Title: INSULATED PANEL AND METHOD OF MANUFACTURING THE SAME

Abstract: The invention relates to a composite panel, and a method for manufacturing a composite. According to the invention, the composite panel includes more than one wood-based material layer (1, 3), and at least one functional layer (2, 4, 5), which is selected from the group: sound-insulation layer, thermal-insulation layer, moisture-barrier layer, and fire-protection layer, and combinations of these is arranged in at least one interspace between the wood-based material layers, and the layers (1, 2, 3, 4, 5) are stacked on top of each other in a predetermined order, adhesive layers (6) are arranged between the layers to join the layers to each other, and the layers are pressed together with the aid of a single compression. At least one layer contains aerogel. In addition, the invention relates to a method for manufacturing a composite panel, and the use of a composite panel as a building and/or protective material.
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Insulated Panel and Method of Manufacturing the Same

The method relates to a composite panel according to the preamble to Claim 1.

Such a panel generally comprises at least one wood-based fibre layer and at least one functional layer, which is attached to the fibre layer, for example, by means of an adhesive layer.

The invention also relates to a method, according to the preamble to Claim 20, for manufacturing a composite panel, as well as a use according to Claim 21 and to a multilayered structure according to the preamble of claim 24, which comprises more than one functional layer.

Previously known are various types of composite panel, which are manufactured by combining wood-based materials and at least one other material. When manufacturing a composite panel, it is sought to maximize the good properties of the material and to minimize the bad properties. It is previously known to form composite panels by mixing together various raw materials in order to create a composite panel. It is also known to form composite panels by surfacing, for example, a wood panel with various materials.

The use of various types of pressing method in the manufacture of various types of panel is also previously known.

The invention is intended to create a new type of composite panel, in which various properties suitable for the intended purpose are combined in one panel. In particular, the invention is intended to create a composite panel, which has good insulating properties.

The invention is based on a composite panel, which is formed from layers of a wood-based material and at least one layer of another material. The composite panel includes more than one layer of a wood-based material, and at least one functional layer, which is selected from the group: sound-insulation layer, thermal-insulation layer, moisture-barrier layer, and fire-protection layer, and combinations of these, is arranged in at least one interspace between the wood-based-material layers. The layers are stacked on top of each other in a predetermined order, adhesive layers are arranged between the layers to attach the layers to each other, and
the layers are pressed together with the aid of a single pressing, in order to create a composite panel.

According to the invention, aerogel is included in at least one functional layer or at least one adhesive layer, or at least one functional layer and at least one adhesive layer.

By means of the invention a multilayered structure is provided which contains in combination more than one functional layer, such as a sound-insulation layer, thermal-insulation layer, moisture-barrier layer, or fire-protection layer, or a combination thereof, which layers are attached together with the aid of an adhesive layer, at least one, preferably several of the said functional layers, or at least one of the adhesive layers contains aerogel or consists thereof.

More specifically, the composite panel according to the invention is characterized by what is stated in the characterizing portion of Claim 1.

For its part, the method according to the invention is characterized by what is stated in the characterizing portion of Claim 20 and the use according to the invention by what is stated in Claim 21.

The multilayered panel structure is characterized by what is stated in the charactering part of claim 24.

Considerable advantages over the prior art are achieved by means of the composite panel according to the invention.

The composite panel according to the invention is a strong, light, and durable structure.

By means of the invention, a multi-purpose composite panel combining many properties is achieved. For example, the composite panel according to the invention permits the panel material to have simultaneously thermal-insulation, sound-insulation, moisture-barrier, and fire-protection properties, as well as ballistic protection.

Thanks to the invention, only a single panel need be used to achieve many different functional purposes in the same application.
According to the invention, functional layers can be hidden under and between a wood or wood-veneer layer or layers. At the same time, a cheap support surface is obtained for expensive special layers, such as a ballistic layer and an aerogel layer, the latter of which acts as both thermal insulation and as a fire-protection layer. Concealment is a function as such, and at the same time provides a conventional aesthetic surface.

It should be noted that aerogels bind organic molecules about 130 more effectively than active carbon (calculated on a weight basis), so that the present panel, in which the aerogel is only covered by a wood material, which can act as an effective temporary remover of toxic substances from the air.

In the following, the invention is examined with the aid of a detailed description, with reference to the accompanying drawing.

