ásványhab (2), **azzal jellemezve, hogy** a habkomponens proteinhab és/vagy felületaktívanyag-hab segítségével van kialakítva.

14. A 12. vagy 13. igénypont szerinti ásványhab (2), **azzal jellemezve, hogy** készítmény-részenként 30 - 60 rész habkomponenst tartalmaz.

15. A 12 – 14. igénypontok bármelyike szerinti ásványhab (2), **azzal jellemezve, hogy** a habkomponens felületaktiv anyag, amelyet zsírsavakat, alkilszulfonátokat, valamint ezek származékait és keverékeit tartalmazó csoportból választunk.

16. A 12 – 15. igénypontok bármelyike szerinti ásványhab (2), **azzal jellemezve, hogy** a habkomponens tartalmaz növényi fehérjét mint hálósítószert tartalmaz.

17. A 16. igénypont szerinti ásványhab (2), **azzal jellemezve, hogy** a hálósítószer az ásványhabban a hidraulikusan megkötő komponens tömegére vonatkoztatva 1% és 3% közötti arányban van jelen.

18. A 12 – 17. igénypontok bármelyike szerinti ásványhab (2), **azzal jellemezve, hogy** a pórusok aránya legalább 70%.

19. A 12 – 18. igénypontok bármelyike szerinti ásványhab (2), **azzal jellemezve, hogy** a pórusok átmérője legfeljebb 0,5 mm.

20. Építőelem építőelem-testtel, **azzal jellemezve, hogy** a 12 – 19. igénypontok bármelyike szerinti ásványhab (2) képezi az építőelem-testet, vagy a 12 – 19. igénypontok bármelyike szerinti ásványhab (2) helyezkedik el az építőelem-test felületén és/vagy az építőelem-testen belül.

21. Eljárás önkeményedő ásványhab (2) előállítására, amelynek során egy készítmény előállításához por formájú alkotórészeket összekeverünk egy első keverési szakaszban (3), így keveréket alakítunk ki, és ehhez a keverékhez vizet adunk, így zagyot alakítunk ki, **azzal jellemezve, hogy** az 1 – 11. igénypontok bármelyike szerinti készítményt állítunk össze és egy második keverési szakaszban (4) habkomponenst adunk a zagyhoz és belekeverjük a zagyba, és ezután az ásványhab (2) megkeményedik.

22. A 21. igénypont szerinti eljárás, **azzal jellemezve, hogy** készítmény-részenként 30 – 60 rész habkomponenst adagolunk.

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Fig.1