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(54) **PANEL CONTAINING BAMBOO**

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(57) **ABSTRACT**

Disclosed is a panel comprising bamboo strands and wood strands.

PANEL CONTAINING BAMBOO

BACKGROUND OF THE INVENTION

[0001] Bamboo is a lignocellulosic material widely used throughout Asia as a building material because of its high strength, durability and excellent dimensional stability, as well as its ready supply and rapid replenishment-bamboo grows very rapidly, reaching full maturity within 2 to 6 years, while even the fastest growing wood tree species take as long as 15 to 30 years to grow to full maturity.

[0002] However, in addition to these advantages, bamboo also has a number of disadvantages. Since bamboo is hollow it cannot be processed into solid lumber board or planks; nor can it be easily process by conventional techniques used to make wood composite materials. Processed bamboo also has a tendency to swell excessively in the presence of moisture, a significant drawback for a material to be used for structural purposes.

[0003] Furthermore, although bamboo's high strength is due in part to its high density which means that bamboo-based material can often be very heavy.

[0004] Despite these disadvantages, because of bamboo's ready supply and excellent performance characteristics, manufacturers have developed techniques to make wood composite materials out of bamboo. For example, composite bamboo structural panels may be made by hand-cutting bamboo strands from the outer part or surface of a bamboo culm, and then weaving (again typically by hand) the strands into mats. These hand-cut, hand-woven bamboo mats are then stacked together along with several other similar mats and the mats then pressed together under high temperature.

[0005] The problem with this method of manufacture of the bamboo boards is that it is time consuming; the steps of cutting the bamboo strips and then weaving the bamboo strips into the form of a mat take a significant amount of time. And not only are these processes time consuming, but they can lead to significant defects in the final board product. Yet another disadvantage of the aforementioned processes is that because they are composed of large numbers of bamboo layers, they are require very high doses of resin per layer, which adds greatly to the price of the product during periods of high petroleum prices. Moreover, this process does nothing to reduce the weight of the bamboo material.

[0006] Given the foregoing there is a need in the art for structural panels that incorporate bamboo but have fewer defects, are relatively light in weight than 100% bamboo panels, are less susceptible to swelling when exposed to water and consume a smaller amount of petroleum-based products.

BRIEF SUMMARY OF THE INVENTION

[0007] The present invention relates to a panel comprising bamboo strands and wood strands.

DETAILED DESCRIPTION OF THE INVENTION

[0008] All parts, percentages and ratios used herein are expressed by weight unless otherwise specified. All documents cited herein are incorporated by reference.

[0009] As used herein, "lignocellulosic material" is intended to mean a cellular structure, having cell walls composed of cellulose and hemicellulose fibers bonded together by lignin polymer. Wood and bamboo are both lignocellulosic materials.

[0010] By "wood composite material" or "wood composite component" it is meant a composite material that comprises lignocellulosic material and one or more other additives, such as adhesives or waxes. Non-limiting examples of wood composite materials include structural composite lumber ("SCL"), waferboard, particle board, chipboard, medium-density fiberboard, plywood, and boards that are a composite of strands and ply veneers. As used herein, "flakes", "strands", and "wafers" are considered equivalent to one another and are used interchangeably. A non-exclusive description of wood composite materials may be found in the Supplement Volume to the Kirk-Othmer Encyclopedia of Chemical Technology, pp 765-810, 6th Edition, which is hereby incorporated by reference.

[0011] The following describes preferred embodiments of the present invention, which provides a composite panel comprising a mixture of bamboo strands and strands from one or more wood materials. The composite panel is prepared by mixing bamboo strands with the conventional wood strands. As discussed in greater detail below, the bamboo strands may be intermixed throughout the layers of the wood composite material or alternatively the strands may be concentrated only in the surface layers where they make a more direct contribution to the strength of the material. Thus, the composite material of the present invention has many advantages of the bamboo material, such as strength, while also being lighter and more resistant to water damage and water-caused swelling.

[0012] Like wood materials, bamboo's basic components are cellulose fibers bonded together by lignin polymer, but bamboo differs from other wood materials in the organization and morphology of its constituent cells. Generally, most strength characteristics of bamboo (tensile strength, flexural strength and rigidity) are greatest in the longitudinal direction of the bamboo and the bamboo fibers. This is due to the relatively small micro-fibrillar angle of the cellulose fibers in the longitudinal direction. The hardness of the bamboo culm itself is dependent on the density of bamboo fibers bundles and their manner of separation. The percentage of fibers does not consist either in the longitudinal direction of the bamboo culm or in a cross section of the culm. In the longitudinal direction, the density of fibers increases from the bottom of the culm to its top, while the density of fibers in the bamboo culm cross-section is highest closer to the outer surface and decreases going deeper into the core of the material.