Figure 1 shows a simplified schematic diagram of one composite panel according to one embodiment of the invention.

In this connection, the term "composite panel" refers to any composite panel whatever, which is formed of layers formed of a wood-based material, and at least one other material layer.

In this connection, the term "wood-based material" refers to any wood material, or material formed of wood-fibre-based materials whatever, for example, wood veneer, such as coniferous or deciduous-wood veneer, plywood or wood panel or a similar wood-based material, such as sawn timber.

In this connection, the term "adhesive layer" refers to an intermediate layer formed of any as such known adhesive substance whatever, for example, resin, phenol-formaldehyde glue, melamine-formaldehyde glue, urea-formaldehyde glue and/or polyurethane glue, or some other adhesive substance suitable for the purpose, for joining different material layers to each other.

In this connection, the term "single pressing" refers to a method, in which all the desired component layers, i.e. the material layers and the adhesive layers, are stacked at one time to form a blank and the panel is formed in a single compression stage.
The term "aerogel" refers to a solid, microporous silicate foam (typically of fibrous silicon dioxide). The compressive strength of aerogel (silica) can be as great as 32 kp/cm², at a density of 0.6 kg/dm³. The compression of plywood typically requires a maximum of 14 kp/cm² and, according to a preferred embodiment of the invention, in the single pressing of the composite panel a compressive force is used, which is clearly less than the compressive strength of aerogel, for example, at least about 20 % less than it, but nevertheless greater than about 5, especially about 10 kp/cm². For example, the compressive force is about 10 - 25 kp/cm².

Aerogels suitable for compression according to the invention can be already manufactured even from sodium silicate (Na₂O:SiO₂).

Because the sound conductivity of aerogels is poor (speed -100 m/s, when the speed of sound in air is about 320 m/s and in normal solids always 6000 m/s), it can be used for excellent sound insulation.

The thermal conductivity of an aerogel is less than that of air, being even as little as 0.004 W/m K, for which reason it is suitable as thermal insulation.

The melting point of one preferred aerogel grade (silica) is about 1200 °C, so that it will withstand continuously temperatures of about 500 °C, at which wood will have already entirely pyrolysed.

The use of wood veneer to protect the aerogel is advantageous. According to our invention, the functional layers can be concealed inside a veneer or wooden panel that looks normal. Thus, a moisture-barrier, thermal-insulation, and ballistic layer can be put into the same product and concealed.

The following is a more detailed description of the functional layers and adhesive layers of the composite panel and their arrangement in the composite panel. As stated in the above description, each of these layers can contain an aerogel, for example, a silica aerogel, for example, to about 0.1 - 95 weight-%, or it can even consist entirely of an aerogel, as in a case in which aerogel felt is used as a functional layer. The functional layer can contain silica aerogel, which has a density of, for example, about 0.1 - 0.6 g/cm³.
In one embodiment of the invention, at least one functional layer is arranged on the surface of the composite panel, in order to form a surface layer.

In one embodiment of the invention, there is one functional layer.

In one preferred embodiment of the invention, the composite panel contains at least two functional layers.

In one embodiment of the invention, more than one functional layer is arranged between two wood-based material layers. In a second embodiment, at least two functional layers are located between wood-based material layers. In a third embodiment, at least three functional layers are located between wood-based material layers. In a fourth embodiment, at least four functional layers are located between wood-based material layers.

Alternatively, one functional layer is arranged between two wood-based material layers.

In one particularly preferred embodiment of the invention, at least one functional layer is arranged between more than one two wood-based material layers.

In a second preferred embodiment of the invention, at least one reinforced layer is arranged as a functional layer between two wood-based material layers.

The functional layer can be a fibre-reinforced layer. In one embodiment, the fibre-reinforced layer is then formed from a fibre-derived material.

In a second preferred embodiment of the invention, the functional layer is a cellular panel. The cellular panel advantageously lightens the structure. The cellular panel can be any, as such known, cellular material whatever suitable for the purpose.

In a third preferred embodiment of the invention, the functional layer is an insulation-material layer.

In a fourth preferred embodiment of the invention, the functional layer is formed of a polymer-based material. In one embodiment, the polymer-based material can advantageously
contain polyethylene, polypropylene, polyamide, aramid, carbon fibre, resin, cellulose, cellulose ester, cellulose ether, viscose fibre, cupro fibre, modal fibre, or other polymers or plastics suitable for the purpose, or various combinations of them.

