

PATENT SPECIFICATION

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(54) BUILDING PANEL

(71) We, DURISOL A.G. FÜR LEICHTBAUSTOFFE a body corporate organised under the laws of Switzerland, of Badenerstrasse 21, 8953 Dietikon, Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a building panel. A process is known (see U. S. Patents Nos. 3,164,511 and 3,271,492) in which building panels are manufactured from a mixture of woodchips, cement and water. The mixture is deposited as layers and the layers are stacked on one another and pressed to the desired panel thickness as packages in a press. In this process the deposition of the chips is preferably carried out in such a way that long cement coated chips predominate at the outer faces of the panel thereby to give as high a bending resistance as possible to the panel. Alternatively these long cement coated chips are distributed equally through the whole panel thickness to produce a single layer panel.

In connection with the deposition of the chips it should be noted that the process of air felting is known (see German Patent 1,601,059 and U.S. Patent 3,271,492).

The disadvantage of the known process mentioned above is that the panels produced have a relatively rough surface. Experience shows that weathering of the panels readily causes the large chips on the surface to swell, especially with cut panels, and with time these chips become detached. In addition the rough surface is often undesirable for aesthetic reasons.

Moreover the type of panel with orientated chips is not invariably of advantage as building is often done in such a way that the same strength is needed in the lengthwise and in the crosswise direction.

Furthermore the composition of the board, and hence the cement distribution is the same over the whole cross section of the panel. In the event of fire therefore, the outer layers of the panel are burned relatively quickly and the panel burned relatively deeply, which has proved to be a disadvantage. A further disadvantage of such panels is that the relatively open outer surface of the panels consisting of long chips over 12 mm long quickly absorbs water, which leads to increased swelling. Furthermore, industrial exploitation of the process runs up against the problem of the manufacture of the desired strands and the question of what to do with the unused fine material which is produced during cutting.

According to the present invention there is provided a building panel made from organic chips, a hydraulic binding agent as herein defined, and a mineral salt, having at least three gradually merging layers of which at least one has chips of greater average length and has a lower proportion of binding agent to chip material than at least one other layer, the average quantity of mineral salt absorbed by the chips and incorporated in them being at least 2% by weight, relative to the weight of absolutely dry chip material. The term hydraulic binding agent as used herein means a binding agent which hardens in contact with water.

The invention also provides a process for the production of a building panel according to the invention, wherein a chip mixture is divided into at least 2 fractions, namely a first fraction with short chips having a length of 2 to 8 mm and a second fraction with long chips having a length of 8 to 20 mm, of which at least 80% is not larger than 12 mm, a mineral salt is added so that the chips of both fractions contain at least 2% of mineral salt based on the weight of absolutely dry

strand material, each fraction is mixed with a hydraulic binding agent and both mixtures are deposited on a base by air felting so that at least three gradually merging layers varying in respect of the ratio of chip material to binding agent are produced.

Preferably the chips are of wood and the binder is cement.

By this process a building panel is created which has a smooth surface, the internal structure of which is characterised by a greater proportion of the short chip material and a greater proportion of cement at the surface of the panel and by the fact that the length of the chips in the case of three layer panels gradually increases towards the middle of the panel thickness. The amount of cement required depends on the surface area of the chips, and so the cement content is somewhat reduced towards the middle of the panel since the long chips present there have a smaller surface to volume ratio.

By virtue of this structure the capacity of the panels to resist external influences, such as the effects of weather, fungus growth and termite attacks, is greatly improved.

The invention is illustrated with reference to the accompanying drawings which are purely schematic and in which:

Figure 1 shows a cross-section through a portion of a deposited mat of chips with a chip length which decreases from the centre of the mat towards both sides.

Figure 2 shows the absorption by the chips of a mineral salt solution expressed in percent by weight based on the weight to absolutely dry wood in the chips, as a function of the effective chip length.

Figure 3 shows the percentage weights of different lengths of chip.

Figure 4 shows the density in the panel over the panel thickness for a panel made from the mat shown in Figure 1.

