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(54) **A WET-FORMED SOLID POROUS BODY, A PROCESS FOR CONTROLLING STRUCTURAL AND MECHANICAL PROPERTIES IN THE MANUFACTURE OF A SOLID POROUS BODY AND PAPER MANUFACTURE, AND A METHOD OF WET-FORMING THE SOLID POROUS BODY**

NASSGEFORMTER FESTER PORÖSER KÖRPER, VERFAHREN ZUR STEUERUNG DER STRUKTURELLEN UND MECHANISCHEN EIGENSCHAFTEN BEI DER HERSTELLUNG EINES FESTEN PORÖSEN KÖRPERS UND PAPIERHERSTELLUNG SOWIE VERFAHREN ZUM NASSFORMEN DES FESTEN PORÖSEN KÖRPERS

CORPS POREUX SOLIDE FORMÉ PAR VOIE HUMIDE, PROCÉDÉ DE RÉGULATION DE PROPRIÉTÉS STRUCTURELLES ET MÉCANIQUES DANS LA FABRICATION D'UN CORPS POREUX SOLIDE ET LA FABRICATION DE PAPIER, ET PROCÉDÉ DE FORMATION PAR VOIE HUMIDE DU CORPS POREUX SOLIDE

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Description

TECHNICAL FIELD

[0001] The present invention relates to a wet-formed solid porous body that has a density of 100 to 400 kg/m^3, and is based on fibrous material from softwood including fractions of fibers separated from one another in a mechanical pulping process.

[0002] It also relates to a process for controlling structural and mechanical properties in the manufacture of a solid porous body and paper manufacture by using combined fiber selection strategy.

[0003] Further, it relates to a method of wet forming a solid porous body that has a density of 100 to 400 kg/m^3 and is based on fibrous material from softwood including fractions of fibers separated from one another in a mechanical pulping process.

[0004] In a mechanical pulping process, pulp is produced with little or no chemicals by mechanically grinding logs or wood chips to defibrate the wood and free the fibers from one another. The pulp is used mainly for newsprint and as an ingredient of base stock for lower grade printing papers. The most important ones of the various grades of mechanical pulps are the fully mechanical pulps Groundwood Pulp (GW), Pressurized Groundwood Pulp (PGW), and Refiner Mechanical Pulp (RMP), and further the mechanical and thermal pulps Thermo Mechanical Pulp (TMP), Thermo Chemi-Mechanical Pulp (TCMP) and Chemi-Thermo-Mechanical Pulp (CTMP).

[0005] The density figures above refer to oven dry density. When the produced bodies are in equilibrium with the moisture in ordinary indoor air, they usually contain about 10-12 % of water.

BACKGROUND ART

[0006] It is known to use fibers from wood for producing wet-formed solid porous bodies, such as fiberboard and molded fibrous objects, for example. Such bodies are eco-friendly alternatives to oil based products such as expanded polystyrene (EPS), polyurethane (PUR), polyisocyanurate (PIR), and further to wood particle board, flax particle board, and mineral wool, for example. There is an increasing demand for products made of materials from renewable sources, but generally, the fibrous products have required an added binder to get the desired strength properties. Other additives are added to make the solid porous bodies heat insulating, flame-retardant, soundproof, moisture repelling, and rot-resistant, for example.

[0007] In addition, during the production of mechanical pulp from wood, many pulp mills get as byproduct a fiber fraction that has no use but has to be discarded, and as a rule, in the mills there is also some waste heat that is not used.

[0008] GB 997798 discloses a wet process for producing fiberboard which is free from added non-cellulose binders.

SUMMARY OF THE INVENTION

[0009] In a first aspect of the present invention, it is an object of the invention to provide a wet-formed solid porous body that has a density of 100 to 400 kg/m^3 and is based on fibrous material from softwood including fractions of fibers separated from one another in a mechanical pulping process, as described in claim 1.

[0010] In accordance with the present invention, this object is achieved in that the solid porous body comprises:

- a fiber fraction wherein the fibers have
  - a weighted average fiber length of from 0.5 to 2.0 mm;
  - a weighted average fiber width of from 20 to 50 μm; and
- a fines fraction wherein the particles have a weighted average length of less than 0.2 mm and constitute from 5 to 50 percent by weight of said fibrous material; and

said solid body being hydrogen bonded and free from added non-cellulose based binders.

[0011] Fiber length and width are fundamental pulp properties that relate directly to paper properties. The traditional method for measuring fiber dimensions involves classifying the pulp into screened fractions and then measuring the weight and length of fibers in each fraction to calculate the weighted average length by weight or weighted average width by weight.

[0012] "Weighted average length" or "length weighted average length" means that the average is influenced by using a weight for each observation, in this case the length of each fiber. Each observation is multiplied by its weight, in this case the length of each fiber is multiplied by the same length. Then, the sum of this product is calculated for all the fibers in the distribution, a sample. To find the length weighted average length, this sum is divided by the sum of the weight, in this case the sum of length of all the fibers.

[0013] "Weighted average width" or "length weighted average width" means that the average is influenced by using a weight for each observation, in this case the length of each fiber. Each observation is multiplied by its weight, in this case the width of each fiber is multiplied by the length. Then, the sum of this product is calculated for all the fibers in the distribution, a sample. To find the length weighted average width, this sum is divided by the sum of the weight, in this case the sum of length of all the fibers.

[0014] For more information how to calculate "weighted average length" and "weighted average width", please see "TAPPI standard T 232 cm-01".

[0015] Another term for hydrogen bonding is hydroxyl bonding.

[0016] Such a wet-formed solid porous body may be produced by a process that to some degree utilizes waste products and waste energy from pulp mills. In addition, new applications for mechanical pulping and fractions thereof are created. The wet-formed solid porous bodies of the invention give excellent soundproofing, have excellent thermal insulation properties and do not burn if treated by including clay and/or flame retardants, and they have an excellent weight to volume ratio. Further, they are eco-friendly, as they are based on reject fractions from the mechanical pulping process (*viz.* the coarsest fiber fraction and the fines fraction) and are made without any addition of a non-cellulose based binder, and they are an eco-friendly alternative to expanded polystyrene (EPS), polyurethane (PUR), polyisocyanurate (PIR), wood particle board, flax particle board, and mineral wool, for example. In addition, as the reject fractions from the mechanical pulping mill are not burnt but incorporated in the produced wet-formed solid porous bodies, the production of the bodies contribute to the lowering of carbon dioxide emissions.

[0017] Preferably, the wet-formed solid porous body has at least one of the following properties:

- modulus of elasticity of 50-500 MPa,
- bending strength of 200-2500 kPa,
- compression strength of 50-1000 kPa, and a
- Janka hardness of 20-500 N.

[0018] The Janka hardness test measures the resistance of a sample of wood to denting and wear. It measures the force required to embed an 11.28 mm (.444 in) steel ball into wood to half the ball's diameter. A common use of Janka hardness ratings is to determine whether a species is suitable for use as flooring.

[0019] The above listed strength properties of the wet-formed solid porous body make the body suitable as a replacement for fiberboard bonded by non-cellulose based binders, petroleum based insulating materials such as expanded polystyrene, for example, and also for replacing wood in a plurality of applications.

[0020] In one preferred embodiment the body has a density of 120 to 140 kg/ m^3, a length weighted average fiber length of from 1.35 to 1.55 mm, a length weighted average fiber width of from 36 to 38 μm, and the fines fraction of particles constitutes from 8 to 12 percent by weight of said fibrous material.

[0021] In another preferred embodiment the body has a density of 120 to 140 kg/ m^3, a length weighted average fiber length of from 1.35 to 1.55 mm, a length weighted average fiber width of from 32 to 34 μm, and the fines fraction of particles constitutes from 8 to 12 percent by weight of said fibrous material.

[0022] In yet another preferred embodiment the body has a density of 210 to 250 kg/m^3, a length weighted average fiber length of from 0.9 to 1.1 mm, a length weighted average fiber width of from 29 to 31 μm, and the fines fraction of particles constitutes from 30 to 40 percent by weight of said fibrous material.

[0023] Suitably, the body has a thermal conductivity of at most 0.060 W/m·K, whereby it can be used for thermal insulation.

[0024] If desired, the properties of the body can be improved in that the body comprises at least one additive.

[0025] The additive is preferably selected from the group consisting of clays, flame retardants, synthetic fibers, non-wood based natural fibers, dyes, moisture repellents, biocides, such as rot-resistant (anti-fouling) additives, and micro-fibrillated cellulose (MFC).

[0026] It is preferred that the softwood used in the mechanical pulping process is Norway spruce (Picea abies), which gives high quality fibers.

[0027] The wet-formed solid porous body may be of various shapes, but a fiberboard panel, a fillet or strip, a pot, or a coffin are examples of shapes in demand.

[0028] In a second aspect of the present invention, it is an object of the invention to provide a process for controlling structural and mechanical properties by using combined fiber selection strategy in the manufacture of a solid porous body and paper manufacture, as described in claim 11.

[0029] In accordance with the present invention, this object is achieved in that the process comprises:

a) selecting a suitable wood raw material;
b) defibering the wood raw material in a mechanical pulping process to get free fibers separated from one another;

c) selecting a degree of treatment of the wood raw material by controlling an amount of energy supplied to the mechanical pulping process;
d) exposing the free fibers to a mechanical after-treatment in at least one refiner;
e) fractionating the obtained pulp by means of screens or hydrocyclones to get fiber fractions useful in the manufacture of a solid porous body and paper manufacture; and
f) selecting at least one fiber fraction suitable for manufacturing of a solid porous body.

[0030] In this context the expression "combined fiber selection strategy" has the meaning that fibers with certain desired characteristics are selected from wood raw material and/or the fibers are also fractionated and/or sorted within the selected wood raw material. Tree fibers selected from a trunk portion close to a tree root or close to a tree top, or fibers selected from a part close to the heartwood or close to the cortex of the tree all comprise fibers with different fiber characteristics. Thus, the length and width of the fibers depend on which part of the tree stem the fibers originate from. Further, the selection of the fiber is made in view of variety of three, genetic material/origin, the habitat of the tree, trunk portion including saw mill chips, and growth rate. Depending on which characteristic of the fibers that is desirable the fibers that are provided with the desired type of characteristic are fractionated and/or sorted out of the wood raw material. The selection from a certain part of the tree stem together with fractioning and/or sorting of the fibers constitute the "combined fiber selection strategy" which facilitate the manufacture the solid porous body with the desired characteristics. The phrase "combined" relates to the combination of these techniques: raw material selection and/or wood sorting and/or fiber fractionating, with the purpose of getting a tailor made defined fiber property distribution necessary to reach the wanted properties of the final product.
[0031] By selecting the right fiber and process, it is possible to produce a wet-formed solid porous body that is low-weight, strong and rigid and has good insulation properties without having to use a non-cellulose based binder.
[0032] To select the right fiber, the selection is made in view of variety of tree, genetic material/origin, the habitat of the tree, trunk portion including saw mill chips, and growth rate. Preferably, the variety of tree selected is Norway spruce (Picea abies).
[0033] According to the present invention, the fiber fraction selected in step f) has weighted average fiber length of from 0.7 to 1.8 mm and a weighted average fiber width of from 25 to 42 μm; and the process further comprises:

g) selecting also a fines fraction of particles having a weighted average length of less than 0.2 mm and constituting from 8 to 40 percent by weight of said fibrous material;
h) mixing said fractions and preparing a stock from the mixture;
i) furnishing the stock to a draining device;
j) draining water from the stock on the draining device to form a stabilized solid porous body; and
k) drying the stabilized solid porous body to produce a hydrogen bonded solid porous body that has a density of 100 to 400 kg/m^3 and is free from added non-cellulose based binders.

[0034] Further the process for controlling structural and mechanical properties by using combined fiber selection strategy in the manufacture of a solid porous body and paper manufacture comprises the step of mixing the two different fiber fractions. In one embodiment the two fiber fractions have a weighted average fiber length of from 0.7 to 1.8 mm and a weighted average fiber width of from 25 to 42 μm, and the other fiber fraction has a fines fraction of particles with a weighted average length of less than 0.2 mm and constituting from 8 to 40 percent by weight of said fibrous material.
[0035] In a third aspect of the present invention, it is an object of the invention to provide a method of wet forming a solid porous body that has a density of 100 to 400 kg/m^3 and is based on fibrous material from softwood including fractions of fibers separated from one another in a mechanical pulping process, as described in claim 12.
[0036] In accordance with the present invention, this object is achieved in that the method comprises:

a) providing a draining device having a wire-net bottom;
b) fractionating the separated fibers to obtain

- a fiber fraction having a weighted average fiber length of from 0.7 to 1.8 mm and a weighted average fiber width of from 25 to 42 μm, and
- a fines fraction of particles having a weighted average length of less than 0.2 mm and constituting from 8 to 40 percent by weight of said fibrous material;

c) mixing said fractions and preparing a stock from the mixture;
d) furnishing the stock to the draining device;
e) draining water from the stock on the draining device to form a stabilized solid porous body; and
f) drying the stabilized solid porous body to produce a hydrogen bonded solid porous body free from added non-

cellulose based binders.

