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(54) **ECOLOGICAL PLATE FOR THERMAL AND ACOUSTICAL INSULATION AND METHOD THEREOF**

(57) The invention relates to an ecological plate for thermal and acoustical insulation, characterized in that it is formed only from cellulose fibers, most preferably from waste paper cellulose, and expanded perlite of grain sizes in a range from 0.1 mm to 10 mm, preferably in a

range from 0.5 mm to 5 mm, where the cellulose content in the plate ranges from 38% to 48%, the perlite content in the plate ranges from 52% to 62%, and the plate heat transfer coefficient is not bigger than 0.05 W/mK. Also, a method for producing such a plate is disclosed.

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Description

[0001] This invention relates to an ecological plate for thermal and acoustical insulation and a method for producing thereof.

[0002] Materials for thermal insulation have been used commonly and for a long time. There are different types of such materials and the materials are produced in different forms. In many applications flat insulation plates are used that are made from various materials and have different sizes. Continuously, new insulation materials are sought that have low heat transfer coefficients, are lightweight, have good mechanical strength, are high temperature resistant, and are cheap. Nowadays, an additional feature of such materials is their eco-friendliness if they are made from natural and/or, frequently, recyclable materials.

[0003] Polish Patent Application P.291024 discloses a method for producing construction/insulating materials from various organic wastes. According to the method, solid waste material is moistened with chemically dissolved wastes of tanned skins, stirred thoroughly, and then formed and dried in temperatures from 60 to 130°C.

[0004] Polish Patent PL182386 describes a method for producing an insulation material from plant fibers, that has a three dimensional tangled structure of isotropic fiber orientation and exhibits the bulk density of 25 kg/m³.

[0005] Polish Patent Application P.330163 shows a new type of soundproofing and heat insulating material for constructional purposes, having a layered structure, and a method for producing such a material. The material consists of a strengthened paper or cardboard layer, of a hot-melt or cold-setting adhesive layer, of a hemp or linen fibers layer, preferably a nonwoven fabric in which tangled fibers are joined by stitching, and an aluminum foil layer. According to the inventors, the material is stable, suppresses vibrations and heat transfer, and is free from environmentally harmful substances.

[0006] Another Polish Patent Application P.332156 discloses a new type of an insulating material comprising a base material formed into spatial cells with a filler residing within the cells. The fibers of the filler material are interlinked by means of foamy binder. Isolating plates made from such a material need, when in use, a special binder, this increasing costs and complicating the manufacture process. Moreover, the binding material should not become a medium for bacteria and/or fungi, this requiring biostatic agents in the case of proteinaceous binder made from skins.

[0007] Polish Patent PL182386 entitled "Insulating material from plant fibers" relates to an insulating element made from a plant fiber nonwoven material of three dimensional tangled structure, having isotropic fiber orientation and the bulk density of 25 kg/m³, wherein the fibers are interlinked by a binder, such as waterglass, bone glue, resins or hot-melt polymer fibers. The material may be a good insulator, but plates made therefrom do not have good mechanical strength and their structure needs

two-sided lamination, this complicating the process of manufacturing and cutting of such plates.

[0008] Polish Patent PL200752 discloses an insulating material from PET (polyethylene terephthalate) wastes.

5 A process of producing this material comprises steps of comminuting PET material containing up to 40% by weight of impurities, mixing with a chemically cured or thermo-setting binder, and pressing in molds. The obtained mats are stiff and of poor repeatability, since they are made from waste material of various properties. 10 Moreover, the method needs an active bonding agent based on synthetic resins, this increasing the cost of such plates. Moreover, resin bonded plates are heavy and difficult to cut and process. Also, the material is water and 15 steam permeable, this imposing the necessity of additional tight insulating of the material itself in the place of application.

[0009] Polish Patent Application P.355450 discloses a new type of environment friendly insulating material for 20 insulating buildings. The material is made from fabric wastes that are comminuted and mixed with a fibrous polystyrene of a low melting point and with linen fibers. Then, from the obtained uniform mixture desired fittings are formed that are heat treated such that the polyester 25 fiber melts and binds the fabric with linen fibers. The manufacturing process of this material uses casual fabric wastes along with polymer fibers that, after thermally binding, create fixed fusion with the natural fibers, that is impossible to separate into fractions. The linen fibers are 30 the only natural component of this material, therefore one cannot call this material an ecological material. Also, the inflammability of the material may be high, this limiting the fields of its applicability.