Figure 5 shows the distribution of the density of wood over the panel thickness for a panel made from the mat shown in Figure 1.

Figure 6 shows the weight of cement per unit volume of wood over the panel thickness for a panel made from the mat shown in Figure 1.

Figure 7 shows the average temperature as a function of time during the fire testing of three different wall coverings A, B and C.

Figure 8 shows the compression strength of a panel according to Figure 4 in the plane of the panel, over the panel thickness.

Figure 9 shows the tensile strength for a panel according to Figure 1, over the panel thickness, the panel having a bending strength of between 120 and 180 kp/cm².

Figure 10 shows the cross-section of a five-layer panel.

Figure 11 shows the distribution of density

for a panel according to Figure 10, analogous to Figure 4.

Figure 12 shows the distribution of the wood weight for a panel according to Figure 10 analogous to Figure 5.

Figure 13 shows the distribution of the cement weight for a panel according to Figure 10, analogous to Figure 6.

Figure 14 shows the tensile strength analogous to Figure 9 for a panel according to Figure 10.

The mat cross-section illustrated in Figure 1 shows that it has a long-chip middle layer but has progressively shorter chip layers towards the outside. The transition should preferably take place gradually.

The addition of mineral salt to the chips forming a panel according to the invention is essential. It is important that the mineral salt, should penetrate completely into the chip material, e.g. wood, in a specified time, preferably in a maximum of one minute. In the example shown in Figure 2 solution of $Al_2(SO_4)_3$ was used in a concentration of 14 grams per litre of water. In this example the mean weight per unit volume for the absolutely dry wood is 280 kg/m³. The correct choice of the strand fractions lead to a surprising result. In Figure 2 the curve *a* shows the quantity of the solution of the mineral salt absorbed by the chips in percent by weight of the dry chips as a function of the chip length. For the chips to which Figure 2 relates, their thickness varies according to the length of the chip. In this instance, as the length of the chip increases from 2 mm to 8 mm its thickness increases from 0.2 mm to 0.4 mm. The chip length is given on the abscissa. It was found that as the chip length increased this quantity asymptotically approached the value of 5%. With a short chip 0.2 mm in length, this quantity is 480% by weight. In the production of such panels a mineral salt solution quantity (1.4% by weight), of approximately 180 to 190% by weight of the chips provides the optimum results, and chips of a length appropriate to that quantity of solution are therefore preferably used.

It was found that with dry chips of the chosen sizes in 1 minute up to 50% more mineral salt solution was absorbed by the chips than in the case of chips which for instance had a moisture content of 80% by weight.

This effect was not that expected from the diffusion theory. However, in practice the conditions on which the theoretical consideration is based cannot economically be attained, a fact which has only been shown by experiment. In practice the conditions are quite different from that which the theory pre-supposes, since total submersion is assumed in the theory which is not economically practicable.

Figure 3 shows the chip length distribution of the chips used in the production of the panel of Fig. 1. The main proportion (64%) consists of chips between 5 and 12 mm long, which provides an excellent reinforcement of the panel and associated therewith the corresponding strength. The short chips (up to 5 mm long) of approximately 14% of the total weight of the strands are incorporated in the outer layers of the panel. The composition of the mat which leads to such a panel is shown in Figure 1. The gradual transition from the outer short-chip layer to the inner long-chip layer provides the desired distribution of tensions in bending stress. The panel is constructed in such a way that the materials of the panel (wood and cement) are distributed in the panel in such a way as to provide the desired properties of the panel, i.e. adequate bending tensile strength, very high pressure resistance and very good behaviour in fire.

Figure 4 shows the variation in the density in kg/m^3 in the cross-section of the panel. The distribution of the quantity of wood (Figure 5) and the quantity of cement (Figure 6) is important in this. The distribution of these materials gives rise to panels with a high degree of weather resistance and fire resistance. In the event of a fire the short-chip outer layer fractures like a fine mesh and remains attached to the rest of the panel. In this way air is prevented from penetrating to the inner part of the panel, and the panel only burns to a depth of 5 to 6 mm.