[0037] Such a method is eco-friendly and well suited for the production of wet-formed solid porous bodies to be used as an eco-friendly alternative to expanded polystyrene, polyurethane (PUR), polyisocyanurate (PIR), wood particle board, flax particle board, and mineral wool, for example, and the body may be produced by a process that to some degree utilizes waste products and waste energy from pulp mills. In addition, new applications for mechanical pulping and fractions thereof are created.

[0038] To provide desirable properties in the produced body, the method suitably further comprises in step c) and/or between steps e) and f) and/or in or after step f) adding an additive other than a non-cellulose based binder. The additive is preferably selected from the group consisting of clays, flame retardants, synthetic fibers, non-wood based fibers, dyes, moisture repellents, biocides, such as rot-resistant (anti-fouling) additives, and microfibrillated cellulose (MFC).

[0039] The prepared stock preferably has a consistency of 0.5 to 5 percent by weight. Lower values mean that unnecessarily large amounts of water have to be handled without giving any advantage, and higher values mean that the produced body risks being inhomogeneous.

[0040] To drain the stock to form the bodies of various shapes, the draining device may be a mold, but if the body is in the shape of a plate or panel, the draining device may include a running forming fabric.

[0041] To assist in the removal of water, if desired, the method suitably further comprises the step of subjecting the stabilized solid porous body to a light pressure of at most 0.1 MPa.

[0042] Preferably, at least part of the drying is carried out by utilization of waste heat, which is eco-friendly and also may reduce the cost of drying. However, if the supply of waste heat is insufficient, it may be supplemented by microwave heating. If desired, microwave heating may also be substituted for the utilization of waste heat. Also microwave heating is regarded as a relatively low-cost alternative.

[0043] The drying may be carried out in a continuous dryer section, which may be suitable for bodies formed on a travelling forming fabric, or in a drying chamber, which may be suitable for bodies formed in a mold.

[0044] If desired, the method also further comprises attaching a protective and/or decorative sheet on at least one surface of the dried solid porous body.

BRIEF DESCRIPTION OF THE DRAWINGS

[0045] In the following, the invention will be described in more detail with reference to preferred embodiments and the appended drawings.

- Fig. 1 is a block diagram showing the principle of refining and fiber fractionating.
- Fig. 2 is a block diagram illustrating a mechanical pulping process delivering fibers to both paper and board production.
- Fig. 3 is a block diagram illustrating production of fiberboard with fiber selection.
- Fig. 4a is a diagram showing sheet density as a function of fiber length (FL).
- Fig. 4b is a diagram showing sheet density as a function of fiber width (FW).
- Fig. 4c is a diagram showing sheet density as a function of fiber wall thickness (FWT).
- Fig. 5 is a diagram showing measured sheet density as a function of sheet density calculated from FL, FW, FWT.
- Fig. 6 is a diagram showing tensile index as a function of sheet density.
- Fig. 7a is a diagram showing the dewatering capacity of the pulp of latewood (LW) and earlywood ((EW) at two temperatures and expressed as freeness (CSF) as a function of specific refining energy supplied to the refiner.
- Fig. 7b is a diagram showing the fiber lengths for pulp of latewood (LW) and earlywood ((EW) at two temperatures as a function of the freeness (CSF).
- Fig. 7c is a diagram showing the sheet densities for pulp of latewood (LW) and earlywood ((EW) at two temperatures as a function of the freeness (CSF).
- Fig. 8a is a diagram showing fiber length as a function of post treatment with low consistency refining at various energy levels.
- Fig. 8b is a diagram showing fiber width as a function of post treatment with low consistency refining at various energy levels.
- Fig. 8c is a diagram showing sheet density as a function of post treatment with low consistency refining at various energy levels.
- Fig. 9 is a diagram showing density of various sheets as a function of pressure on the sheet during forming.
- Fig. 10 is a diagram showing sheet density for board made from different fiber selections and additives.

MODE(S) FOR CARRYING OUT THE INVENTION

Production of fiberboard and other board products in general

[0046] Fig. 1 illustrates the principle of refining and fiber fractionation. Wood chips **1** are fed to first refiner **2,** which is supplied with a variable input of energy **3.** The resulting fibers are delivered to a first separating device **4,** e.g. one or more screens or hydrocyclones, to form a first fine (accept) fraction **5** and a first coarse (reject) fraction **6** of fibers. Part of the first coarse fiber fraction **6** is fed to a second refiner **7,** which is supplied with a variable input of energy **8.** The resulting fibers are delivered to a second separating device **9,** e.g. one or more screens or hydrocyclones, to form a second fine (accept) fraction **10** and a second coarse (reject) fraction **11** of fibers. Part of the second coarse fiber fraction **11** is fed to a third refiner **12,** which is supplied with a variable input of energy **13.** The resulting fibers delivered from the third refiner **12** forms a fifth fiber fraction **14.**

[0047] By controlling the energy input and conditions in the three refiners **2, 7,** and **12** and by using suitable separation techniques in the separating devices **4** and **9,** it is possible to get different fiber fractions or pulps from a mechanical pulping process. The five fiber fractions **5, 6, 10, 11,** and **14** will be different with respect to length, width, cell wall thickness and fines content. The system may be simplified or more complex in a real application, but the block diagram illustrates the principles.

[0048] The block diagram in Fig. 2 illustrates possibilities in a conventional mechanical pulping process delivering fibers to both paper and board production. The selected wood raw material **15,** usually chips from a chipper, is fed to a TMP pulp mill **31** including a series of groups (only one group is shown), each of which includes a refiner **16** and a fractionator **17.** The fractionators in the groups deliver a normal fiber fraction **A** suitable for papermaking, a coarse fiber fraction **B** and an extra coarse fiber fraction **C.** Usually, the normal fiber fraction **A** has a weighted average fiber length in an interval of 0.95-1.15 mm, a weighted average fiber width in an interval of 29-31 μm, and a fines content by weight of 30-36 %. Similarly, the coarse fiber fraction **B** has a weighted average fiber length in an interval of 1.35-1.55 mm, a weighted average fiber width in an interval of 32-34 μm, and a fines content by weight of 8-12 %. The extra coarse fiber fraction **C** has a weighted average fiber length in an interval of 1.35-1.55 mm, a weighted average fiber width in an interval of 36-38 μm, and a fines content by weight of 8-12 %.

[0049] The normal fiber fraction **A** and a first part of the coarse fiber fraction **B** are delivered to a paper production mill **18** for production of a first paper grade **19** and a second paper grade **20,** respectively. A second part of the coarse fiber fraction **B** is delivered to a fiberboard production mill **21**for production of a first fiberboard grade **22.** A third part of the coarse fiber fraction **B** is branched off from the second part and delivered to the fiberboard production mill **21,** which includes a mixer **25** for mixing with a first part of the extra coarse fiber fraction **C** for production of a second fiberboard grade **23.** A second part of the extra coarse fiber fraction **C** is delivered to the fiberboard production mill **21** for production of a third fiberboard grade **24.**

[0050] Another block diagram is shown in Fig. 3 and illustrates other aspects of a conventional mechanical pulping process delivering fibers to both paper and board production. A vertical dotted line **26** divides the diagram into a left-hand part representing paper manufacturing and a right-hand part representing fiberboard manufacturing. Roundwood **27** from a wood yard is delivered to a station **28** for sorting and mixing of wood, barking, and production of wood chips. The wood chips are delivered to a storage **29,** where mixing may be carried out. Mixing is necessary if saw mill chips **30** are added to the wood chips. The chips are fed to a TMP pulp mill **31** as shown in Fig. 2, where refining, screening and fractionating is carried out to produce fibers **32** for paper and fibers **35** for fiberboard. In the shown embodiment, the fibers **32** for paper are delivered to a first paper machine **33** and a second paper machine **34.**

[0051] The fibers **35** for fiberboard are delivered to a mixing station **36,** which also receives desirable chemical additives **37** such as flame retardants, dyes, moisture repellents, biocides, such as rot-resistant (anti-fouling) additives, and microfibrillated cellulose (MFC), for example, and fillers **38** such as clay, synthetic fibers, non-wood based natural fibers, for example. The obtained slush of fibers, chemical additives and fillers is diluted to a stock that is delivered to a fiberboard machine **39** for wet forming and dewatering on a running, endless forming fabric or in a mold. Then, the formed fibrous sheet is exposed to a light pressing (preferably at most 0.1 MPa), if desired, to assist in the dewatering. After the optional pressing, the sheet is still wet, and at a station **40,** the wet sheet can be provided with a cover of one or more of the chemical additives **37,** if desired. Then, the optionally wet covered fibrous sheet is delivered to a saw **41** for wet sawing essentially to desired length before being passed on to a dryer **42.**

[0052] The dryer **42** may include a continuous dryer section or a drying chamber, and suitably at least part of the drying is carried out to oven dryness by means of waste heat from the pulp mill **31** and/or microwave heating. Thereafter, the obtained dry fiberboard panels are trimmed (at **43)** to desired length, width and thickness, and passed on to a joining or finishing station **44,** where they may be covered with some sheet decor, if desired, or combined with other building elements to form structural insulated panels (SIP) having an insulating layer of rigid core sandwiched between two layers of structural board. Finally, the fiberboard products are packed at a packaging station **45,** from where they are delivered to a store **46** or shipped to customer.

Raw materials - Fibers from wood

[0053] For fibers used for fiberboard it is common to try to use as little energy as possible in the defibration, and therefore the fibers have a low bonding ability. Typical energy levels are some hundred kWh/t fiber. By using refining, the conditions that normally are used for fibers for printing paper will result in a fiber that is much more bonding active. Here the energy level is from about 500 kWh/t to about 2500 kWh/t, preferably between 1000 kWh/t and 2000 kWh/t.

[0054] By using a fiber fractionation after the main fractionation as illustrated in Fig. 1, it is possible to separate fibers for printing paper and fibers for fiberboard. For printing paper the most thin-walled and flexible fibers, the so called fine fraction, is selected. Here also much of the fine material will be included. The coarser and thick-walled fibers are selected for fiberboard, these are called the coarse fraction. The coarse fraction fibers provide high bulk and low density, but at the same time these fibers provide a well developed fiber surface with much better ability to create stronger bonds to one another in comparison to conventional fibers for fiberboard. The improved surface development is due to the fact that these fibers have been exposed to a high amount of refining energy. Thereby, it is possible to produce an entirely new product, namely fiberboard or other wet-formed solid porous bodies with a substantially lower density but with the same strength/stiffness as products produced by conventional production technique. In addition to lower weight, the lower density gives improved thermal insulation and sound proofing ability. Further, this is achieved without any addition of a non-cellulose based binder, and you avoid any possible evaporation of solvents or glue components that may be harmful for the interior housing environment.

[0055] A mechanical defibration is carried out by exposing wood of a correct moisture content to high mechanical shearing forces simultaneously with a heating of the wood. The large shearing forces cause the fibers to break loose from one another, but the breaks will not always occur between the fibers or wood cells. Consequently, also fiber fragments will break loose and create much fine material. Traditionally, the mechanical defibration was carried out by rotating grindstones in the groundwood pulp process, where short logs were pressed against wet grindstones rotating at a very high speed and partly submerged in water. As time went by, refiners were developed, having steel discs with blade bars and grooves there between. Wood chips now could be supplied between the discs and be defibrated to form refiner mechanical pulp (RMP) without any pre-treatment. By enclosing the discs in a housing, it became possible to increase temperature and pressure in the process, so that the defibration could be carried out in a more lenient way to form thermo mechanical pulp (TMP).

[0056] The TMP process includes moisturizing the chips to get a predetermined moisture content, steam treating them and passing them under high pressure and temperature through a refiner, where the chips are rubbed between the steel discs with blade bars and grooves. The fibers break free and their surface is activated, fibrillated. Fibrillation is a structural change in the fiber walls e.g. through beating, whereby a number of fibrils are completely or partially removed and the binding between the remaining fibrils is weakened. Fibrillation makes it possible for the fibers to form hydrogen bonds with one another and thereby create a strong network. Also internally in the fiber wall there will be a large amount of minor breaks in the structure and result in an inner fibrillation, such that the fiber will be suppler and more flexible. The amount of energy used in this process will determine the degree of fibrillation and dimensional change of and in the wood fibers.

[0057] Other process parameters like pressure, temperature, pulp consistency, rotational speed, distance between discs, disc patterns and residence time between the discs will also affect the defibration. The amount of fine material, i.e. fiber fragments that are formed in connection with the defibration, will also be influenced by the amount of energy that is used and the mentioned defibration conditions. The type of raw material used, i.e. variety of tree, age (thinning, final felling), growing conditions, genetic material/origin, the habitat of the tree, trunk portion (root, stem, top) including saw mill chips, and growth rate (wide or thin annual rings), will also be of importance for the quality of the fibers and their dimensions. As a rule, softwood is chosen as raw material and suitably wood that is pale and has a low extractable content, preferably spruce and silver fir. Norway spruce (Picea abies) is most preferred in the process.