[0010] An alternative for the above solutions for producing insulating plates may be the use of perlite that is 35 a natural rock which, after expanding, creates a lightweight, porous and nonflammable insulating material. An interest in perlite for insulating purposes is not new.

[0011] Polish Patent Application P.306314 describes 40 perlite based insulating products, hydraulically bonded, made from a mixture comprising up to 60% by weight of expanded perlite of granularity 0-4 and 0-1 mm and 40% by weight of portland cement, and, preferably, up to 40% by weight of silica. Such mixture is mixed with water and 45 then plates are formed which are bonded by cement. Such plates are made from a form of lightweight concrete, are heavy and cannot be recycled.

[0012] An alternative solution is a composite material described in Polish Patent PL234159, having an addition 50 of perlite dust. The material is produced from concrete in an amount from 41.40% to 46.00% by weight, volatile ash in an amount from 19.5% to 24.10% by weight, cellulose fibers in an amount from 7.07% to 10.61% by weight, mica in an amount from 14.12% to 17.65% by weight, perlite dust in an amount from 10.60% to 17.66% 55 by weight, water in an amount from 70% to 80% by weight, foam reducer in an amount from 0.01% to 0.03% by weight, and flocculating agent in an amount from

0.01% to 0.03% by weight. After mixing, the mixture is foamed and bonded by the employed cement, creating a porous structure. It is a sort of ceramic cement based construction material of increased insulating properties. The material is not suitable to be recycled, and the cellulose fibers within it play a role of foam stabilizer. This material is not of high mechanical strength when having high porosity, and when its density is bigger, then its insulating properties are not very good.

[0013] Polish Patent PL193671 discloses the use of perlite as a lightweight additive for making soundproof plates in a water based felting process. Mineral wool is used for making such plates instead of natural or polymer fibers. Such a plate is intended for absorbing acoustic waves rather than for insulating purposes. The use of mineral wool in such plates has a drawback that, with time and aging of the plates, glass fiber may be emitted from them with a harmful effect for lungs. Moreover, the perlite material used in the mixture needs a pretreatment hydrophobization process, this increasing the manufacture costs. The use of starch as a binder is unfavorable since starch is prone to microorganisms.

[0014] In US Patent US 7,550,202, a method is described for producing a thermal insulation mat from an aerodynamically formed fleece of natural fibers, thermoplastic fibers, and perlite particles with thermoplastic binding agent. The forming process of a plate is performed by passing hot air (170°C) through a pre-conditioned fleece. The obtained material reaches a density of 135 kg/m³, and the manufacturing process itself is a dry process. The process of forming the fleece before fixing its structure is performed in an aerodynamic mixer, and obtaining a uniform mixture of all the fleece components seems to be difficult.

[0015] US Patent US 5,749,954 discloses a method for producing perlite based insulating plates. The raw material mixture contains dry expanded perlite, natural fibers, starch, bitumen additives (asphalt), and alum for controlling the pH of the slurry. Perlite grains are, initially, covered with hot asphalt. Water based slurry is created from the components, the slurry being then poured into a mold, where it is drained, and then the plate is dried. During the drying process, the mat components are merging into a durable structure. The method employs asphalts for making the plate structure, this limiting the possible range of application to moderate temperatures only, and results in all negative consequences of containing asphalts, such as specific smell and a risk of releasing harmful compounds, such as PAH (polycyclic aromatic hydrocarbons).

[0016] The same authors, in a later US Patent US 6,149,831, described a similar perlite based insulating mat, and suggested, for producing it, beside the asphalts (bitumen), also synthetic latexes, such as PVA based acrylic latex, styrene-butadiene latex, etc. The plate, after forming it from a water slurry, was drained and dried in a temperature of approximately 120°C overnight. Not only is the plate, produced using that method, more expen-

sive, because of the use up to 10% by weight of synthetic latexes, but also it has the same drawbacks as previous solutions of the same authors.

[0017] A very similar solution is presented in US Patent US 4,126,512, where, additionally, waste paper fibers were suggested to be used and combined with asphalt.

[0018] Also, acoustic panels produced with the use of perlite are described in US Patent US 5,277,762. For making these panels, beside the perlite material and cellulose fibers, also mineral wool, synthetic latexes, and clay are used, and the process of forming the plates is preceded by a process of flotation of the plate ingredients in a water slurry. The same authors, in a previous US Patent US 4,963,603, described a method for producing composite plates without perlite and mineral wool, using only cellulose fibers from waste paper, joined by synthetic latexes.