Figure 7 shows the mean temperature in a room resulting from the same initial fire as a function of time for different wall coverings. Curve A relates to a building material which is completely non-inflamable. Curve B results when a room is lined with normal inflammable building materials. Curve C gives the temperature curve when the lining comprises the panels produced according to this invention, curve C being quite similar to curve A. The curves were obtained by igniting a specific quantity (20 kg) of wood in a lined test room of approximately 8 m^3 . As a result of the temperature rise in the room the lining of the test room can also ignite, thereby further raising the temperature.

Figure 8 shows the distribution of the compression strength which provides very high strength against impact.

Figure 9 shows the curve of the tensile strength, which results in a corresponding bending strength of 120 to 180 kp/cm^2 .

In cases where still higher bending strengths are required, another embodiment of the panel described below meets this need. Figure 10 shows the construction of such a panel. The outer layers 1 and 5 of

short-chip materials perform the same protective function as in the case of the panel according to Figure 1. Layers 2 and 4 containing only long-chip material are provided inwardly of layers 1 and 5 respectively, and provide the outer zones with increased tensile strength. The middle layer 3 of short-chip material provides a very good transmission of tractive force and provides for high transverse tensile strength.

This variant of the panel facilitates a saving of material consumption of 15 to 20% of wood and cement, or a corresponding increase of strength.

The distribution of tensile strength for the panel of Figure 10 can be seen in Figure 14.

The distribution of material in such a five layer panel is shown in Figure 11. Figure 12 shows the wood distribution in the panel cross-section and Figure 13 shows the corresponding cement distribution. A five layer panel behaves even better in fire than the three layer panel described earlier. The layers do not break together suddenly, but each one breaks separately, the effect being similar to laminated glass.

An embodiment of a five layer panel with a specific spray head sequence shows a great improvement of the mechanical and other characteristics of the panel, if the first outer short-chip layer is then followed by the second layer with longer chips then the middle layer with short-chip material and then again a layer with longer chips and finally the last, outer short-chip layer. This panel, which from the technological point of view is the best, has the following characteristics. It has short-chip outer layers with a smooth, weather and fire-proof surface; the second and fourth layers with the longer chips contribute greatly to the improvements of the bending strength of the panel; the middle short-chip layer greatly improves the transverse tensile strength, which is double that of the three layer embodiment.

In the case of the embodiment according to Figure 10 it is possible after the first spray head and before the last spray head to incorporate reinforcements 6 and 7, e.g. glass fibres, glass filaments plastics or metal nets, and thus to increase substantially the bending strength of the panel.

The following points should also be noted. The difference between the densities in the outer layers and the middle corresponds at least to the ratio 1.3:1.

The ratio of short-chip material to long-chip material is 2:4—6, and preferably 2:5.

In the five layer panel at least 70% of the long-chip material is packed into the second to outer-most layers and the short-chip material is packed mainly in the middle layer.

It is also possible to fit an aluminium or

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plastics sheet 8 onto a handling apparatus and a second aluminium or plastics sheet 9 onto the finished moulded product and the whole assembly is bonded together with appropriate binding agents in a press. With this embodiment the quantity of water required for the setting of the cement can be reduced to the theoretically minimum necessary quantity, because the water cannot evaporate. These surface reinforced panels have the highest bending strength.

This embodiment permits the reduction of the density of the panels from 1250 kg/m³ to 600 kg/m³ for special designs.

It is also possible to add fine, fire resistant constituents such as mica and perlite to the cement-wood chip mixture, and in this way to increase the fire resistance of the panels still further.

It has been found that the quantity of water required for the cement can be reduced and better covering of the chips attained, by mixing cement with a proportion of the mixing water to form grout and adding this into the mixer. In this way the mixing time is shortened and the mixing water is not extracted from the wood.