Fiber dimensions and their importance

[0058] In wood, the fibers of Norway spruce have a length of 1-5 mm, but there is also a minor share of fibers that are shorter than 0.5 mm. During the production of TMP, the fibers are shortened, and the final length will typically be 0.7-1.6 mm. A large amount of the pulp will consist of fiber parts and fragments with lengths shorter than 0.2 mm and is called fine material. The amount of fine material is determined by the defibrating conditions.

[0059] The properties of panelboard and other wet-formed solid porous bodies based on wood fiber will to a great extent be determined by the dimensions of the fibers and the amount of fine material. Fine material amount as well as fiber dimensions like length and width can be influenced by sorting fibers both prior to and after the defibration. Prior to the defibration, such sorting can be done by classifying the pulp wood by variety of tree, age (thinning, final felling), growing conditions, genetic material/origin, the habitat of the tree, trunk portion (root, stem, top) including saw mill chips, and growth rate (wide or thin annual rings), as all of these conditions affect length, width and wall thickness of the fibers.

Such wood classification is well adapted for controlling fiber dimensions with respect to length, width and wall thickness. The fibers may also be sorted after the defibration. Such sorting is known as fiber fractionating and is generally carried out by using screens and hydrocyclones. Screens have slit openings of a predetermined size, and fibers that are smaller than the slits and sufficiently flexible will pass through the slits. Screens are specially suited for sorting fibers by length.

[0060] The combination of fiber sorting based on wood classifying, screening and hydrocyclones gives a very good control of the fiber length distribution and the net work properties afforded by the fibers. Thereby it is possible to control and guarantee the strength of the final product as well as its soundproofing and thermal insulating and fire retarding capability.

Raw materials - other additives

[0061] Addition of various additives like clay, mineral ash, various synthetic fibers such as polylactide (PLA), other non-wood-based natural fibers like hemp, bamboo, bagasse, reed, (waste) haulm, etc., may also be used to control properties of the product. Microfibrillated cellulose (MFC) or cellulose nanofibers (CNF) may be mixed into the mechanical pulp to increase the bonding between fibers, and other components or may be spread over the surface to form a barrier against air flow there through. It is also possible to add fire retardants and biocides, such as rot-resistant (anti-fouling) additives, and also various chemicals for coloring the product.

Conclusion

[0062] Thus, by controlling structural and mechanical properties by using combined fiber selection strategy in the manufacture of a solid porous body and paper manufacture, it is possible to produce a wet-formed solid porous body that is low-weight, strong and rigid and has good insulation properties without having to use a non-cellulose based binder.

[0063] In accordance with the present invention, a process for controlling the structural and mechanical properties by using combined fiber selection strategy in the manufacture of a solid porous body and paper manufacture comprises:

a) selecting a suitable wood raw material;
b) defibering the wood raw material in a mechanical pulping process to get free fibers separated from one another;
c) selecting a degree of treatment of the wood raw material by controlling an amount of energy supplied to the mechanical pulping process;
d) exposing the free fibers to a mechanical after-treatment in at least one refiner;
e) fractionating the obtained pulp by means of screens or hydrocyclones to get fiber fractions useful in the manufacture of a solid porous body and paper manufacture; and
f) selecting at least one fiber fraction suitable for manufacturing of a solid porous body.

[0064] Each one of the individual steps a) to f) above has been known for more than 50 years, but they have not been used in the specified combination with one another, maybe because they require knowledge in a wide spectrum of special fields. However, by selecting the right fiber and process, it is now possible to produce a wet-formed solid porous body that is low-weight, strong and rigid and has good insulation properties without having to use a non-cellulose based binder.

[0065] To select the right fiber, the selection is made in view of variety of tree, genetic material/origin, the habitat of the tree, trunk portion including saw mill chips, and growth rate. Suitably, the variety of tree selected is softwood, preferably Norway spruce (Picea abies).

[0066] The fiber fraction selected in step f) has weighted average fiber length of from 0.7 to 1.8 mm and a weighted average fiber width of from 25 to 42 μm; and the process further comprises:

g) selecting also a fines fraction of particles having a weighted average length of less than 0.2 mm and constituting from 8 to 40 percent by weight of said fibrous material;
h) mixing said fractions and preparing a stock from the mixture;
i) furnishing the stock to a draining device;
j) draining water from the stock on the draining device to form a stabilized solid porous body; and
k) drying the stabilized solid porous body to produce a hydrogen bonded solid porous body that has a density of 100 to 400 kg/m^3 and is free from added non-cellulose based binders.

[0067] The wet-formed solid porous bodies of the invention give excellent soundproofing, have excellent thermal insulation properties and do not burn if treated by including clay and/or flame retardants, and they have an excellent weight to volume ratio. Further, they are eco-friendly, as they are based on reject fractions from the mechanical pulping process *(viz.* the coarsest fiber fraction and the fines fraction) and are made without any addition of a non-cellulose based binder, and they are an eco-friendly alternative to expanded polystyrene (EPS), polyurethane (PUR), polyisocyanurate (PIR), wood particle board, flax particle board, and mineral wool, for example. In addition, as the reject fractions from the mechanical pulping mill are not burnt but incorporated in the produced wet-formed solid porous bodies, the production of the bodies contribute to the lowering of carbon dioxide emissions.

[0068] Preferably, by using the method of wet forming a solid porous body, , the wet-formed solid porous body has at least one of the following properties:

- modulus of elasticity of 50-500 MPa,
- bending strength of 200-2500 kPa,
- compression strength of 50-1000 kPa, and a
- Janka hardness of 20-500 N.

[0069] The Janka hardness test measures the resistance of a sample of wood to denting and wear. It measures the force required to embed an 11.28 mm (.444 in) steel ball into wood to half the ball's diameter. A common use of Janka hardness ratings is to determine whether a species is suitable for use as flooring.

[0070] The above listed strength properties of the wet-formed solid porous body make the body suitable as a replacement for fiberboard bonded by non-cellulose based binders, petroleum based insulating materials such as expanded polystyrene, for example, and also for replacing wood in a plurality of applications.

[0071] In one preferred embodiment the body has a density of 120 to 250 kg/ m3, a length weighted average fiber length of from 0.9 to 1.55 mm, a length weighted average fiber width of from 29 to 38 μm, and the fines fraction of particles constitutes from 8 to 40 percent by weight of said fibrous material.

[0072] In another preferred embodiment the body has a density of 120 to 140 kg/ m^3, a length weighted average fiber length of from 1.35 to 1.55 mm, a length weighted average fiber width of from 36 to 38 μm, and the fines fraction of particles constitutes from 8 to 12 percent by weight of said fibrous material.

[0073] In another preferred embodiment the body has a density of 120 to 140 kg/ m^3, a length weighted average fiber length of from 1.35 to 1.55 mm, a length weighted average fiber width of from 32 to 34 μm, and the fines fraction of particles constitutes from 8 to 12 percent by weight of said fibrous material.

[0074] In another preferred embodiment the body has a density of 210 to 250 kg/m^3, a length weighted average fiber length of from 0.9 to 1.1 mm, a length weighted average fiber width of from 29 to 31 μm, and the fines fraction of particles constitutes from 30 to 40 percent by weight of said fibrous material.

[0075] Suitably, the body has a thermal conductivity of at most 0.060 W/m·K, whereby it can be used for thermal insulation.

[0076] If desired, the properties of the body can be improved in that the body comprises at least one additive. The additive is preferably selected from the group consisting of clays, flame retardants, synthetic fibers, non-wood based natural fibers, dyes, moisture repellents, biocides, such as rot-resistant (anti-fouling) additives, and microfibrillated cellulose (MFC).

[0077] It is preferred that the softwood used in the mechanical pulping process is Norway spruce (Picea abies), which with due regard to tree age (thinning, final felling), growing conditions, genetic material/origin, the habitat of the tree, trunk portion (root, stem, top) including saw mill chips, and growth rate (wide or thin annual rings), as all of these conditions affect length, width and wall thickness of the fibers gives high quality fibers.

[0078] The wet-formed solid porous body may be of various shapes, but a fiberboard panel, a fillet or strip, a pot, or a coffin are examples of shapes in demand. If desired, the wet-formed solid porous body may constitute a core and/or any one of the two covering layers of a structural insulating panel (SIP).

<u>A method of wet forming a solid porous body produced from the fiber material obtained in steps a) to f) above</u>

[0079] In accordance with a third aspect of the present invention, a method of wet forming a solid porous body that is produced from the fiber material obtained in steps a) to f) above and has a density of 100 to 400 kg/m^3 and is based on fibrous material from softwood including fractions of fibers separated from one another in a mechanical pulping process comprises:

a) providing a draining device having a wire-net bottom;
b) fractionating the separated fibers to obtain

- a fiber fraction having a weighted average fiber length of from 0.7 to 1.8 mm and a weighted average fiber width of from 25 to 42 μm, and
- a fines fraction of particles having a weighted average length of less than 0.2 mm and constituting from 8 to 40 percent by weight of said fibrous material;

c) mixing said fractions and preparing a stock from the mixture;
d) furnishing the stock to the draining device;
e) draining water from the stock on the draining device to form a stabilized solid porous body; and
f) drying the stabilized solid porous body to produce a hydrogen bonded solid porous body free from added non-cellulose based binders.

[0080] Such a method is eco-friendly and well suited for the production of wet-formed solid porous bodies to be used as an eco-friendly alternative to expanded polystyrene, polyurethane (PUR), polyisocyanurate (PIR), wood particle board, flax particle board, and mineral wool, for example, and the body may be produced by a process that to some degree utilizes waste products and waste energy from pulp mills. In addition, new applications for mechanical pulping and fractions thereof are created.

[0081] To provide desirable properties in the produced body, the method suitably further comprises in step c) and/or between steps e) and f) and/or in or after step f) adding an additive other than a non-cellulose based binder. The additive is preferably selected from the group consisting of clays, flame retardants, synthetic fibers, non-wood based fibers, dyes, moisture repellents, biocides, such as rot-resistant (anti-fouling) additives, and microfibrillated cellulose (MFC).

[0082] The prepared stock preferably has a consistency of 0.5 to 5 percent by weight. Lower values mean that unnecessarily large amounts of water have to be handled without giving any advantage, and higher values mean that the produced body risks being inhomogeneous.

[0083] To drain the stock to form the bodies of various shapes, the draining device may be a mold, but if the body is in the shape of a plate or panel, the draining device may include a running forming fabric.

[0084] To assist in the removal of water, if desired, the method suitably further comprises the step of subjecting the stabilized solid porous body to a light pressure of at most 0.1 MPa.

[0085] Preferably, at least part of the drying is carried out by utilization of waste heat, which is eco-friendly and also may reduce the cost of drying. However, if the supply of waste heat is insufficient, it may be supplemented by microwave heating. If desired, microwave heating may also be substituted for the utilization of waste heat. Also microwave heating is regarded as a relatively low-cost alternative.

[0086] The drying may be carried out in a continuous dryer section, which may be suitable for bodies formed on a travelling forming fabric, or in a drying chamber, which may be suitable for bodies formed in a mold.

[0087] If desired, the method also further comprises attaching a protective and/or decorative sheet on at least one surface of the dried solid porous body.

EXAMPLES

Standard procedure

[0088] Finished fibers are mixed with possible additives and water to form a stock where the dry material content is 0.5 to 5 percent by weight. This stock is then discharged from a headbox onto a travelling endless forming fabric. The water starts draining through the forming fabric, while a fibrous web is being formed on top of the fabric. The dry material content of the fiber web will increase as the fiber web is being transported forward on the fabric. To assist in the dewatering of the fiber web, fabric supporting suction boxes may be provided. It is also possible to apply a light pressure of at most 0.1 MPa on the fiber web to increase the dry solids content even more, but that will increase the density of the finished product. The pressure may be applied by means of at least one press roll or by providing a covering fabric on top of the fiber web and applying pressure on the top fabric. Water will now be pressed out on the bottom side and/or the top side and will be removed. At the end of the fabric, the fiber web will be separated from the fabric and transferred to another fabric. The side edges of the web will be trimmed and the web will be cross-cut to form single fiberboard panels. The fiberboard panels are fed into drying pockets in a stack having a plurality of fiberboard panels on top of one another but with air gaps in between and travel into a drying chamber, where they are being dried by means of added heat and moisture. It is important to control temperature and moisture during the drying process to achieve an even drying of the product and avoid formation of local hardened areas or other problems.

[0089] At the end of the drying process the fiberboard panels are conditioned to a normal indoor climate before they are finished to desired dimensions (cutting, profiling, smoothing).

[0090] The wet-formed solid porous body may also be produced by molding. Then wet undried fiber web mats or thick pulp is fed to a suitable mold and dried in the mold. This can be done in a piece by piece process or in a continuous process.