[0019] Also, US Patent US 4,863,979, describes a composite plate from cellulose, perlite, mineral wool, and clay, joined by synthetic latex resin, and US Patent US 4,313,997 describes a plate made from perlite only. Perlite is merged using asphalt and polyacrylic resin, creating porous plates. The material formed in this way cannot be recycled and has a smell of asphalt, and its thermal strength is limited by thermal strength parameters of the employed polyacrylic resin.

[0020] Insulating plates produced using perlite, described in other patents, are either costly, due to the complexity of the composition and expensive additives, or have a smell of asphalt (bitumens) and may release harmful compounds. They are not suited to be reused or recycled and became a waste material after having been used.

[0021] Unexpectedly, it has turned out that durable insulating plates may be produced from perlite, that are free of the above drawbacks, may be recycled, and are produced from all natural materials. Cellulose fibers sourced from waste paper perfectly bond mineral grains of perlite, creating very robust structure of small density and excellent insulating properties.

[0022] This invention relates to an ecological plate for thermal and acoustical insulation characterized in that it is produced only from cellulose fibers, most preferably waste paper cellulose, and expanded perlite of grain size from 0.1 mm to 10 mm, preferably from 0.5 mm to 5 mm, where the cellulose content in the plate ranges from 38% to 48%, the perlite content in the plate ranges from 52% to 62%, and the plate heat transfer coefficient is not bigger than 0.05 W/mK.

[0023] Preferably, the cellulose content in the plate ranges from 41% to 45%, and the perlite content in the plate ranges from 55% to 59%.

[0024] Preferably, the plate density ranges from 140 kg/m³ to 210 kg/m³, preferably from 160 kg/m³ to 190 kg/m³.

[0025] This invention also relates to a method for producing an ecological plate for thermal and acoustical insulation, the method being characterized in that the plate

is formed only from a water slurry of cellulose fibers and grains of expanded perlite of grain sizes in a range from 0.1 mm to 10 mm, preferably in a range from 0.5 mm to 5 mm, and the slurry is poured into a flat mold with a mesh bottom, and then excess water is drained away using a press, under a pressure from 300 kg/m² to 1200 kg/m², simultaneously giving the shape to the produced insulating plate, and then the plate is dried to a final moisture content not bigger than 5% by weight, preferably in a drying room in a temperature from 40°C to 150°C, preferably in a temperature from 100°C to 130°C, and the cellulose content in the obtained plate ranges from 38% to 48%, the perlite content in the plate ranges from 52% to 62%, and the plate heat transfer coefficient is not bigger than 0.05 W/mK.

[0026] Preferably, the excess water is drained away in a press under a pressure from 500 kg/m² to 800 kg/m².

[0027] Preferably, the cellulose content in the plate ranges from 41% to 45% by weight, and the perlite content in the plate ranges from 55% to 59% by weight.

[0028] The insulating plate according to the invention is produced from cellulose fibers sourced from waste paper. Unexpectedly, it has turned out that the bonding between the cellulose fibers and the perlite grains gives, after drying, a very strong and lightweight material without the necessity of using additional bonding agents. Therefore, the plates are of ecological nature since they are formed from all natural materials without using any auxiliary materials. The formed plate is of high porosity and the plate material is lightweight, is easily workable, it is totally recyclable, and, after transforming into a water slurry, new insulating plates may be formed from it.

[0029] In order to produce plates, a portion of waste paper is pulverized into a water slurry such that it is possibly well defibratized. Then, a predetermined portion of perlite grains are introduced into the slurry of the cellulose fibers, and the whole batch is stirred to obtain a uniform suspension. So prepared water slurry of the cellulose fibers and perlite is poured into molds having dense mesh bottoms. In the molds, the slurry is drained gravitationally forming a pre-compacted layer that is pressed, subsequently, in a press for removing the water from it more thoroughly. As a result a plate is obtained, still damp, having a size of the employed mold and a thickness resulting from the amount of the material put onto the mold. The plate is removed from the mold and is dried in an elevated temperature to remove residual water. As a result, a lightweight and strong plate is obtained that can be easily cut and smoothened. The water drained from the plates when in the forms, is recycled back to the pulverization step to process next portions of the waste paper. Simultaneously, it has turned out that the produced plates also have very good soundproofing properties.

[0030] Embodiments of a process for producing cellulose-perlite plates according to the invention are described in detail in the following Examples.