[0013] In the present invention the bamboo strands are preferably cut into thicknesses of less than about 0.2 inch, such as less than 0.15 inches, such as in the range of about 0.01 inches to about 0.15 inches; and cut into widths of preferably greater than about 0.1 inches, such as more than about 0.15 inches, such as more than about 0.5 inches. This cutting may be done either manually or with mechanized clipping equipment. For purposes of improved strength the bamboo strands should be cut along the longitudinal axis into strands preferably longer than about 2 inches, such as about 3 inches, such as about 5 inches. While not intending to be limited by theory, it is believed that the longer strip length will result in more closely aligned strands when the strands are oriented using a disk strand orienter, and without being limited by theory, it is believed that more closely aligned strands will result in a final wood composite board product that has an improved modulus of elasticity along the longitudinal axis.

[0014] After being cut, the bamboo strands are dried (as described below) and coated with isocyanate polymeric resin. The binder concentration of the isocyante resin is in the range of about 2 wt % to about 12 wt %, based on the dry weight of the bamboo. One or more isocyanate binder resins may be used, preferably the isocyanates are selected from the diphenylmethane-p,p'-diisocyanate group of polymers, which have NCO— functional groups that can react with other organic groups to form polymer groups such as polyurea, —NCON—, and polyurethane, —NCOON—; a binder with about 50 wt % 4,4-diphenyl-methane diisocyanate ("MDI") or in a mixture with other isocyanate oligomers ("pMDI") is preferred. A suitable commercial pMDI product is Rubinate 1840 available from Huntsman, Salt Lake City, Utah, and Mondur 541 available from Bayer Corporation, North America, of Pittsburgh, Pa. Also suitable for use are phenol formaldehyde ("PF"), melamine formaldehyde, melamine urea formaldehyde ("MUF"), urea-formaldehyde, polyvinyl acetate ("PVA"), and the co-polymers thereof. Suitable commercial MUF binders are the LS 2358 and LS 2250 products from the Dynea corporation.

[0015] A wax additive is commonly employed to enhance the resistance of the bamboo strands to moisture penetration. Preferred waxes are slack wax or an emulsion wax. The wax solids loading level is preferably in the range of about 0.1 wt % to about 3.0 wt % (based on the weight of the bamboo).

[0016] As used in the present invention, the bamboo is mixed with strands cut from naturally occurring hard or soft woods, singularly or mixed, whether such wood is dry (having a moisture content of between 2 wt % and 12 wt %) or green (having a moisture content of between 30 wt % and 200 wt %). Suitable soft and hard wood species include cedar, pine, fir, aspen, oak, maple, and other species as well. Typically, the raw wood starting materials, either virgin or reclaimed, are cut into strands, wafers or flakes of desired size and shape, which are well known to one of ordinary skill in the art. The bamboo strands and the hard/soft wood strands are each separately dried and coated with polymer resin binder, and then after the separate coating stages the coated hard/soft wood strands and coated bamboo strands are admixed together.

[0017] The binder resin and the other various additives that are applied to the wood materials are referred to herein as a coating, even though the binder and additives may be in the form of small particles, such as atomized particles or solid particles, which do not form a continuous coating upon the wood material. Conventionally, the binder, wax, and other additives are applied to the wood materials by one or more spraying, blending or mixing techniques, a preferred technique is to spray the wax, resin, fungicide and other additives upon the wood strands as the strands are tumbled in a drum blender.

[0018] After being coated and treated with the desired coating and treatment chemicals, these coated strands are used to form a multi-layered mat, preferably a three layered mat which is then pressed to form a composite wood component. This layering may be done in the following fashion. The coated flakes are spread on a conveyor belt to provide a first ply or layer having flakes oriented substantially in line, or parallel, to the conveyor belt, then a second ply is deposited on the first ply, with the flakes of the second ply oriented substantially perpendicular to the conveyor belt. Finally, a third ply having flakes oriented substantially in line with the conveyor belt, similar to the first ply, is deposited on the second ply such that plies built-up in this manner have flakes oriented generally perpendicular to a neighboring ply. Alternatively, but less preferably, all plies can have strands oriented in random directions. The multiple plies or layers can be deposited using generally known multi-pass techniques and strand orienter equipment. In the case of a three ply or three layered mat, the first and third plys are surface layers, while the second ply is a core layer. The surface layers each have an exterior face.

[0019] The above example may also be done in different relative directions, so that the first ply has flakes oriented substantially perpendicular to conveyor belt, then a second ply is deposited on the first ply, with the flakes of the second ply oriented substantially parallel to the conveyor belt. In the present invention, the longitudinal edge of the board is formed parallel to the conveyor belt, so that flakes oriented substantially parallel to the conveyor belt will be oriented substantially arranged substantially parallel to the conveyor belt, will end up being substantially parallel to the longitudinal edge of the final wood panel product. Finally, a third ply having flakes oriented substantially perpendicular with the conveyor belt, similar to the first ply, is deposited on the second ply.