Example 1 - Fiber length, width and wall thickness in wood raw materials and their effect on sheet density

[0091] Figs. 4a-4c show the sheet density in kg/m^3 as a function of fiber length (FL) in mm, fiber width (FW) in μm, and fiber wall thickness (FWT) in μm, respectively. "R^2" designates the coefficient of explanation (which again is the square of the coefficient of correlation R), indicating that the length, width and wall thickness of the fibers together explains about 70 % of the total variation of sheet density observed.

[0092] The sheet density was measured on hand sheets from 848 different unbleached, never-dried Kraft pulps originated from wood samples of Norway spruce and Scots Pine grown on different locations in Norway (Molteberg D. and Storebråten S. (2002) Styring av fiberdimensjoner - hvordan? Paper read at Skogbrukets og skogindustriens temadag 28.8.2002 (in Norwegian)). The pulps were produced in laboratory scale, and beaten in a PFI mill at 250 revs prior to hand sheet forming. Fiber properties were measured on unbeaten pulps with a Kajaanii FS-200 fiber analyzer. Fiber wall thickness and fiber width were calculated according to Braaten K. R. and Molteberg D. (2004), A mathematical method for determining fiber wall thickness and fiber width. Tappi Journal Vol 3(2):9-12.

[0093] Fiber wall thickness is the most important single fiber dimension describing sheet density, explaining 53 % of the total sheet density variation observed in this material. Fiber length alone describes 28 %, and fiber width 0 % of the sheet density, accordingly. Higher sheet density is obtained with shorter fibers and thinner fiber walls.

Example 2 - Fiber dimensions in raw material controls density of paper sheets and fiberboard

[0094] Fig. 5 is a diagram showing measured sheet density as a function sheet density calculated from FL, FW, FWT.

[0095] A multiple regression model of sheet density based on fiber length (FL), fiber width (FW) and fiber wall thickness (FWT) was formed and explains 70 % of the variation of density measured on hand sheets made from several hundred wood samples from Norway. All fiber dimensions give statistical significant contribution to the model (Molteberg and Storebråten, 2002, *supra)*

[0096] This is shown for laboratory Kraft pulp samples, but the same relation (with an offset) is valid for mechanical pulps refined to the same energy level.

Example 3 - Density of sheet structure controls material strength (tensile strength

[0097] Fig. 6 is a diagram showing tensile index as a function of sheet density.

[0098] A simple regression model of tensile strength based on sheet density was formed and explains 71 % of the variation of tensile strength measured on hand sheets made from several hundred wood samples from Norway (Molteberg and Storebråten, 2002, *supra).*

[0099] This is shown for laboratory Kraft pulp samples, but the same relation (with an offset) is valid for mechanical pulps refined to the same energy level.

Example 4 - Effect of increased refining energy on fiber dimensions and sheet density

[0100] A common way to quantify the result of refining is to measure the dewatering capacity of the pulp, the Freeness (Canadian Standard Freeness, CSF, measured in ml). Increased refining will decrease freeness, as is shown in Fig. 7a. Increased temperature during refining (from 120 to 160 °C) will lower the energy needed to reach a certain freeness level. Earlywood (spring wood, EW) needs more refining energy than latewood (summer wood, LW) to reach the same freeness level.

[0101] Increased refining energy will also reduce fiber length (and fiber width and wall thickness), shown as shorter fibers for lower freeness in Fig. 7b. The higher levels observed for the latewood samples (LW) are due to the higher refining energy required to reach a certain freeness observed in Fig. 7a.

[0102] As a result, compressibility, flexibility and collapsibility of the fiber will increase, and therefore the sheet density also increases with refining, as shown in Fig. 7c. Here, the sheet density increases when freeness is reduced due to the refining.

[0103] The source of the data in this example is Huang, F., Lanouette, R. and Law, K.N. (2007) Jack pine TMP: earlywood versus latewood and effect of refining temperature. Proceedings of International Mechanical Pulping Conference, Minneapolis, Minnesota, USA.

Example 5 - Effect of post treatment with low consistency refining on fiber length, width and sheet density

[0104] Figs. 8a-8c show results from a mill trial at Norske Skog Saugbrugs. Increased refining energy during low consistency refining (LC) will reduce fiber length (Fig. 8a) and fiber width (Fig. 8b), and increase sheet density (Fig. 8c) as reported by Molteberg D (2014) Studie LC raffinør TMP feb2014. A-rapport Norske Skog Saugbrugs 201404 (in Norwegian). "SEC" designates the specific energy consumption during the refining and is denoted in kWh/t.

Example 6 - Pressure during sheet forming changes sheet properties, but original differences due to fiber selection remains (may even increase)

[0105] A series of test runs was performed to investigate the use of various pressures during sheet forming with various fibers and possible fillers. With the classification of fiber fractions used in the description of Fig. 2 above, the sheets were made of normal fibers for paper (fraction A), extra coarse fibers (fraction C), coarse fibers (fraction B), fibers with two different additions of clay, and fibers with addition of microfibrillated cellulose (MFC) from Kraft pulp. The results are shown in Fig. 9. it is obvious that a heavier pressure increases the density of the sheet, but original differences due to fiber selection remains and may even increase.

[0106] Fig. 10 shows the density of the various sheets of Fig. 9 when no pressure was used to assist in the dewatering. All fiber selections were made from same raw material (80 % round wood and 20 % saw mill chips, Norway spruce), clay 1 and 2 designates different amounts of clay, and MFC designates microfibrillated cellulose from Kraft pulp.

Example 7 - raw material selection

[0107] Molteberg and Storebråten, 2002 *(supra)* have investigated fiber separation by raw material selection, and data from their investigation are assembled in Tables 1a, 1b and 1c. The fiber dimensions are shown as weighted averages.

Table 1a

Elevation	Tree age, years	Ring width, mm	Fiber length, mm	Fiber width, µm	Fiber wall thickness, µm	Sheet density, kg/m^3
Scots Pine, Southern part of Norway						
Low	20-40	1-2	2.31	27.8	2.44	574
Low	20-40	2-3	2.13	28.2	2.28	617
Low	20-40	>3	2.12	29.3	2.25	647
Low	80+	0-1	2.61	27.1	2.44	595
Low	80+	1-2	2.48	27.7	2.36	599
Low	80+	2-3	2.38	29.1	2.33	590
High	20-40	1-2	2.18	28.1	2.27	626
High	20-40	2-3	2.03	30.5	2.29	664
High	20-40	>3	1,89	31.6	2.3	696
High	80+	0-1	2.52	27.5	2.31	632
High	80+	1-2	2.35	28.5	2.32	648
High	80+	2-3	2.1	29.2	2.22	661

Table 1b

Elevation	Tree age, years	Ring width, mm	Fiber length, mm	Fiber width, µm	Fiber wall thickness, µm	Sheet density, kg/m^3
Norway Spruce, Southern part of Norway						
Low	20-40	1-2	2.35	24.7	2.07	631
Low	20-40	2-3	2.3	25.9	1.95	668
Low	20-40	>3	2.18	27.1	1.92	714
Low	80+	0-1	2.9	26.6	2.33	621
Low	80+	1-2	2.73	26.7	2.26	626
Low	80+	2-3	2.59	27.8	2.35	610
High	20-40	1-2	-	-	-	-

(continued)

Elevation	Tree age, years	Ring width, mm	Fiber length, mm	Fiber width, µm	Fiber wall thickness, µm	Sheet density, kg/m³
Norway Spruce, Southern part of Norway						
High	20-40	2-3	2.13	27.6	2.01	695
High	20-40	>3	1.98	28.2	1.99	712
High	80+	0-1	2.62	26.3	2.18	661
High	80+	1-2	2.53	26.9	1.15	656
High	80+	2-3	2.35	26.1	2.03	678

Table 1c

Elevation	Tree age, years	Ring width, mm	Fiber length, mm	Fiber width, µm	Fiber wall thickness, µm	Sheet density, kg/m³
Norway Spruce, Northern part of Norway						
Low	20-40	1-2	2.19	26.1	2.19	658
Low	20-40	2-3	2.12	25.5	1.9	690
Low	20-40	>3	-	-	-	-
Low	80+	0-1	2.65	25	2.27	615
Low	80+	1-2	2.67	26.1	2.24	625
Low	80+	2-3	-	-	-	
High	20-40	1-2	2.12	23.9	1.89	679
High	20-40	2-3	2.06	25.6	1.89	692
High	20-40	>3	1.84	26.9	1.82	738
High	80+	0-1	2.62	26.1	2.29	623
High	80+	1-2	2.54	26.5	2.1	659
High	80+	2-3	2.11	26.2	1.99	691

[0108] The tablesla-1c show *inter alia* the following:

- Fiber length: spruce has longer fibers than pine. Length is diminished with latitude, altitude (elevation), growth speed (ring width), but increases with tree-age.
- Fiber width: pine has wider fibers than spruce. Width increases with growth speed (ring width) and tree-age.
- Fiber wall thickness: pine has thicker walls than spruce. Wall thickness is diminished with latitude, altitude (elevation) and growth speed (ring width), but increases with three age.
- Sheet density: pine has generally lower sheet density than spruce. Increased growth speed (ring width), latitude and altitude (elevation) increases sheet density. Increased age diminishes sheet density.

Example 8 - Comparison between Inventive Product and Commercial Samples

[0109] In Table 2, the "fibers for paper" are "fraction A" in the description of Fig. 2 above, the "extra coarse fibers" are "fraction C", and the "coarse fibers" are "fraction B". Further, when clay or MFC was added, the fiberboard contained 30 % clay and 25 % MFC. The commercial samples include fibers from wood, aluminum sulfate, paraffin, silicate, waterproofing agents, and a bonding agent between layers. No percentages are known (not stated by the manufacturer).

[0110] Table 2 shows that the inventive product based on coarse fibers alone can achieve the same or higher modulus of elasticity, bending strength, compression strength, hardness, and a lower thermal conductivity than the best commercial sample (sample 2), and in addition have much lower density or weight. If the inventive product is pressed harder to have the same density or weight as a commercial sample (sample 1), the invented product based on extra coarse fibers gives much better physical properties. When using a normal TMP (i.e. fibers for papermaking), the strength (modulus of elasticity, bending strength, and compression strength), is increased even more and 3-4 doubles the strength of the best commercial sample (sample 2). Adding MFC to coarse fibers make this effect even larger for modulus of elasticity, bending strength and compression strength. Adding clay as a filler will increase density, but lower strength (bending strength, compression strength and hardness). It will also increase thermal conductivity. Generally, the amount of energy supplied to the mechanical pulping process is about 1400 kWh/t for extra coarse fibers, about 1700 kWh/t for coarse fibers, and about 2300 kWh/t for TMP, i.e. fibers for papermaking.

Table 2

Properties for board made from different fiber selections and additives								
		Raw material for fiberboard					Commercial samples	
Property	Unit	Fibers for paper (Fraction A)	Extra coarse fibers (Fraction C)	Coarse fibers (Fraction B)	Coarse fibers + clay	Coarse fibers + MFC	Sample 1	Sample 2
Thickness	mm	50	50	50	50	50	50	50
Density (oven diy)	kg/m^3	257	132	164	204	270	177	270
Modulus of elasticity	MPa	357	53	104	129	430	34	95
Bending strength	kPa	1617	240	800	630	2700	153	429
Compression strength	kPa	640	95	342	285	1000	61	170
Thermal conductivity , λ	W/m·K	-	0.042	0.048	0.053	-	0.043	0.048
Hardness (Janka)	N	323	48	173	144	320	31	86

[0111] The Janka hardness test measures the resistance of a sample of wood to denting and wear. It measures the force required to embed an 11.28 mm (.444 in) steel ball into wood to half the ball's diameter. A common use of Janka hardness ratings is to determine whether a species is suitable for use as flooring.

[0112] In the foregoing, the invention has been described with reference to a few embodiments. It is appreciated, however, that also other embodiments and variants are possible within the scope of the following claims.

INDUSTRIAL APPLICABILITY

[0113] The present invention is applicable in a process for controlling structural and mechanical properties by using combined fiber selection strategy in the manufacture of a solid porous body and paper manufacture, further in a method of wet forming a solid porous body that has a density of 100 to 400 kg/m^3 and is based on fibrous material from softwood including fractions of fibers separated from one another in a mechanical pulping process, and the fiberboard panel or other solid porous body produced, e.g. a fillet or strip, a pot, or a coffin, is applicable in the construction or furniture industry, for example.

Claims

1. A wet-formed solid porous body that has a density of 100 to 400 kg/m^3 and is based on fibrous material from softwood including fractions of fibers separated from one another in a mechanical pulping process, said solid porous body comprising:

- a fiber fraction wherein the fibers have

  - a weighted average fiber length of from 0.5 to 2.0 mm;
  - a weighted average fiber width of from 20 to 50 μm, both calculated according to TAPPI standard T232cm-01; and

- a fines fraction wherein the particles have a weighted average length of less than 0.2 mm, calculated according to TAPPI standard T232cm-01, and constitute from 5 to 50 percent by weight of said fibrous material; and

said solid body being hydrogen bonded and free from added non-cellulose based binders.