Example 1

[0031] 2500 kg of water was added to an atomizer of a capacity of 4 m³ equipped with a high speed rotary blade stirrer, and then, after starting the stirrer, 125 kg of mixed newspaper/cardboard waste paper was added gradually in portions for next 2 hours. The pulverization process was ended 20 minutes after adding the last portion of the waste paper. The obtained slurry was reloaded into a tank of a capacity of 5 m³ having a ribbon stirrer, and then, while stirring continuously, 150 kg of expanded perlite was added into the slurry, the perlite having grain sizes from 0.2 mm to 5.3 mm and the average grain diameter of 3.6 mm. After introducing the whole amount of perlite, the slurry was mixed yet for 15 minutes, obtaining a uniform slurry of cellulose fibers and perlite particles. Then, the obtained slurry was loaded, in an amount of 4 dm³, into a flat frame mold of dimensions 60 cm by 80 cm and the edge height of 10 cm, the mold having a metal mesh bottom with openings of sizes of 0.15 mm. The slurry in the mold was gravitationally drained for 90 seconds, and then the sediment remaining in the mold was pressed in a press with a pressing force of 300 kg for 10 seconds. After removing the mold from the press, a wet plate was obtained of a thickness of 60 mm. The plate was then dried for 6 hours in a drying room in a temperature of 115°C. After drying, the plate had a weight of 3.8 kg and a density of 132 kg/m³. The plate heat transfer coefficient, as measured, was 0.04 W/mK. The soundproofing coefficient of the obtained plate was 35.0 dB. Moreover, the plate was flame retardant this being confirmed by tests of kindling the plate with a gas burner where after removing the plate from the burner flame, the fire in the plate was quickly self stifled.

Example 2

[0032] In an atomizer, in the same manner as in Example 1, a slurry of waste paper cellulose fibers and perlite was prepared using 130 kg of waste paper and 160 kg of expanded perlite. After adding the whole amount of the perlite, the slurry was stirred yet for 15 minutes, obtaining a uniform suspension of cellulose fibers and perlite particles. Next, so prepared slurry was loaded, in an amount of 63 dm³, into a flat frame mold of dimensions 795 mm by 545 mm and the edge height of 15 cm, the mold having a metal mesh bottom with openings of sizes of 0.15 mm. The slurry in the mold was gravitationally drained for 60 seconds, and then the sediment remaining in the mold was pressed in a press with a pressing force of 350 kg for 10 seconds. After removing the mold from the press, a wet plate was obtained of a thickness of 100 mm. After drying, the plate had a weight of 6,4 kg and a density of 148 kg/m³. the plate heat transfer coefficient, as measured, was 0.04 W/mK. The soundproofing coefficient of the obtained plate was 58,3 dB.

Claims

1. An ecological plate for thermal and acoustical insulation, **characterized in that** the plate is formed only from a water slurry of cellulose fibers, most preferably from waste paper cellulose, and expanded perlite of grain sizes in a range from 0.1 mm to 10 mm, preferably in a range from 0.5 mm to 5 mm, where the cellulose content in the plate ranges from 38% to 48%, the perlite content in the plate ranges from 52% to 62%, and the plate heat transfer coefficient is not bigger than 0.05 W/mK. 5
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2. The plate according to claim 1, **characterized in that** the cellulose content in the plate ranges from 41% to 45%, and the perlite content in the plate ranges from 55% to 59%. 15
3. The plate according to claim 1 or 2, **characterized in that** the density of the plate ranges from 140 kg/m³ to 210 kg/m³, preferably from 160 kg/m³ to 190 kg/m³. 20
4. A method for producing an ecological plate for thermal and acoustical insulation, **characterized in that** the plate is formed only from a water slurry of cellulose fibers and expanded perlite of grain sizes in a range from 0.1 mm to 10 mm, preferably in a range from 0.5 mm to 5 mm, and the slurry is poured into a flat mold with a mesh bottom, and then excess water is drained away using a press, under a pressure from 300 kg/m² to 1200 kg/m², simultaneously giving the shape to the produced insulating plate, and then the plate is dried to a final moisture content not bigger than 5% by weight, preferably in a drying room in a temperature from 40°C to 150°C, preferably in a temperature from 100°C to 130°C, and the cellulose content in the obtained plate ranges from 38% to 48%, the perlite content in the plate ranges from 52% to 62%, and the plate heat transfer coefficient is not bigger than 0.05 W/mK. 25
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5. The method according to claim 4, **characterized in that** excess water is drained away in a press under a pressure from 500 kg/m² to 800 kg/m². 45
6. The method according to claim 4 or 5, **characterized in that** the cellulose content in the plate ranges from 41% to 45% by weight, the perlite content in the plate ranges from 55% to 59% by weight. 50

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EUROPEAN SEARCH REPORT

Application Number
EP 21 16 6196

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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