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METHOD OF MAKING WET FELTED BOARD OF FIBER BUNDLES AND FLAKES

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This application is a continuation-in-part of application Serial Number 87,550, filed February 7, 1961, and now abandoned. This invention relates to a wet felted particle board, and a method of producing this board.

Particle boards, sometimes also known as chip or flake boards, are well known on the market, and are made up mainly of resin and wood particles, such as shavings, chips, flakes, strands and the like. These boards have good dimensional stability and fair technical properties regarding nail and screw holding, and workability, such as cutting, drilling, sanding, etc. The technical properties depend upon the amount of resin present in the board, the type of wood particles used and the density of the board. The particles are bonded together only by the function of the resin and therefore a high amount of resin, usually from 5–10% resin solids, based on the dry weight of the particles, has to be used. This high amount of resin adds to the cost and has been found to be hard on cutting elements of tools, such as planer knives, chisels and saws. The boards are produced in a dry process with specifically designed equipment which cannot be used for other purposes. The particles with resin are formed into a mat which is transported on cauls or trays to the press. Another disadvantage of particle board is the quality of the surface. The boards are generally sanded but even then, the large size of the particles leaves voids between them which affects the paintability and appearance. Another disadvantage of particle boards is the necessity to dry the particles to a predetermined moisture content before making the boards.

Standard wet felted hardboard is comparatively inexpensive to produce, and has adequate technical properties regarding nail and screw holding and workability. This hardboard consists of suitable cellulosic materials which has been defibrated by one of several well-known processes, the fibres so produced being formed into mats by the commonly known wet felting process in a Fourdrinier machine or a deckle box, after which the mats are pressed into boards. The cellulosic material may be wood, bagasse, straw and the like. The normal density of such boards is approximately from 50 pounds per cubic foot up to 66 pounds per cubic foot. Softer boards of lower density are made, but these have poor technical properties, especially with regard to workability.

The standard wet felting process is normally used to produce hardboard up to about 5/16 inch in thickness. It is not practical to go much above 5/16 inch thickness because the wet lap necessary to produce a board beyond this thickness is too thick. As the thickness of the wet lap is increased, the drainage time and pressing time greatly increase beyond the practical point. On the other hand, an advantage of the wet felting process is that the wet lap after an initial pressing is selfsupporting and therefore easy to transfer to the press.

The main object of the present invention is the provision of a low density board in a comparatively inexpensive manner and having good technical properties, that is, good nail and screw holding properties and good workability.

Another object is the provision of a wet felted board having very good dimensional stability.

A further object is the provision of a wet felted particle board having a smooth surface without the necessity of sanding, and better paintability than standard particle board.

A further object is the provision of a method of making a particle board without the use of binders, or with very small percentages of binders.

A further object is the provision of a particle board without the necessity of pre-drying the wood particles.

A further object is the provision of a particle board provided with a pre-finished surface consisting of fine fibres.

Another object is the provision of a method of making wet felted particle boards utilizing standard board felting apparatus so that a manufacturer may make either standard wet felted hardboard, or the present wet felted particle board with the same apparatus.

A wet felted particle board according to the present invention consists essentially of substantially uniformly distributed and consolidated ligno-cellulosic fibre bundles containing their natural lignin which was previously softened by heat and moisture, and solid ligno-cellulosic flakes in their natural state, said bundles and flakes being randomly arranged, whereby the fibrous nature of the bundles and the lignin thereof assist in retaining the bundles and flakes in consolidated form and the solid nature of the flakes reinforce the board and provide the latter with dimensional stability and good nail and screw holding ability.

The ligno-cellulosic fibre bundles mainly comprise groups of fibres which have not been separated from each other and extend longitudinally of the bundles. These bundles are of different sizes and of different numbers of fibres, even down to one fibre. They are of the type and size generally used in the production of hardboard. The cellulosic material, usually wood, has previously been treated in any suitable manner by heat and moisture to soften the lignin thereof before defibration, but not sufficiently to remove any lignin or damage the fibres. Ordinary chemical wood pulp is not suitable since a large percentage of the lignin has been removed therefrom. Normal mechanical groundwood is not suitable because it contains a very high percentage of short broken fibre bundles. It has been found that fibre bundles are ideal for this purpose which have been produced by subjecting chip to high temperatures and steam, followed by defibration without removing natural lignin or damaging the fibres, such as the processes known in the industry as Masonite steam gunmethod or Asplund method. The defibrated fibre bundles are further refined in order to produce bundles of a size suitable for the present board. It has been found that it is desirable to exclude bundles that are too coarse and those having very little fibre length. It is known that with hardboard, the finer the fibre, the higher the strength of the board. However, the use of very fine fibre bundles is not practical because the drainage time increases as finer fibres are used. Therefore, it is desirable to use in the present board fibre bundles of different sizes in order to

produce in an economical manner a board of comparatively high strength while utilizing a high percentage of the cellulose material which has been reduced to the fibre bundle form.