2. A wet-formed solid porous body as claimed in claim 1, wherein said solid body has at least one of the following properties:

- modulus of elasticity of 50-500 MPa,
- bending strength of 200-2500 kPa,
- compression strength of 50-1000 kPa, and a
- Janka hardness of 20-500 N, measured as the force required to embed an 11.28 mm steel ball into the wet-formed solid porous body to half the ball's diameter.

3. A wet-formed solid porous body as claimed in claim 1 or 2, wherein said body has a density of 120 to 140 kg/ m^3, a length weighted average fiber length of from 1.35 to 1.55 mm, a length weighted average fiber width of from 36 to 38 μm, and the fines fraction of particles constitutes from 8 to 12 percent by weight of said fibrous material.

4. A wet-formed solid porous body as claimed in claim 1 or 2, wherein said body has a density of 120 to 140 kg/ m^3, a length weighted average fiber length of from 1.35 to 1.55 mm, a length weighted average fiber width of from 32 to 34 μm, and the fines fraction of particles constitutes from 8 to 12 percent by weight of said fibrous material.

5. A wet-formed solid porous body as claimed in claim 1 or 2, wherein said body has a density of 210 to 250 kg/m^3, a length weighted average fiber length of from 0.9 to 1.1 mm, a length weighted average fiber width of from 29 to 31 μm, and the fines fraction of particles constitutes from 30 to 40 percent by weight of said fibrous material.

6. A wet-formed solid porous body as claimed in any one of claims 1-5, said body having a thermal conductivity of at most 0.060 W/m·K.

7. A wet-formed solid porous body as claimed in any one of claims 1-6, further comprising at least one additive.

8. A wet-formed solid porous body as claimed in claim 7, wherein the additive is selected from the group consisting of clays, flame retardants, synthetic fibers, non-wood based natural fibers, dyes, moisture repellents, biocides, such as rot-resistant for example anti-fouling additives, and microfibrillated cellulose (MFC).

9. A wet-formed solid porous body as claimed in any one of claims 1-8, wherein said softwood is Norway spruce (Picea abies).

10. A wet-formed solid porous body as claimed in any one of claims 1-9, wherein said body has a shape of a fiberboard panel, a fillet or strip, a pot, or a coffin.

11. A process for controlling structural and mechanical properties by using combined fiber selection strategy, by selecting fibers with certain desired characteristics from wood raw material and/or the fibers are also fractioned and/or sorted within the selected wood raw material in the manufacture of a solid porous body and paper manufacture, comprising:

a) selecting a suitable wood raw material;
b) defibering the wood raw material in a mechanical pulping process to get free fibers separated from one another;
c) selecting a degree of treatment of the wood raw material by controlling an amount of energy supplied to the mechanical pulping process;
d) exposing the free fibers to a mechanical after-treatment in at least one refiner;
e) fractionating the obtained pulp by means of screens or hydrocyclones to get fiber fractions useful in the manufacture of a solid porous body and paper manufacture; and

f) selecting at least one fiber fraction suitable for manufacturing of a solid porous body, wherein the fiber fraction has a weighted average fiber length of from 0.7 to 1.8 mm and a weighted average fiber width of from 25 to 42 μm; and wherein the process further comprises:
g) selecting also a fines fraction of particles having a weighted average length of less than 0.2 mm and constituting from 8 to 40 percent by weight of said fibrous material;
h) mixing said fractions and preparing a stock from the mixture;
i) furnishing the stock to a draining device;
j) draining water from the stock on the draining device to form a stabilized solid porous body; and
k) drying the stabilized solid porous body to produce a hydrogen bonded solid porous body that has a density of 100 to 400 kg/m^3 and is free from added non-cellulose based binders.

12. A method of wet forming a solid porous body that has a density of 100 to 400 kg/m^3 and is based on fibrous material from softwood including fractions of fibers separated from one another in a mechanical pulping process, comprising:

a) providing a draining device having a wire-net bottom;
b) fractionating the separated fibers to obtain
c) a fiber fraction having a weighted average fiber length of from 0.7 to 1.8 mm and a weighted average fiber width of from 25 to 42 μm, both calculated according to TAPPI standard T232cm-01; and
d) a fines fraction of particles having a weighted average length of less than 0.2 mm, calculated according to TAPPI standard T232cm-01, and constituting from 8 to 40 percent by weight of said fibrous material;
e) mixing said fractions and preparing a stock from the mixture;
f) furnishing the stock to the draining device;
g) draining water from the stock on the draining device to form a stabilized solid porous body; and
h) drying the stabilized solid porous body to produce a hydrogen bonded solid porous body free from added non-cellulose based binders.

13. A method as claimed in claim 12, further comprising adding at least one additive other than a non-cellulose based binder in step c) and/or between steps e) and f) and/or in or after step f).

14. A method as claimed in claim 13, further comprising selecting said at least one additive from the group consisting of clays, flame retardants, synthetic fibers, non-wood based natural fibers, dyes, moisture repellents, biocides, such as rot-resistant for example anti-fouling additives, and microfibrillated cellulose (MFC).

15. A method as claimed in claims 13 or 13, wherein the prepared stock has a consistency of 0.5 to 5 percent by weight.

16. A method as claimed in any one of claims 13-15, wherein the draining device is a mold.

17. A method as claimed in any one of claims 13-16, wherein the draining device includes a running forming fabric.

18. A method as claimed in any one of claims 13-17, further comprising the step of subjecting the stabilized solid porous body to a light pressure of at most 0.1 MPa to assist in the removal of water.

19. A method as claimed in any one of claims 13-18, further comprising carrying out at least part of the drying by means of waste heat.

20. A method as claimed in any one of claims 13-19, further comprising carrying out at least part of the drying by means of microwave heating.

21. A method as claimed in any one of claims 13-20, wherein the drying is carried out in a continuous dryer section.

22. A method as claimed in any one of claims 13-21, wherein the drying is carried out in a drying chamber.

23. A method as claimed in any one of claims 13-22, further comprising attaching a protective and/or decorative sheet on at least one surface of the dried solid porous body.

Patentansprüche

1. Nassgeformter fester poröser Körper, der eine Dichte von 100 bis 400 kg/m^3 aufweist und auf Fasermaterial aus Weichholz basiert, das Fraktionen von Fasern einschließt, die in einem mechanischen Aufschlussverfahren voneinander getrennt werden, wobei der feste poröse Körper umfasst:

   - eine Faserfraktion, wobei die Fasern

     - eine gewichtete durchschnittliche Faserlänge von 0,5 bis 2,0 mm,
     - eine gewichtete durchschnittliche Faserbreite von 20 bis 50 μm, beides berechnet nach dem TAPPI-Standard T232cm-01, aufweisen; und

   - eine Feingutfraktion, wobei die Partikel eine gewichtete Durchschnittslänge von weniger als 0,2 mm aufweisen, berechnet nach dem TAPPI-Standard T232cm-01, und 5 bis 50 Gewichtsprozent des Fasermaterials ausmachen; und

   wobei der feste Körper wasserstoffgebunden und frei von zugegebenen, nicht auf Zellulose basierenden Bindemitteln ist.

2. Nassgeformter fester poröser Körper nach Anspruch 1, wobei der feste Körper mindestens eine der folgenden Eigenschaften aufweist:

   - Elastizitätsmodul von 50-500 MPa,
   - Biegefestigkeit von 200-2500 kPa,
   - Druckfestigkeit von 50-1000 kPa und eine
   - Janka-Härte von 20-500 N, gemessen als die Kraft, die erforderlich ist, um eine 11,28 mm große Stahlkugel bis zum halben Kugeldurchmesser in den nassgeformten festen porösen Körper einzubetten.

3. Nassgeformter fester poröser Körper nach Anspruch 1 oder 2, wobei der Körper eine Dichte von 120 bis 140 kg/m^3, eine längengewichtete durchschnittliche Faserlänge von 1,35 bis 1,55 mm, eine längengewichtete durchschnittliche Faserbreite von 36 bis 38 μm aufweist und die Feingutfraktion von Partikeln 8 bis 12 Gewichtsprozent des Fasermaterials ausmacht.

4. Nassgeformter fester poröser Körper nach Anspruch 1 oder 2, wobei der Körper eine Dichte von 120 bis 140 kg/m^3, eine längengewichtete durchschnittliche Faserlänge von 1,35 bis 1,55 mm, eine längengewichtete durchschnittliche Faserbreite von 32 bis 34 μm aufweist und die Feingutfraktion von Partikeln 8 bis 12 Gewichtsprozent des Fasermaterials ausmacht.

5. Nassgeformter fester poröser Körper nach Anspruch 1 oder 2, wobei der Körper eine Dichte von 210 bis 250 kg/m^3, eine längengewichtete durchschnittliche Faserlänge von 0,9 bis 1,1 mm, eine längengewichtete durchschnittliche Faserbreite von 29 bis 31 μm aufweist und die Feingutfraktion von Partikeln 30 bis 40 Gewichtsprozent des Fasermaterials ausmacht.

6. Nassgeformter fester poröser Körper nach einem der Ansprüche 1 - 5, wobei der Körper eine Wärmeleitfähigkeit von höchstens 0,060 W/m·K aufweist.

7. Nassgeformter fester poröser Körper nach einem der Ansprüche 1 - 6, weiter umfassend mindestens ein Additiv.

8. Nassgeformter fester poröser Körper nach Anspruch 7, wobei das Additiv aus der Gruppe ausgewählt ist, bestehend aus Tonen, Flammschutzmitteln, synthetischen Fasern, nicht holzbasierten Naturfasern, Farbstoffen, feuchtigkeitsabweisenden Mitteln, Bioziden, wie fäulnisresistenten, zum Beispiel bewuchsverhindernden Additiven und mikrofibrillierter Zellulose (MFC).

9. Nassgeformter fester poröser Körper nach einem der Ansprüche 1 - 8, wobei das Weichholz Norwegische Fichte (Picea abies) ist.

10. Nassgeformter fester poröser Körper nach einem der Ansprüche 1 - 9, wobei der Körper die Form einer Faserplatte, einer Leiste oder Streifens, eines Topfes oder eines Sarges aufweist.

11. Verfahren zum Steuern struktureller und mechanischer Eigenschaften durch Verwendung einer kombinierten Faserauswahlstrategie, indem Fasern mit bestimmten gewünschten Eigenschaften aus Holzrohmaterial ausgewählt werden und/oder die Fasern auch fraktioniert und/oder innerhalb des ausgewählten Holzrohmaterials sortiert werden, bei der Herstellung eines festen porösen Körpers und der Papierherstellung, umfassend:

a) Auswählen eines geeigneten Holzrohmaterials;
b) Zerfasern des Holzrohmaterials in einem mechanischen Aufschlussverfahren, um freie Fasern voneinander zu trennen;
c) Auswählen eines Behandlungsgrades des Holzrohmaterials durch Steuern einer dem mechanischen Aufschlussverfahren zugeführten Energiemenge;
d) Aussetzen der freien Fasern einer mechanischen Nachbehandlung in mindestens einem Refiner;
e) Fraktionieren der erhaltenen Pulpe mit Hilfe von Sieben oder Hydrozyklonen, um Faserfraktionen zu erhalten, die bei der Herstellung eines festen porösen Körpers und der Papierherstellung nützlich sind; und
f) Auswählen mindestens einer Faserfraktion, die zur Herstellung eines festen porösen Körpers geeignet ist, wobei die Faserfraktion eine gewichtete durchschnittliche Faserlänge von 0,7 bis 1,8 mm und eine gewichtete durchschnittliche Faserbreite von 25 bis 42 μm aufweist; und wobei das Verfahren weiter umfasst:
g) Auswählen auch einer Feingutfraktion von Partikeln, die eine gewichtete durchschnittliche Länge von weniger als 0,2 mm aufweisen und 8 bis 40 Gewichtsprozent des Fasermaterials ausmachen;
h) Mischen der Fraktionen und Herstellen einer Brühe aus dem Gemisch;
i) Einbringen der Brühe in eine Entwässerungsvorrichtung;
j) Entwässern der Brühe an der Entwässerungsvorrichtung, um einen stabilisierten festen porösen Körper zu bilden; und
k) Trocknen des stabilisierten festen porösen Körpers, um einen wasserstoffgebundenen festen porösen Körper zu erzeugen, der eine Dichte von 100 bis 400 kg/m^3 aufweist und frei von zugegebenen nicht auf Zellulose basierenden Bindemitteln ist.