In a fifth preferred embodiment of the invention, the functional layer is formed of a metal-based material.

The fibre-based material can contain natural fibres, such as vegetable fibres, for example, seed flock such as cotton, stalk fibre such as linen, leaf fibre such as sisal, or fruit fibre such as coconut, or animal fibres, for example, keratin substances such as wool or glandular secretions such as silk, or mineral fibres, for example asbestos; or artificial fibres, such as regenerated fibres, for example cellulose such as viscose, modal, cupro, or lyocell, or cellulose-acetate such as acetate or triacetate, or synthetic fibres, for example, polyamide, acryl, polyester, polyvinylchloride fibre, polypropylene or elastane, or inorganic fibres, for example, glass, metal, or rubber, or various combinations of these.

In one embodiment, the functional layer is formed of a polymer-based material, a fibre-based material, a metal-based material, or various combinations of these.

In one embodiment, the sound-insulation layer is formed of a cellular panel, a fibre-based material, a polyurethane insulation material, a cork material, a cork-composite material, or some other sound-insulating material suitable for the purpose.

In a second embodiment, the thermal-insulation layer is formed of a cellular panel, a fibre-based material, a polyurethane insulation material, a cork material, a cork-composite material, or some other thermally insulating material suitable for the purpose.

The reinforcement layer can be formed of a polymer-based material, a fibre-based material, glass, basalt, carbon, asbestos, wollastonite, silicates, or various combinations of these.

The reinforcement layer is preferably formed essentially in connection with an adhesive layer, for example, by arranging a suitable reinforcing material or suitable reinforcing fibres in the adhesive layer or by impregnating the reinforcement layer with an adhesive substance, thus creating an advantageously combined adhesive and reinforcement layer, or aerogel.
The moisture-barrier layer can be formed on a polymer-based material, which can be any polymer or plastic-based material whatever suitable for the purpose, for example, one of the polymer-based materials listed above.

In one embodiment, the fire-protection layer is formed of a metal-based material, for example, an aluminium film, or other fire-protection material suitable for the purpose.

In one preferred embodiment of the invention, at least one ballistic layer is arranged as a functional layer in connection with the composite panel. In one embodiment, the surface layer is a ballistic layer, preferably a ballistic protective layer. In one embodiment, the ballistic layer is arranged between wood-based material layers. In one embodiment, the ballistic layer is formed of a metal material, a metal-based material, a stone, mineral, or ceramic-based material, or various combinations of these, an the ballistic layer can be in a tile-like, sheet-like, or film-like form, always according to the embodiment.

The ballistic layer can also be formed of fibres with ballistic properties, or of other materials with ballistic properties. In one embodiment, a material with ballistic properties, for example fibres or a ceramic tile material, can be arranged in connection with some other functional layer to form combination layers with various properties. In this connection, the term ballistic protection refers to protection against flying pieces, preferably shrapnel or bullets.

The surface layer can be a reinforcement layer, a moisture-barrier layer, an insulation-material layer, or a combination of various types of layer.

In addition, the invention comprises a method for manufacturing any of the composite panels described above. According to the invention, more than one layer of wood-based material is stacked on each other, and at least one functional layer, which is selected from the group a sound-insulation layer, a thermal-insulation layer, and a fire-protection layer and combinations of these, is arranged between the wood-based material layers, and adhesive layers are arranged between the layers to joint the layers to each other, and the layers are compressed with the aid of a single pressing.
In addition, the invention is based on the use of any of the composite panels described above as a building material and/or a protective material, such as a thermal-insulation material, a sound-insulation material, a moisture-barrier material, a door material, or a fire-protection material, or as a protective panel, such as a ballistic shield or similar shield.

In one embodiment, the composite panel can be used as a floor, wall, ceiling, or roof material in permanent or temporary solutions in outdoor or indoor rooms. In addition, the composite panel can be used as a floor basepanel, for example, as a basepanel for a parquet or laminate floor.

Embodiments incorporating an aerogel layer as a fire-protection and thermal-insulation layer can be difficult to glue, if the composite product is thick, because the aerogel layer effectively insulates the transfer of heat. The aerogel layer (silica) is a highly efficient absorber of water. If polyvinyl alcohol, for example, is used as an adhesive on both sides of the aerogel layer, gluability of this layer can then be rapidly created even at room temperature (PVA hardens when water leaves it).