The smooth, sealed surface resulting from this panelled structure permits economic and effective painting, coating with synthetic resin bonded dressings and other coating materials.

By means of the air felting process it is possible to pigment the outer layer with for example mineral fine ground colour pigments.

A panel produced in this way is best made from short chip material fractions of 2 to 8 mm length and long chip material fractions of 8 to 20 mm length, and the chips under 12 mm should constitute 80% of the long chip material. The thickness of the chips should not exceed 0.8 mm, since this particularly ensures that the introduction of mineral salt into the panel will be properly achieved.

Although the above statements describe wood as the chip material, a different material such as linter or similar material can be used instead of or together with wood. Portland cement is particularly suitable as a hydraulic binding agent, although other cements, plastics or similar binding agents can also be used.

WHAT WE CLAIM IS:—

1. A building panel made from organic chips, a hydraulic binding agent, as herein defined, and a mineral salt, having at least three gradually merging layers of which at least one has chips of greater average length and has a lower proportion of binding agent to chip material than at least one other layer, the average quantity of mineral salt absorbed by the chips and incorporated in

them being at least 2% by weight, relative to the weight of absolutely dry chip material.

2. A panel according to Claim 1 wherein in that chips varying in length from 1 to 25 mm are present.

3. A panel according to either preceding Claim wherein at least 75% by weight of the chips are not longer than 12 mm.

4. A panel according to any preceding claim, wherein the organic chips are wood chips.

5. A building panel substantially as herein described with reference to Figure 1 to 9 or Figures 10 to 14 of the accompanying drawings.

6. A process for the production of a building panel according to Claim 1, wherein a chip mixture is divided into at least 2 fractions, namely a first fraction with short chips having a length of 2 to 8 mm and a second fraction with long chips having a length of 8 to 20 mm, of which at least 80% is not larger than 12 mm, a mineral salt is added so that the chips of both fractions contain at least 2% of mineral salt based on the weight of absolutely dry strand material, each fraction is mixed with a hydraulic binding agent and both mixtures are deposited on a base by air felting so that at least three gradually merging layers varying in respect of the ratio of chip material to binding agent are produced.

7. A process according to Claim 6 wherein the ratio of the densities of the outer layers to that of the middle layer is at least 1.3:1.

8. A process according to Claim 6 or 7 wherein the ratio of the first fraction to the second fraction is between 2:4 and 2:6 by weight.

9. A process according to Claim 7 wherein the said ratio is 2:5.

10. A process according to Claim 6, wherein a five layer panel is produced, at least 70% of the long-chip material being in the second to outermost layers and at least 50 % of the short-chip material being located in the middle layer.

11. A process according to any one of Claims 6 to 10, wherein at least part of the chip material is wood.

12. A process according to Claim 11, wherein the first fraction further comprises a fire resistant constituent which is deposited in the surface layers of the panel.

13. A process according to Claim 12, wherein the fire resistant constituent is mica or perlite.

14. A process according to Claim 12 or 13 wherein in the case of a five layer panel the fire resistant constituent is also located in the middle layer.

15. A process according to any one of Claims 6 to 14, wherein fire resistant reinforcing material is incorporated after the first and before the last layer.



plastics sheet 8 onto a handling apparatus and a second aluminium or plastics sheet 9 onto the finished moulded product and the whole assembly is bonded together with appropriate binding agents in a press. With this embodiment the quantity of water required for the setting of the cement can be reduced to the theoretically minimum necessary quantity, because the water cannot evaporate. These surface reinforced panels have the highest bending strength.

This embodiment permits the reduction of the density of the panels from 1250 kg/m³ to 600 kg/m³ for special designs.

It is also possible to add fine, fire resistant constituents such as mica and perlite to the cement-wood chip mixture, and in this way to increase the fire resistance of the panels still further.

It has been found that the quantity of water required for the cement can be reduced and better covering of the chips attained, by mixing cement with a proportion of the mixing water to form grout and adding this into the mixer. In this way the mixing time is shortened and the mixing water is not extracted from the wood.