[0020] An important aspect of the present invention is the distribution of the bamboo strands throughout the wood panel. The bamboo strands may be evenly distributed throughout the wood panel, located in all three plies. Alternatively, the bamboo strands may be instead be located only in the surface layers. When the bamboo strands are located solely in the surface layers, they are there in order to affect the basic and novel properties of the surface layers such as strength and material weight. [This sentence is for legal purposes]

[0021] After the multi-layered mats are formed according to the process discussed above, they are compressed under a hot press machine that fuses and binds together the wood materials, binder, and other additives to form consolidated OSB panels of various thickness and sizes. The high temperature also acts to cure the binder material. Preferably, the panels of the invention are pressed for 2-15 minutes at a temperature of about 175° C. to about 240° C. The thickness of the OSB panels will be from about 0.6 cm (about ¼") to about 5 cm (about 2"), such as about 1.25 cm to about 6 cm, such as about 2.8 cm to about 3.8 cm.

EXAMPLES

[0022] Composite panels were made according to the prior art and the present invention as follows. Bamboo strands were cut on a CAE disk flaker to an approximate size of 0.032 inch by 3 inches by 6 inches. Pine flakes were made under normal stranding conditions to a size of 0.032 inch by 3 inches by 5 inches. The strands were then mixed together in ratios of 75:25, 50:50, and 25:75 of pine to bamboo (see

Table I, below). In the tables below it is noted as to whether the bamboos is distributed throughout the material, or whether the bamboo strands are found in the surface layers only. In all cases, the core constituted 40% of the weight of the composite panel, while the surface layers constituted 60%. A resin concentration of 5% MDI was used along with the wax concentration being 1.5%. The panels were pressed at 400° F. for 175 seconds at 200+ PSI to a target density of 44 pcf and a target thickness of ¾ inch thick.

[0023] The panels were then tested for several different wood composite performance characteristics according to the protocol specified in ASTM D1037. These performance characteristics included Modulus of Elasticity ("MOE", a measure of panel stiffness) in both the parallel and the perpendicular directions (with the results then averaged); Modulus of Rupture ("MOR", a measure of panel strength) in both the parallel and the perpendicular directions (again, the results were then averaged); 1 inch thickness swell, and edge swell.

[0024] The results were as follows.

TABLE I

Ratio: Pine/Bamboo	Thickness Swell (at 1")	Edge Swell
100/0	5.2	9.2
75/25	5.4	9.8
50/50	4.1	8.4
25/75	3.8	7.3
0/100	8.3	11.3
100/0	5.2	9.2

[0025] As can be seen in table I, the addition of pine greatly reduced the amount of swelling that an all-bamboo panel showed. In fact, the best performance was obtained when an even mixture of pine and bamboo strands was used. The measurements obtained were somewhat different depending on whether they were made at the edge or at a distance of 1 inch from the edge, toward the interior of the sample as required by ASTM D1037, but for both measurement methods the overall trend was exactly identical.

TABLE II

Average MOE of Samples		
Ratio: Pine/Bamboo	Bamboo strands distributed throughout material	Bamboo only in surface layers
100/0	848307	848307
75/25	896859	876046
50/50	935900	917397
25/75	1109851	1034548
0/100	1117454	—

[0026]

TABLE III

Average MOR of Samples		
Ratio: Pine/Bamboo	Bamboo strands distributed throughout material	Bamboo only in surface layers
100/0	5625	5625
75/25	3990	4351
50/50	6070	6503
25/75	6891	6538
0/100	7923	—

[0027] As can be seen in tables II and III, the addition of bamboo to form a panel made of a blend of bamboo and pine strands significantly improves the strength of the panel compared to the strength of a panel that is 100% pine. This was true when strength was measured both by MOE and MOR.

[0028] It will be appreciated by those skilled in the art that changes could be made to the embodiments described above without departing from the broad inventive concept thereof. It is understood, therefore, that this invention is not limited to the particular embodiments disclosed, but it is intended to cover modifications within the spirit and scope of the present invention as defined by the appended claims.

We claim:

1. A panel comprising bamboo strands and wood strands.

2. The panel according to claim 1, wherein the panel contains about 25% to about 75% bamboo strands, and about 75% to about 25% wood strands.

3. The panel according to claim 1, wherein the panel includes an upper surface layer, a lower surface layer and a core layer, wherein the bamboo strands are located exclusively in the upper surface layer and a surface layer.

4. The panel according to claim 1, wherein the panel includes an upper surface layer, a lower surface layer and a core layer, wherein the upper surface layer, and the lower surface layer consist essentially of bamboo strands and wood strands, and the core layer consists essentially of wood strands.

5. The panel according to claim 1, wherein the wood strands are selected from the group comprising cedar, pine, fir, aspen, oak, and maple.

6. The panel according to claim 1, wherein the wood strands are pine strands.

7. The panel according to claim 1, wherein the panel is in the form of OSB.

8. A panel comprising: (1) about 25% to about 75% bamboo strands, (2) about 75% to about 25% pine strands, and (3) a binder resin.

9. The panel according to claim 8, wherein the binder resin is an isocyanate resin.

10. The panel according to claim 1, wherein the panel contains about 25% to about 75% bamboo strands, and about 75% to about 25% wood strands, and wherein the panel includes an upper surface layer, a lower surface layer and a core layer, wherein the upper surface layer, and the lower surface layer consist essentially of bamboo strands and wood strands, and the core layer consists essentially of wood strands.

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