12. Verfahren zum Nassformen eines festen porösen Körpers, der eine Dichte von 100 bis 400 kg/m^3 aufweist und auf Fasermaterial aus Weichholz basiert, das Fraktionen von Fasern einschließt, die in einem mechanischen Aufschlussverfahren voneinander getrennt werden, umfassend:

a) Bereitstellen einer Entwässerungsvorrichtung mit einem Drahtnetzboden,
b) Fraktionieren der getrennten Fasern zur Gewinnung von
c) einer Faserfraktion, die eine gewichtete durchschnittliche Faserlänge von 0,7 bis 1,8 mm und eine gewichtete durchschnittliche Faserbreite von 25 bis 42 μm aufweist, beide berechnet nach dem TAPPI-Standard T232cm-01; und
d) einer Feingutfraktion von Partikeln, die eine gewichtete durchschnittliche Länge von weniger als 0,2 mm aufweisen, berechnet nach dem TAPPI-Standard T232cm-01, und die 8 bis 40 Gewichtsprozent des Fasermaterials ausmachen;
e) Mischen der Fraktionen und Herstellen einer Brühe aus dem Gemisch;
f) Einbringen der Brühe in die Entwässerungsvorrichtung;
g) Entwässern der Brühe an der Entwässerungsvorrichtung, um einen stabilisierten festen porösen Körper zu bilden; und
h) Trocknen des stabilisierten festen porösen Körpers, um einen wasserstoffgebundenen festen porösen Körper zu erzeugen, der frei von zugegebenen nicht auf Zellulose basierenden Bindemitteln ist.

13. Verfahren nach Anspruch 12, weiter umfassend die Zugabe mindestens eines anderen Additivs als eines nicht auf Zellulose basierenden Bindemittels in Schritt c) und/oder zwischen den Schritten e) und f) und/oder in oder nach Schritt f).

14. Verfahren nach Anspruch 13, weiter umfassend das Auswählen des mindestens einen Additivs aus der Gruppe bestehend aus Tonen, Flammschutzmitteln, synthetischen Fasern, nicht holzbasierten Naturfasern, Farbstoffen, feuchtigkeitsabweisenden Mitteln, Bioziden, wie fäulnisresistenten, zum Beispiel bewuchsverhindernden Additiven und mikrofibrillierter Zellulose (MFC)..

15. Verfahren nach Anspruch 13 oder 13, wobei die hergestellte Brühe eine Konsistenz von 0,5 bis 5 Gewichtsprozent aufweist.

16. Verfahren nach einem der Ansprüche 13-15, wobei die Entwässerungsvorrichtung eine Gießform ist.

17. Verfahren nach einem der Ansprüche 13 - 16, wobei die Entwässerungsvorrichtung ein laufendes Formiergewebe einschließt.

18. Verfahren nach einem der Ansprüche 13 - 17, weiter umfassend den Schritt des Aussetzens des stabilisierten festen porösen Körpers einem leichten Druck von höchstens 0,1 MPa, um das Entziehen von Wasser zu unterstützen.

19. Verfahren nach einem der Ansprüche 13 - 18, weiter umfassend die Durchführung mindestens eines Teils der Trocknung mit Hilfe von Abwärme.

20. Verfahren nach einem der Ansprüche 13 - 19, weiter umfassend die Durchführung mindestens eines Teils der Trocknung mit Hilfe von Mikrowellenerwärmung.

21. Verfahren nach einem der Ansprüche 13 - 20, wobei die Trocknung in einem Durchlauftrocknerbereich durchgeführt wird.

22. Verfahren nach einem der Ansprüche 13 - 21, wobei die Trocknung in einer Trockenkammer durchgeführt wird.

23. Verfahren nach einem der Ansprüche 13-22, weiter umfassend das Anbringen einer Schutz- und/oder Dekorfolie auf mindestens einer Oberfläche des getrockneten festen porösen Körpers.

Revendications

1. Corps poreux solide formé par voie humide qui présente une densité de 100 à 400 kg/m^3 et est basé sur un matériau fibreux d'un bois tendre incluant des fractions de fibres séparées les unes des autres dans un processus de fabrications de la pâte mécanique, ledit corps poreux solide comprenant :

- une fraction de fibres, dans lequel les fibres présentent

  - une longueur de fibre moyenne pondérée de 0,5 à 2,0 mm ;
  - une largeur de fibre moyenne pondérée de 20 à 50 μm, l'une et l'autre étant calculées selon la norme TAPPI T232cm-01 ; et

- une fraction de particules fines, dans lequel les particules présentent une longueur moyenne pondérée de moins de 0,2 mm, calculée selon la norme TAPPI T232cm-01 et constituent de 5 à 50 pour cent en poids dudit matériau fibreux ; et

ledit corps solide étant lié à de l'hydrogène et dépourvu de liants non cellulosiques ajoutés.

2. Corps poreux solide formé par voie humide selon la revendication 1, dans lequel ledit corps solide présente au moins une des propriétés suivantes :

- un module d'élasticité de 50-500 MPa,
- une résistance à la flexion de 200-2 500 kPa,
- une résistance à la compression de 50-1 000 kPa, et
- une dureté Janka de 20-500 N, mesurée en tant que force nécessaire pour enfoncer une bille d'acier de 11,28 mm dans le corps poreux solide formé par voie humide jusqu'à la moitié du diamètre de la bille.

3. Corps poreux solide formé par voie humide selon la revendication 1 ou 2, dans lequel ledit corps présente une densité de 120 à 140 kg/m^3, une longueur de fibre moyenne pondérée en longueur de 1,35 à 1,55 mm, une largeur de fibre moyenne pondérée en longueur de 36 à 38 μm et la fraction de fines particules constitue de 8 à 12 pour cent en poids dudit matériau fibreux.

4. Corps poreux solide formé par voie humide selon la revendication 1 ou 2, dans lequel ledit corps présente une densité de 120 à 140 kg/m^3, une longueur de fibre moyenne pondérée en longueur de 1,35 à 1,55 mm, une largeur de fibre moyenne pondérée en longueur de 32 à 34 μm et la fraction de fines particules constitue de 8 à 12 pour cent en poids dudit matériau fibreux.

5. Corps poreux solide formé par voie humide selon la revendication 1 ou 2, dans lequel ledit corps présente une densité de 210 à 250 kg/m^3, une longueur de fibre moyenne pondérée en longueur de 0,9 à 1,1 mm, une largeur de fibre moyenne pondérée en longueur de 29 à 31 μm et la fraction de fines particules constitue de 30 à 40 pour cent en poids dudit matériau fibreux.

6. Corps poreux solide formé par voie humide selon l'une quelconque des revendications 1-5, ledit corps présentant une conductivité thermique d'au maximum 0,060 W/m·K.

7. Corps poreux solide formé par voie humide selon l'une quelconque des revendications 1-6, comprenant en outre au moins un additif.

8. Corps poreux solide formé par voie humide selon la revendication 7, dans lequel l'additif est sélectionné dans le groupe constitué par des argiles, des produits ignifuges, des fibres synthétiques, des fibres naturelles non ligneuses, des colorants, des produits anti-humidité, des biocides, tels que des additifs antisalissures, par exemple, résistant à la putréfaction et la cellulose microfibrillée (MFC).

9. Corps poreux solide formé par voie humide selon l'une quelconque des revendications 1-8, dans lequel ledit bois tendre est l'épicéa de Norvège (Picea abies).

10. Corps poreux solide formé par voie humide selon l'une quelconque des revendications 1-9, dans lequel ledit corps présente la forme d'un panneau de fibres de bois, d'un filet ou d'une bande, d'un pot ou d'un cercueil.

11. Procédé pour réguler des propriétés structurelles et mécaniques en utilisant une stratégie combinée de sélection de fibres en sélectionnant des fibres présentant certaines caractéristiques souhaitées d'un bois tendre et/ou les fibres sont également fractionnées et/ou triées dans la matière première ligneuse sélectionnée dans la fabrication d'un corps poreux solide et la fabrication de papier, comprenant :

a) la sélection d'une matière première ligneuse appropriée ;
b) le défibrage de la matière première ligneuse dans un processus de fabrication de pâte mécanique pour obtenir des fibres libres séparées les unes des autres ;
c) la sélection d'un degré de traitement de la matière première ligneuse par régulation d'une quantité d'énergie fournie au processus de fabrication de pâte mécanique ;
d) l'exposition des fibres libres à un post-traitement mécanique dans au moins un raffineur ;
e) le fractionnement de la pâte obtenue au moyen de tamis ou d'hydrocyclones pour obtenir des fractions de fibres utiles dans la fabrication d'un corps poreux solide et la fabrication de papier ; et
f) la sélection d'au moins une fraction de fibres appropriée pour la fabrication d'un corps poreux solide, dans lequel la fraction de fibres présente une longueur de fibre moyenne pondérée de 0,7 à 1,8 mm et une largeur de fibre moyenne pondérée de 25 à 42 μm ; et dans lequel le procédé comprend en outre :
g) également la sélection d'une fraction de particules fines, présentant une longueur moyenne pondérée de moins de 0,2 mm et constituent de 8 à 40 pour cent en poids dudit matériau fibreux ;
h) le mélange desdites fractions et la préparation d'un stock à partir du mélange ;
i) la fourniture du stock à un dispositif de vidange ;
j) l'évacuation de l'eau du stock sur le dispositif de vidange pour former un corps poreux solide stabilisé ; et
k) le séchage du corps poreux solide stabilisé pour produire un corps poreux solide lié à de l'hydrogène qui présente une densité de 100 à 400 kg/m^3 et est dépourvu de liants non cellulosiques ajoutés.

12. Procédé de formation par voie humide d'un corps poreux solide qui présente une densité de 100 à 400 kg/m^3 et est basé sur un matériau fibreux d'un bois tendre incluant des fractions de fibres séparées les unes des autres dans un processus de fabrications de la pâte mécanique, comprenant :

a) la fourniture d'un dispositif de vidange ayant un fond en treillis ;
b) le fractionnement des fibres séparées pour obtenir
c) une fraction de fibres présentant une longueur de fibre moyenne pondérée de 0,7 à 1,8 mm et une largeur de fibre moyenne pondérée de 25 à 42 μm, l'une et l'autre étant calculées selon la norme TAPPI T232cm-01 ; et
d) une fraction de particules fines présentant une longueur moyenne pondérée de moins de 0,2 mm, calculée selon la norme TAPPI T232cm-01 et constituant de 8 à 40 pour cent en poids dudit matériau fibreux ;
e) le mélange desdites fractions et la préparation d'un stock à partir du mélange ;
f) la fourniture du stock au dispositif de vidange ;

g) l'évacuation de l'eau du stock sur le dispositif de vidange pour former un corps poreux solide stabilisé ; et
h) le séchage du corps poreux solide stabilisé pour produire un corps poreux solide lié à de l'hydrogène dépourvu de liants non cellulosiques ajoutés.

13. Procédé selon la revendication 12, comprenant en outre l'ajout d'au moins un additif autre qu'un liant non cellulosique à l'étape c) et/ou entre les étapes e) et f) et/ou à l'étape f) ou après celle-ci.

14. Procédé selon la revendication 13, comprenant en outre la sélection dudit au moins un additif sélectionné dans le groupe constitué par des argiles, des produits ignifuges, des fibres synthétiques, des fibres naturelles non ligneuses, des colorants, des produits anti-humidité, des biocides, tels que des additifs antisalissures, par exemple, résistant à la putréfaction et la cellulose microfibrillée (MFC).

15. Procédé selon les revendications 13 ou 13, dans lequel le stock préparé présente une consistance de 0,5 à 5 pour cent en poids.

16. Procédé selon l'une quelconque des revendications 13-15, dans lequel le dispositif de vidange est un moule.

17. Procédé selon l'une quelconque des revendications 13-16, dans lequel le dispositif de vidange inclut une toile de formation ininterrompue.

18. Procédé selon l'une quelconque des revendications 13-17, comprenant en outre l'étape de soumission du corps poreux solide stabilisé à une légère pression d'au maximum 0,1 MPa pour aider à l'élimination de l'eau.

19. Procédé selon l'une quelconque des revendications 13-18, comprenant en outre la réalisation d'au moins une partie du séchage au moyen de la chaleur perdue.

20. Procédé selon l'une quelconque des revendications 13-19, comprenant en outre la réalisation d'au moins une partie du séchage au moyen d'un chauffage par micro-ondes.

21. Procédé selon l'une quelconque des revendications 13-20, dans lequel le séchage est réalisé dans une section de sécheur continue.

22. Procédé selon l'une quelconque des revendications 13-21, dans lequel le séchage est réalisé dans une chambre de séchage.

23. Procédé selon l'une quelconque des revendications 13-22, comprenant en outre la fixation d'une feuille de protection et/ou décorative sur au moins une surface du corps poreux solide séché.