On the basis of the above, in the composite panel according to the invention the layer containing aerogel comprises an adhesive layer, which contains aerogel mixed with an adhesive.

The layer containing aerogel or consisting of aerogel can be glued to the other layers by means of a water-soluble polymer, such as polyvinyl alcohol.

The ballistic layer of the product can be supported by a polymer-fibre layer. This is suitable particularly in cases, in which the ballistic layer consists of a ceramic, concrete, or especially an MDF material (macro-defect-free cement product), or a combination of these. In this way, the manufacture of the product can be promoted.

A layer of MDF material even 3-mm thick can be used to stop a handgun bullet. A composite material according to the invention, in which there is an aerogel layer or a layer containing aerogel, as well as possibly an MDF layer, is suitable for very many special purposes. Thus, the product is highly suitable for manufacturing loudspeaker enclosures, particularly when wood, aerogel, and MDF-material layers are combined, as aerogel and
wood attenuate vibration well, and the MDF product, as is known, possesses a good vibration-attenuating property (tan δ) and an advantageous Young’s modulus (E = elongation tension/strain).

The composite panel according to the invention, shown in Figure 1, is intended to be used simultaneously as a building material and a protective material, such as a thermal-insulation material, a sound-insulation material, a moisture-barrier material, and a fire-protection material. The composite panel can be used as, for example, a ballistic shield or door material, or a floor, wall, or ceiling material.

In the composite panel of Figure 1, it is possible to use as such known wood-based veneers as the wood-based material 1, 3.

The composite panel of Figure 1 includes a first wood-based veneer layer 1, three different functional layers 2, 4, 5, and a second wood-based veneer layer 3. The functional layers 2, 4, 5 are located between the wood-based veneer layers 1, 3. The composite material includes two reinforcing layers 2 as functional layers, and cellular-panel layer 4 and an aluminium-film layer 5 arranged between them. The reinforcing layers 2 are formed of natural fibres and/or artificial fibres, or their staple fibres. A ballistic protective layer, which is formed of ceramic tile, is arranged as a surface layer 7 on the first wood-based veneer layer 1 of the composite panel. All the material layers 1, 2, 3, 4, 5 are joined to each other by adhesive layers 6, which contain an adhesive suitable for the application.

The composite panel according to the invention is suitable for use, as different embodiments, in connection with the most diverse practical applications.

The invention is not restricted to concern only the examples presented above, but instead many variations are possible, while remaining within the scope of the inventive idea defined in the Claims.

Though a solution is described above, in which the composite material always contains a wood layer, it is also possible to manufacture a multi-layer structure, which contains a combination of more than one functional layer, which is selected from a group, which comprises sound-insulation layers, thermal-insulation layers, moisture-barrier layers, as well
as combinations of these, in which case adhesive layers are arranged in the interspaces between the layers to join the layers together, and in which case at least one layer, which is selected from the said functional layers and adhesive layers, comprises aerogel. The aerogel layer in question can either contain aerogel to about 0.1 - 95 weight-% of the layer, or can consist entirely of it (e.g. aerogel felt).

All the composite structures described above, which are stated to contain wood layers, can also be implemented without the said wood or wood-fibre layers, and such structures are also included in the present invention as alternative solutions.
Claims:

1. Composite panel which comprises at least one wood-based material layer (1, 3), and, in at least one interspace between the wood-based material layers, there is arranged at least one functional layer (2, 4, 5), which is selected from the group: sound-insulation layer, thermal-insulation layer, moisture-barrier layer, and fire-protection layer, and combinations of these, in which case adhesive layers (6) are arranged in the interspaces between the layers (1, 2, 3, 4, 5), in order to join the layers to each other, characterized in that at least one selected layer of the functional layers (2, 4, 5) and adhesive layers (6) comprises aerogel and the wood-based material layer (1, 3) is a wood or wood veneer layer.

2. The composite panel according to claim 1, characterized in that the layer containing aerogel is aerogel felt.

3. The composite panel according to claim 1 or 2, characterized in that the functional layer contains silica-aerogel, the density of which is advantageously 0.1 - 0.6 g/cm³.

4. The composite panel according any of claims 1 - 3, characterized in that the layer containing aerogel is an adhesive layer, which contains aerogel mixed with adhesive.