The smooth, sealed surface resulting from this panelled structure permits economic and effective painting, coating with synthetic resin bonded dressings and other coating materials.

By means of the air felting process it is possible to pigment the outer layer with for example mineral fine ground colour pigments.

A panel produced in this way is best made from short chip material fractions of 2 to 8 mm length and long chip material fractions of 8 to 20 mm length, and the chips under 12 mm should constitute 80% of the long chip material. The thickness of the chips should not exceed 0.8 mm, since this particularly ensures that the introduction of mineral salt into the panel will be properly achieved.

Although the above statements describe wood as the chip material, a different material such as linter or similar material can be used instead of or together with wood. Portland cement is particularly suitable as a hydraulic binding agent, although other cements, plastics or similar binding agents can also be used.

WHAT WE CLAIM IS:—

1. A building panel made from organic chips, a hydraulic binding agent, as herein defined, and a mineral salt, having at least three gradually merging layers of which at least one has chips of greater average length and has a lower proportion of binding agent to chip material than at least one other layer, the average quantity of mineral salt absorbed by the chips and incorporated in

them being at least 2% by weight, relative to the weight of absolutely dry chip material.

2. A panel according to Claim 1 wherein in that chips varying in length from 1 to 25 mm are present.

3. A panel according to either preceding Claim wherein at least 75% by weight of the chips are not longer than 12 mm.

4. A panel according to any preceding claim, wherein the organic chips are wood chips.

5. A building panel substantially as herein described with reference to Figure 1 to 9 or Figures 10 to 14 of the accompanying drawings.

6. A process for the production of a building panel according to Claim 1, wherein a chip mixture is divided into at least 2 fractions, namely a first fraction with short chips having a length of 2 to 8 mm and a second fraction with long chips having a length of 8 to 20 mm, of which at least 80% is not larger than 12 mm, a mineral salt is added so that the chips of both fractions contain at least 2% of mineral salt based on the weight of absolutely dry strand material, each fraction is mixed with a hydraulic binding agent and both mixtures are deposited on a base by air felting so that at least three gradually merging layers varying in respect of the ratio of chip material to binding agent are produced.

7. A process according to Claim 6 wherein the ratio of the densities of the outer layers to that of the middle layer is at least 1.3:1.

8. A process according to Claim 6 or 7 wherein the ratio of the first fraction to the second fraction is between 2:4 and 2:6 by weight.

9. A process according to Claim 7 wherein the said ratio is 2:5.

10. A process according to Claim 6, wherein a five layer panel is produced, at least 70% of the long-chip material being in the second to outermost layers and at least 50 % of the short-chip material being located in the middle layer.

11. A process according to any one of Claims 6 to 10, wherein at least part of the chip material is wood.

12. A process according to Claim 11, wherein the first fraction further comprises a fire resistant constituent which is deposited in the surface layers of the panel.

13. A process according to Claim 12, wherein the fire resistant constituent is mica or perlite.

14. A process according to Claim 12 or 13 wherein in the case of a five layer panel the fire resistant constituent is also located in the middle layer.

15. A process according to any one of Claims 6 to 14, wherein fire resistant reinforcing material is incorporated after the first and before the last layer.

(11)

16. A process according to Claim 15 wherein the fire resistant material is glass fibres, glass filaments or glass fibre nets.
- 5 17. A process according to any one of Claims 6 to 16 wherein the manufacturing process a reinforcement layer in particular a sheet of for example aluminium or plastic is placed on a handling means therefor and a second reinforcement layer is placed on the finished moulded product, and the whole assembly is bonded together in a press.
- 10 18. A process according to any one of Claims 6 to 17, wherein the hydraulic binding agent is cement.
- 15 19. A process according to Claim 18 wherein the cement is introduced in the form of a grout into a mixer for mixing with the chips.
20. A process for manufacturing a building panel, substantially as herein described with reference to Figures 1 to 9 or Figures 10 to 14 of the accompanying drawings.

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