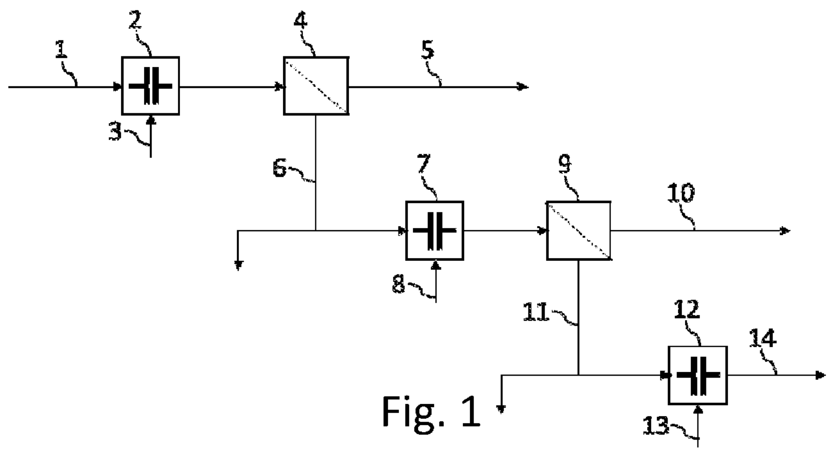


Fig. 1

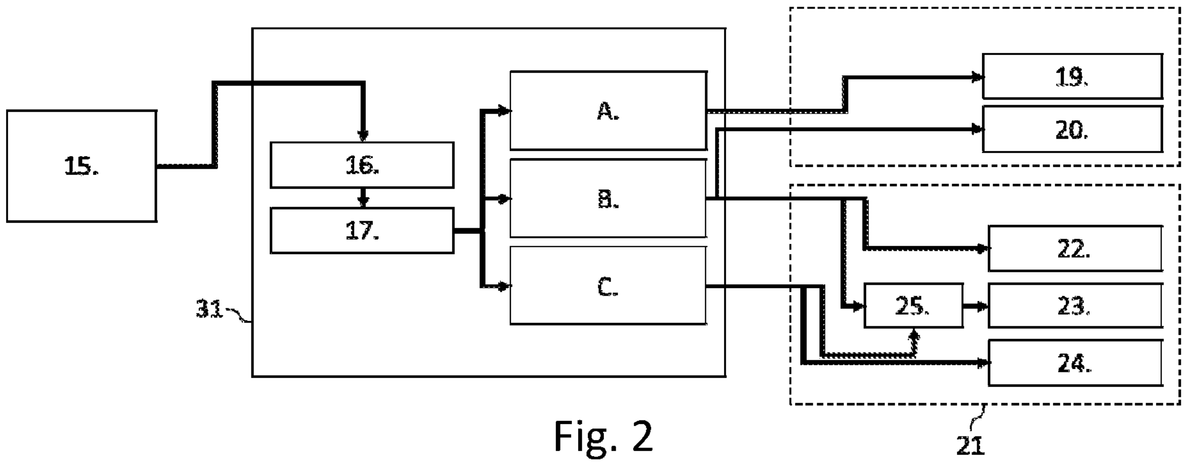


Fig. 2

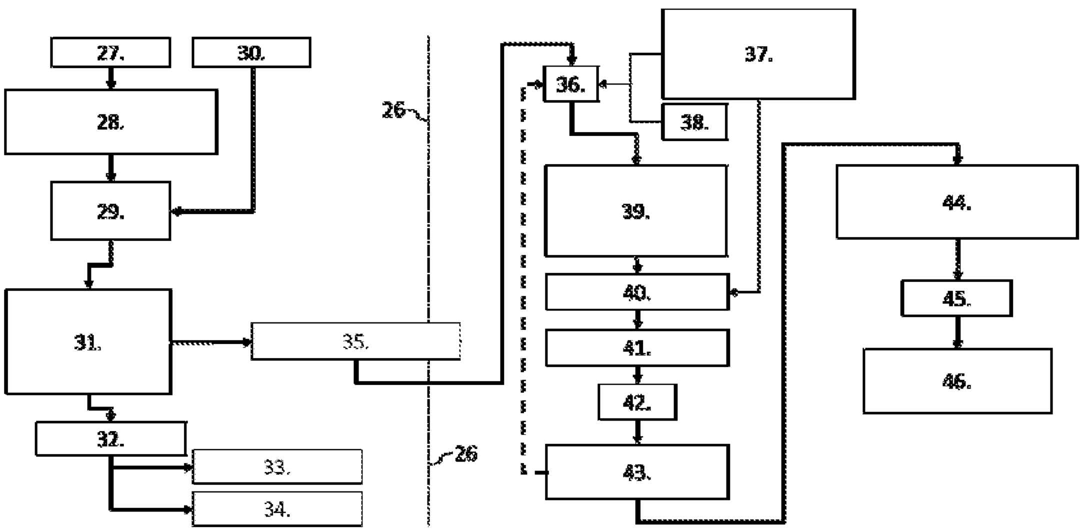


Fig. 3

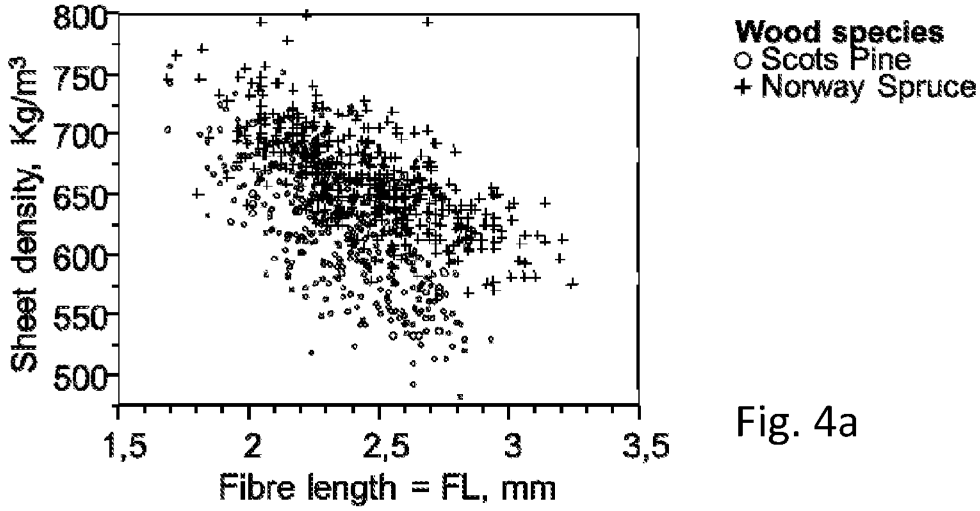


Fig. 4a

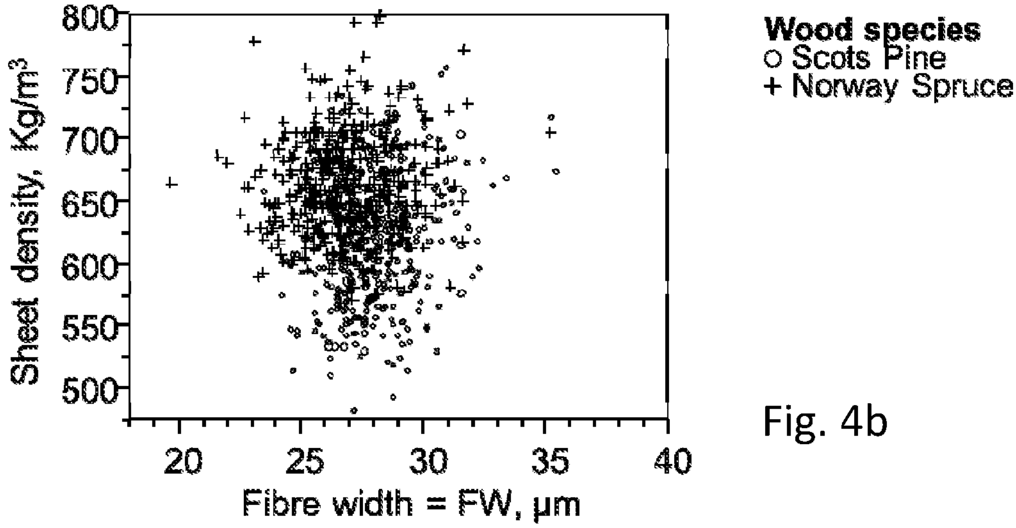


Fig. 4b

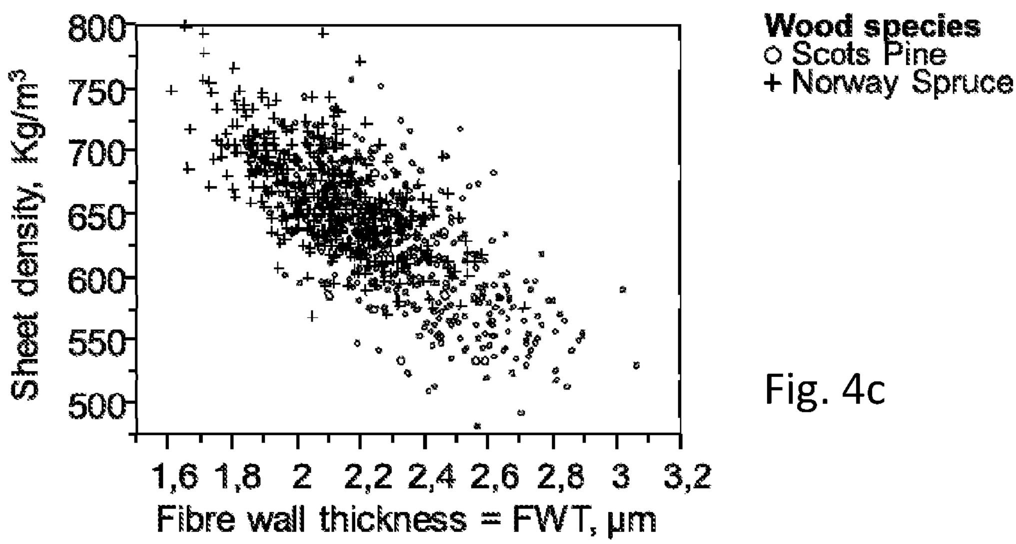


Fig. 4c

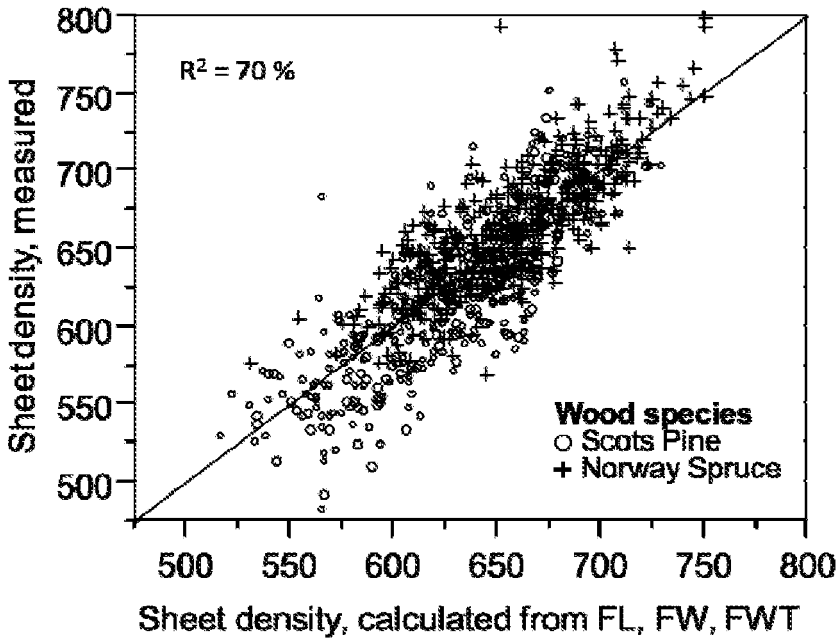

R^2 = 70 %
Sheet density, measured
Sheet density, calculated from FL, FW, FWT
Wood species
Scots Pine
Norway Spruce
800
750
700
650
600
550
500
500
550
600
650
700
750
800

Fig. 5

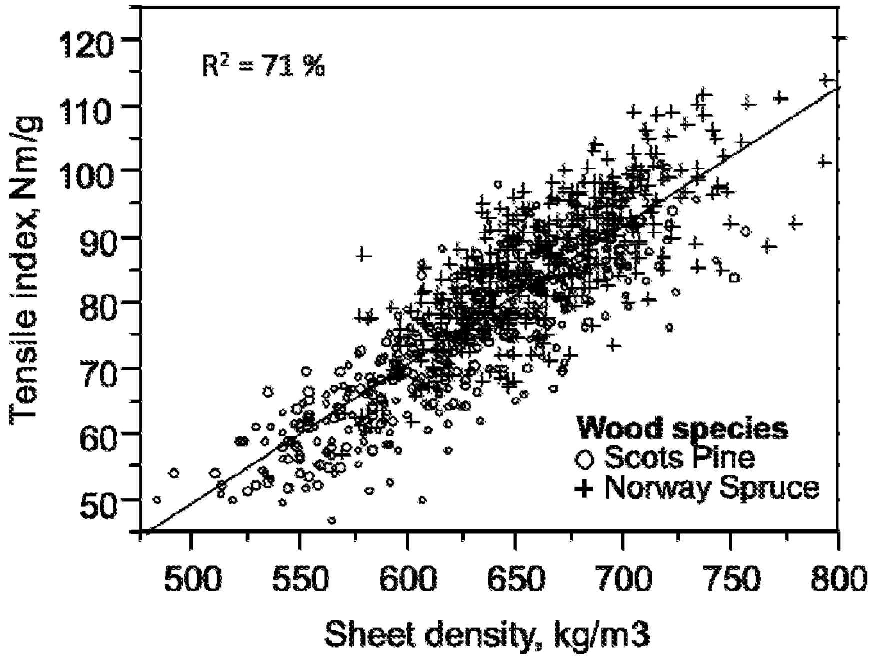

R^2 = 71 %
Tensile index, Nm/g
Sheet density, kg/m3
Wood species
Scots Pine
Norway Spruce
120
110
100
90
80
70
60
50
500
550
600
650
700
750
800