The following indicates the relationship and effect of fibre bundles of different sizes. For each test, ten grams of dry fibre bundles which had been further refined after the Asplund process were passed through a fibre classifier.

Screen Mesh	Retained on Screen, Percentage of the 10 Grams	
	"A"	"B"
8	22.4	35.2
14	26.8	22.6
28	22.5	20.4
65	11.3	11.8
Through last screen	17.0	10.0
Total	100.0	100.0

Type "A" is the finer fibre and is preferred for use in the wet felted particle board. For practical purposes, type "B" is about the upper limit of the amount of coarse fibre bundles that may be used without material affecting the characteristics of the final board.

The flakes are small particles of ligno-cellulosic material, usually wood, in its natural state wtih the grain essentially parallel to the surface thereof. These are more dense than the fibre bundles, and therefore give the final board a degree of solidity and render it dimensionally stable. Although wood is preferred, the particles may be made of bagasse, straw and the like. The flakes are formed by mechanical means and, therefore, are in solid form. It has been found that very good results are attained by using cedar flakes since cedar naturally includes bonding constituents which are not available in most other wood. In addition to this, shingle hay, a waste product from the manufacture of cedar shingles and shakes, is good for this purpose since it is stringy, and only requires to be milled into suitable lengths. Cedar flakes have high self-bonding properties, and a high affinity for phenolic resin. California redwood has similar properties to cedar in this respect, and therefore, is well suited for this purpose.

The flakes should be in string-like form and of a thickness from about 0.011 to 0.025 inch, of a width of about 1/16 to 1/2 inch, and of a length from about 1/4 to 1 1/2 inch.

In general terms, the process of forming the wet felted particle board comprises mixing the ligno-cellulosic fibre bundles and ligno-cellulosic particles in a slurry, directing the slurry on to a foraminous sheet and subjecting it to an initial press to form a wet lap, and finally pressing into a board of a desired thickness and density in a hot press. For certain end uses, a board can be produced without the addition of any binder, the felting effect of the fibre bundles acting as a binder. If improved properties are required, a comparatively small amount of resin may be added, and it has been found that a maximum of about 4% resin solids based on the dry weight of the board is all that need be used.

The process according to this invention is as follows:

(1) Form a slurry of ligno-cellulosic fibre bundles and ligno-cellulosic flakes. The bundles and flakes may be simultaneously or consecutively added to water to produce the slurry, but it has been found advantageous to form a normal slurry of the cellulosic fibre bundles, and to form a slurry of cellulosic flakes, after which the two slurries are thoroughly mixed to obtain a uniform distribution of the cellulosic bundles and flakes. Each slurry is governed by a consistency regulator and metered into a common mixing vat.

(2) If addition of resin is required, it is found to be necessary to add separately the proper amount to the fibre bundles and the proper amount to the flakes. The addition of the resin separately to the fibres and to the flakes is essential in order to prevent a large part of the resin being washed away and lost, to ensure complete coating of each fibre bundle and flake throughout the mat, and an even distribution of the resin in the mat.

(3) The finally mixed fibre-flake slurry is flowed on to a foraminous sheet, either a deckle box or a Fourdrinier wire and given an initial press to form a wet lap, and finally consolidated in a hot press.

The ligno-cellulosic fibre bundles used in this process have an affinity for resins, especially phenol-formaldehyde resins. The resin is added to the slurry containing the fibre bundles, and the slurry is acidified sufficiently to ensure precipitation of the resin on to the fibres. The acidification causes flocculation of the resin. The flocks are attached by the fibre bundles due to their affinity for the resin. Thus, the fibre bundles are coated with the resin. Some resin in flock form is distributed throughout the slurry and is mechanically carried by the fibre bundles into the final board. A large percentage of this free resin is retained in the board by the filtering action of the fibre mat during drainage on the formainous sheet.