5. The composite panel according to any of claims 1 - 4, characterized in that the layer containing or consisting of aerogel is glued to the other layers by means of a water-soluble polymer, such as polyvinylalcohol.

6. The composite panel according to any of claims 1 - 5, characterized in that it is manufactured by stacking the layers on top of each other in a predefined order and pressing the layers together with the aid of a single compression.

7. The composite panel according to any of the preceding claims, characterized in that at least one functional layer is arranged on the surface of the composite panel, in order to create a surface layer (7).
8. The composite panel according to any of the preceding claims, characterized in that the composite panel contains at least two functional layers (2, 4, 5, 7).

9. The composite panel according to any of the preceding claims, characterized in that more than one functional layer (2, 4, 5) is arranged between two wood-based material layers (1, 3).

10. The composite panel according to any of the preceding claims, characterized in that at least one functional layer (2, 4, 5) is arranged between more than one of the wood-based material layers (1, 3).

11. The composite panel according to any of the preceding claims, characterized in that at least one reinforcing layer is arranged as a functional layer (2, 4, 5) between two wood-based material layers (1, 3).

12. The composite panel according to any of the preceding claims, characterized in that the functional layer (2, 4, 5, 7) is a fibre-reinforced layer.

13. The composite panel according to any of the preceding claims, characterized in that the functional layer (2, 4, 5, 7) is a cellular panel.

14. The composite panel according to any of the preceding claims, characterized in that the functional layer (2, 4, 5, 7) is an insulating-material layer.

15. The composite panel according to any of the preceding claims, characterized in that the functional layer (2, 4, 5, 7) is formed of a polymer-based material.

16. The composite panel according to any of the preceding claims, characterized in that the functional layer (2, 4, 5, 7) is formed of a metal-based material.
17. The composite panel according to any of the preceding claims, characterized in that a ballistic layer is arranged as a functional layer (2, 4, 5, 7) in connection with the composite panel.

18. The composite panel according to any of the preceding claims, characterized in that the layer comprising aerogel can contain aerogel to about 0.1 - 95 weight-% of the layer, or can consist entirely of aerogel.

19. The composite panel according to any of the preceding claims, characterized in that at least one, preferably every wood-containing material layer of the composite panel consists of a wood veneer layer, plywood or sawn timber.

20. Method for manufacturing a composite panel according to any of the preceding claims, characterized in that more than one layer of a wood-based material are stacked on top of each other, at least one functional layer, which is selected from the group: sound-insulation layer, thermal-insulation layer, moisture-barrier layer, and fire-protection layer, and combinations of these, is arranged in the interspace between at least one of the wood-based material layers, and adhesive layers are arranged in the interspaces between the layers to join the layers together, and the layers are compressed together with the aid of a single pressing, in which case at least one layer is selected from the functional layers (2, 4, 5) and the adhesive layers (6) comprise aerogel.

21. Use of a composite panel according to any of Claims 1 - 19 as a building material or as a protective material.

22. Use according to Claim 20, characterized in that the panel's ability to insulate sound, heat, moisture, or to protect from fire, or to act as a ballistic shield material is exploited.

23. Use of a composite panel according to any of Claims 1 - 19 for manufacturing a loudspeaker enclosure.

24. Multi-layer structure, which contains, as a combination, more than one functional layer, which is selected from a group that comprises sound-insulation layers, thermal-insulation
layers, moisture-barrier layers, and fire-protection layers, as well as combinations of these, in which case adhesive layers are arranged in the interspaces between the layers in order to join the layers to each other, characterized in that at least one layer, which is selected from the said functional layers and adhesive layers, comprises aerogel.

25. Multi-layer structure according to Claim 22, characterized in that it contains aerogel by about 0.1-95 weight-% of the layer, or consists entirely of it.
**INTERNATIONAL SEARCH REPORT**

**International application No.**

PCT/FI201 2/050795

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**A. CLASSIFICATION OF SUBJECT MATTER**

See extra sheet

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

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**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC: B32B, E04B

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**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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[X] Further documents are listed in the continuation of Box C.  
[X] See patent family annex.

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* Special categories of cited documents:
  "A" document defining the general state of the art which is not considered to be of particular relevance  
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Form PCT/ISA/210 (second sheet) (July 2009)
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