Fig. 6

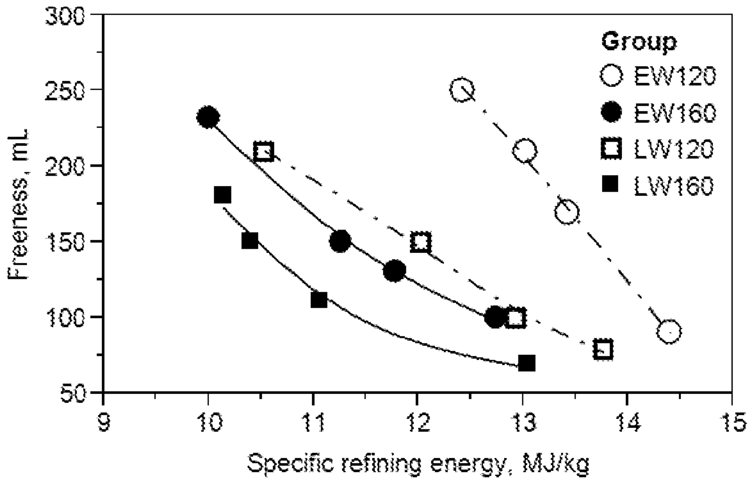


Fig. 7a

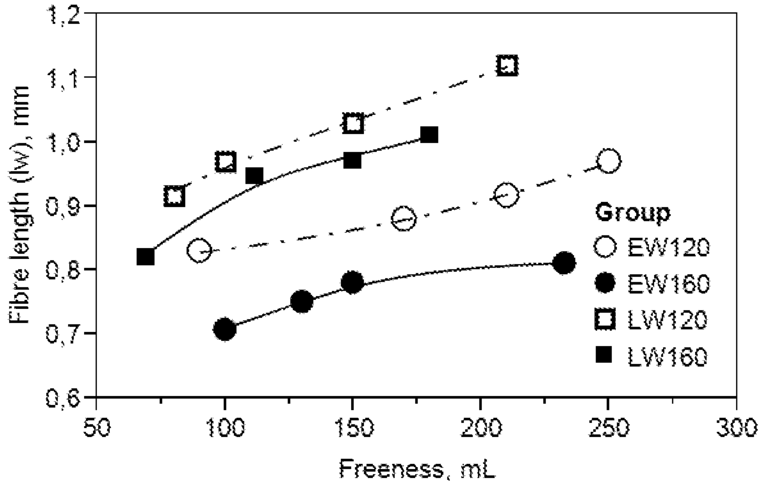


Fig. 7b

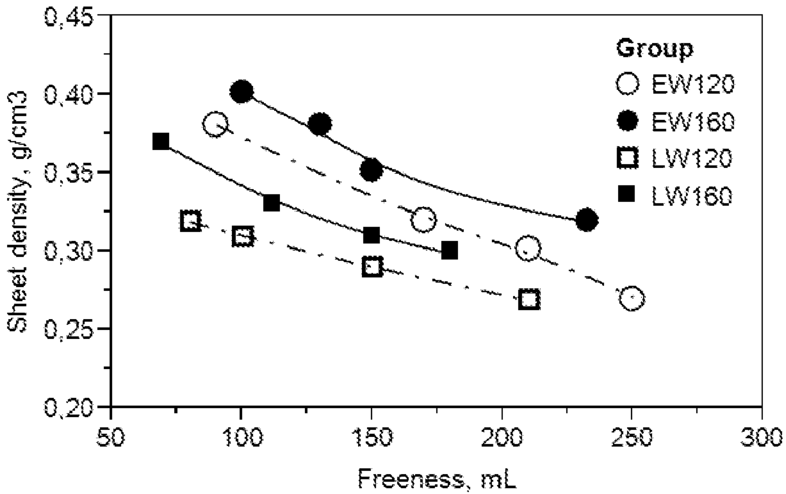


Fig. 7c

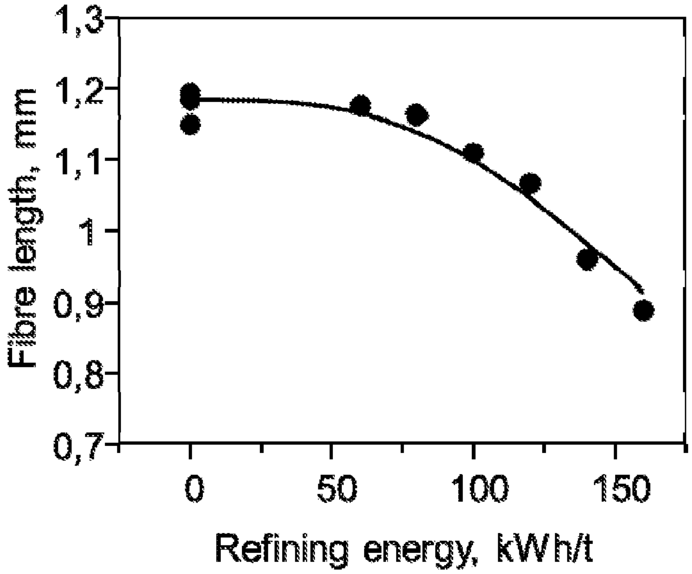


Fig. 8a

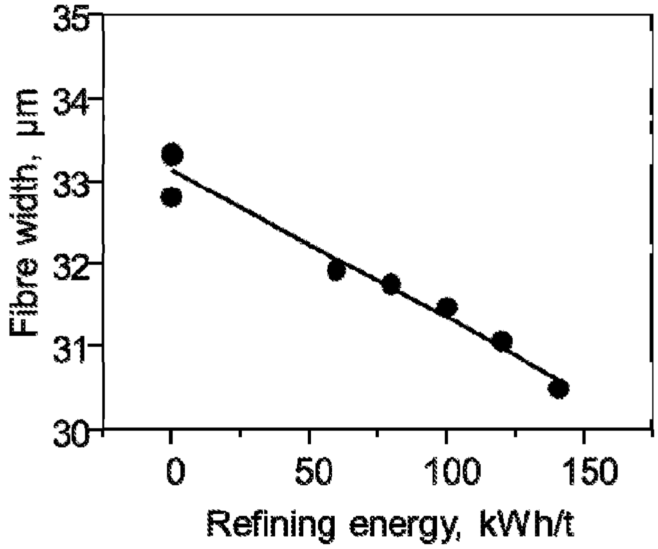


Fig. 8b

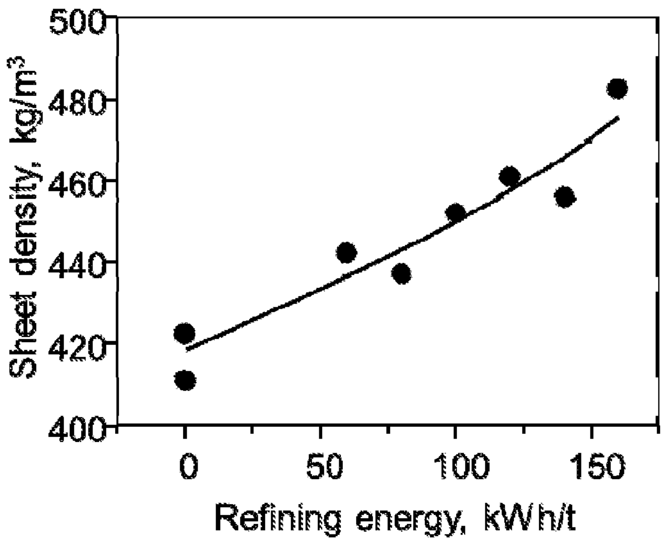
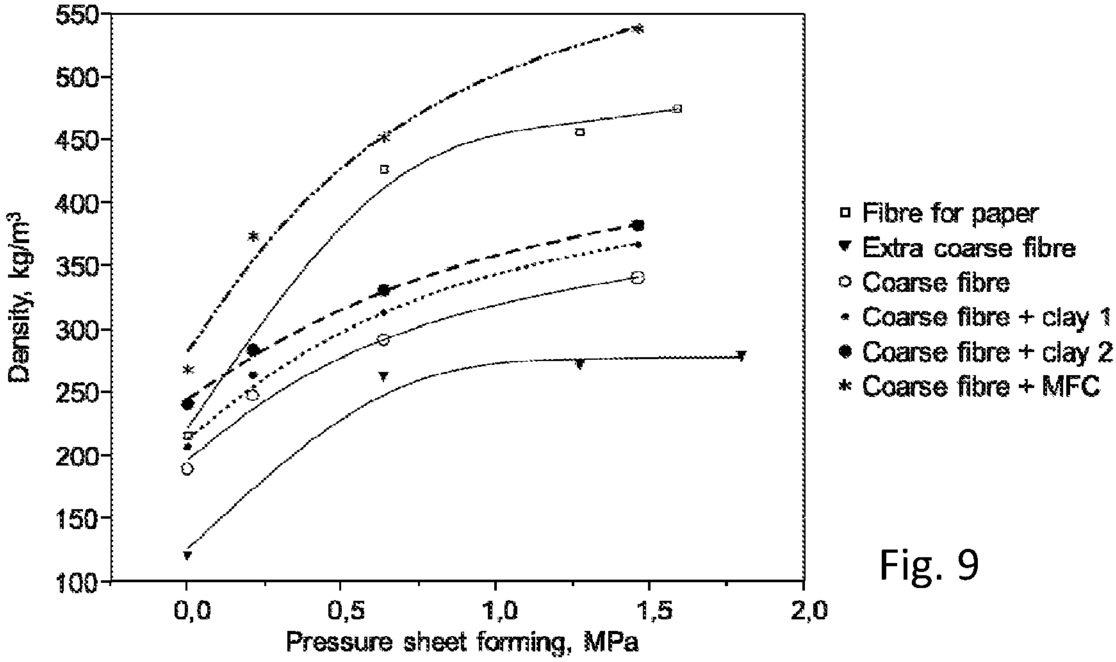
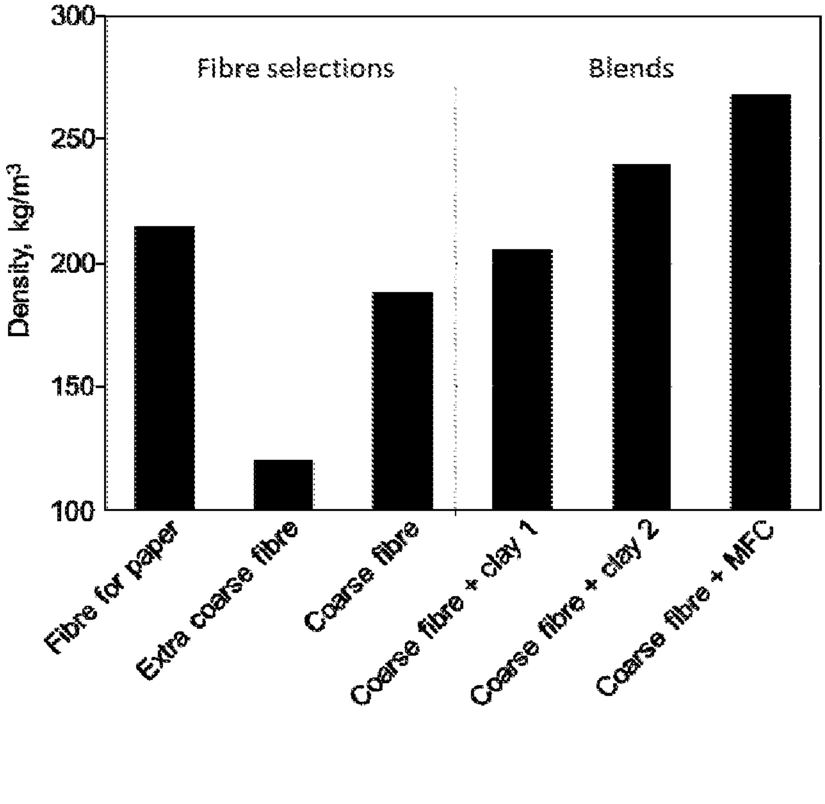


Fig. 8c



550
500
450
400
350
300
250
200
150
100
Density, kg/m³
0,0
0,5
1,0
1,5
2,0
Pressure sheet forming, MPa
Fibre for paper
Extra coarse fibre
Coarse fibre
Coarse fibre + clay 1
Coarse fibre + clay 2
Coarse fibre + MFC

Fig. 9



300
250
200
150
100
Density, kg/m³
Fibre selections
Blends
Fibre for paper
Extra coarse fibre
Coarse fibre
Coarse fibre + clay 1
Coarse fibre + clay 2
Coarse fibre + MFC

Fig. 10

REFERENCES CITED IN THE DESCRIPTION

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