The ligno-cellulosic flakes have very little affinity for the resin and therefore have to be treated differently from the fibre bundles. The best results have been attained by dipping the flakes into a 5 to 10% solids resin water solution. The retention of the resin on the flakes is regulated by the dipping time and the concentration of the solution. Surplus resin solution is drained off before the flakes are mixed with the fibre bundles. The resin penetrates into the surface of the flakes, and is fixed to the flakes as soon as the latter are brought into contact with the acidic slurry of the fibre bundles. From 80 to 85% of the original amount of resin is retained in a conventional fibreboard. Part of this resin is concentrated on the bottom surface of the board, having been retained there by the filtering action of the mat. This concentration of resin is undesirable since it unbalances the board, and represents a loss if this surface is planed or sanded. If wet felted particle boards were produced by the addition of resin into a slurry of fibre bundles and flakes, followed by acidification, a considerable amount of resin would be lost because of the low affinity of the flakes and the decreased filtering action of the faster-draining mat. The separate application of the resin to the flakes, as mentioned above, results in a larger percentage of resin being retained in the board, and the accumulation of the resin at the lower surface of the board reduced.

The ratio of fibre bundles to flakes is preferably about 50–50 but it can be varied from approximately 15% of fibre bundles and 85% flakes correspondingly to approximately 85% fibre bundles and 15% flakes. The finer the fibre stock, the better felting effect is achieved, and better board properties attained. In the standard production of hardboard, the fineness of the fibre stock is governed by the required freeness of the slurry in order to gain the shortest drainage time possible consistent with the properties desired in the hardboard. However, the flakes which are uniformly distributed throughout the wet lap provide for very good drainage of the latter because of their generally larger size than the fibre bundles. The mixture of fibre bundles and flakes has such a short drainage time that a relatively high percentage of fine fibres may be used without materially affecting the economics of the production of the board.

The surface of the board can be improved simply by the addition, prior to the final pressing operation, of a thin coat of fine cellulosic fibre, such as, for example, groundwood. The added fine fibres may be in dry form, but it is preferable to have them wet as is the case of groundwood pulp so that the fibres may be sprayed on to the board surface. This coat serves as a sealer and pro-

vides an extremely good paintable surface. Furthermore, this pulp can be colored either by dyes or pigments to provide the panel with a decorative pre-finished surface. Resin and oils may be incorporated into this pulp to increase the wear resistance of the surface as well.

A board produced by the above process has good dimensional stability similar to standard dry formed particle board. The fibre bundles being interlaced form a mat in the board while the flakes give it strength and stability in all directions. As these flakes extend in different directions throughout the mat, they tend to resist warping due to changes in atmospheric conditions. The finished board has a very smooth surface, much smoother than standard dry formed particle boards, since the cellulose fibre bundles fill the voids between the cellulose flakes at said surface. Thus, no sanding is required after the pressing operation, as is the case with standard particle boards. As the present board has considerably less adhesive in it than ordinary particle board, it provides a better surface for painting, staining and the like. For the same reason, the wet felted particle board is easier to plane, chisel and saw than a dry formed particle board. Paintability of the surface is improved by providing the boards with a coat of groundwood pulp previous to hot pressing. In addition to this, the present board has a decorative appearance because of the cellulose flakes scattered therethrough and, therefore, is more salable for many purposes than standard hardboard. The density of this board may be less than standard hardboard, but it has good nail and screw holding properties since the latter are gripped by the comparatively solid cellulosic flakes.

A great advantage of this wet felted particle board is the versatility of the equipment which can be used for the production of normal wet felted hardboards or the wet felted particle boards of this invention. Furthermore, it requires considerably less adhesive than the dry formed particle boards, since the felting of the fibres adds to the strength of the board.

The present board has an advantage over normal hardboard since the former drains on the foraminous sheet much quicker than the latter. It has been found that a standard hardboard fibre tested on an Asplund Freeness Tester registered 17 to 18 seconds drainage time. The same fibre mixed in a ratio of 50–50 with flakes registered only 14 second drainage time, a time saving of from 17 to 22%.

The following chart indicates the effect on the strength of the final board of different percentages of fibre bundles and flakes, and the improvement resulting from the use of cedar flakes:

	Cellulosic Material	Modulus of Rupture (lbs. per sq. in.)	Density (lbs. per cu. ft.
A	Refined Douglas Fir Asplund Fibre (1.5% resin solids).	2,810	41.5
B	50% cedar shingle hay flakes, 50% Douglas fir fibre bundles (1.5% resin solids).	2,866	41.5
C	80% cedar shingle hay flakes, 20% Douglas fir fibre bundles (1.5% resin solids).	2,270	41.5
D	70% Douglas fir flakes, 30% Douglas fir fibre bundles (1.5% resin solids).	1,000	41.5
E	50% Douglas fir flakes, 50% Douglas fir fibre bundles (1.5% resin solids).	1,700	41.5

It will be noted that the board B having an equal amount of cedar flakes and Douglas fir fibre bundles has practically the same modulus of rupture as the board A made from fibre bundles alone. When the amount of cedar flakes is increased relative to the amount of fibres in board C, the modulus of rupture drops. When Douglas fir flakes are substituted for the cedar flakes, the modulus of rupture drops further, and this even when the percentage of fir flakes is less than the cedar flakes.

The following examples illustrate the effect of variations in the cellulosic fibre bundles and cellulosic flakes:

Example 1

Raw materials:
50% Douglas fir fibre bundles
50% Douglas fir flakes (by Pallman flaker from chips)
Chemicals: 0.75% wax solids
Modulus of rupture: 990 lbs. per sq. in.
Density: 44 lbs. per cu. ft.

Example 2

30% Douglas fir fibre bundles
35% cedar shingle hay flakes
35% flakes (other woods)
0.3% phenolic resin precipitated
Acidified to pH 4.5
Modulus of rupture: 1317 lbs. per sq. in.
Density: 43.3 lbs. per cu. ft.

Example 3

Same as Example 2, but 0.45% phenolic resin added
Modulus of rupture: 1794 lbs. per sq. in.
Density: 46.9 lbs. per cu. ft.

Example 4

50% Douglas fir fibre bundles
50% cedar shingle hay flakes
1.5% phenolic resin precipitated
Modulus of rupture: 2866 lbs. per sq. in.
Density: 41.5 lbs. per cu. ft.

Example 5

Flakes, fibre bundles and phenolic resin mixed together then acidified in a slurry:
50% flakes
50% fibre bundles
2% phenolic resin solids
0.75% Paracol wax
Acidified to pH 4.5
Modulus of rupture—1,250 lbs. per sq. in.
Density—37.7 lbs. per cu. ft.

Examples 2 and 3 prove the influence of the resin in a board comprising 70% flakes and 30% fibre bundles. Examples 4 and 5 show the superiority of cedar flake over flakes of other wood, even with a smaller amount of resin.

Example 6

60% shaving flakes
40% fibre bundles
Shaving flakes dipped into 3.5% resin solids solution, then drained and transferred to the acidified fibre slurry. Approximately 3.6% solid phenolic resin absorbed by the flakes.
Modulus of rupture—2255 lbs. per sq. in.
Density—37.7 lbs. per cu. ft.

Example 7

50% Douglas fir fibre bundles
50% flakes
5% phenolic resin precipitated in bundle and flake slurry
0.75% Paracol wax
Modulus of rupture—2135 lbs. per sq. in.
Density—37.7 lbs. per cu. ft.

Examples 6 and 7 prove the superiority of applying the resin to the flakes separately and by dipping.

What we claim as our invention is:

A method of making particle fibreboard comprising forming a slurry, the solid contents of said slurry consisting essentially of ligno-cellulosic fibre bundles containing their natural lignin which was previously softened by heat and moisture mixing a resin binder in said slurry to coat the fibre bundles and acidifying the slurry to render the resin insoluble, thoroughly mixing solid ligno-

cellulosic flakes in their natural state with a resin binder solution, adding the resin coated flakes to the acidified slurry, the resin of the flakes being rendered insoluble by the acidity of the slurry, the solid contents of the final slurry consisting essentially of from about 15 to 85% of fibre bundles and correspondingly from about 85 to 15% of flakes, mixing said slurry to uniformly distribute said cellulosic bundles and flakes therein, forming a mat by felting and draining the mixed bundles and flakes on a foraminous support, and hot pressing the mat to form a sheet.

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