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MANUFACTURE OF GLAZED HARDBOARD

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The present invention relates generally to the manufacture of consolidated fiber bodies by hot-pressing fiber felts, and more particularly to the use therein of air-laid felts characterized by lack of an appreciable quantity of water expressible from the felt during hot-pressing, with special reference to a desirable surface effect produced by the controlled application and use of water.

Heretofore, such products have been made by forming water-laid felts, pressing these to express excess water and thereby leaving wet felts, then pressing and consolidating the wet felts with or without added binder in a press employing heat and pressure. In this so-called "wet" process a serious deficiency is the loss of water-soluble material of the original fiber stock to the white water which is drained away in forming the wet felt. When the wet felt is subjected to the initial stages of hot-pressing, the moisture content is such that there is an appreciable amount of water squeezed out of the felt, and this water carries away an additional quantity of water-solubles. Nevertheless, one advantage accruing from such losses of water-solubles is minimizing the danger of staining the product in hot-pressing, as will appear hereinafter, and as such is purposely included as a process step by many manufacturers. The loss of solubles, however, is uneconomic and desirably to be minimized and preferably avoided, because of lowered product yield and particularly to avoid loss of the bonding properties of the solubles. The processing costs are high when using water in felting. Because of the high content of residual water in the felt to be hot-pressed, and because substantially all of the water present in the mat must be removed in part by expressing it or wholly or in part by volatilizing it, high costs are encountered in the manufacture of a hot-pressed product.

There are ways to overcome one or more of these disadvantages. Improved yield of product is achieved by use of fiber in which a large proportion or all of the water-solubles have been retained, and in particular by use of fiber which contains substantially all the substance of the natural lignocellulose from which the fiber is derived. The common case is wood, from which such fiber may be prepared in numerous ways. Loss of solubles by being expressed with the water in felt formation may be obviated by forming the felt in the absence of suspending water, as by air-laying it. Numerous methods and apparatus are available for such practice. Any selected procedure may dictate a range of and a favorable value for the moisture content of the fiber to be felted, or of the resulting felt. The use of whole natural lignocellulose and the air laying technique are sometimes combined.

Therefore, preferred practice in production of consolidated fiber products calls for directly hot-pressing an air-

laid felt of fibers containing moisture but not wet with water. By the expedient of using air-laid felts the moisture in the fiber may readily be maintained sufficiently low, to avoid expressing liquid in the consolidation process. However, doing so leads to a deficiency of water at smooth platen areas in a hot press so that the resulting surface formed against a smooth platen or caul face is a fibrous matte surface. Consequently, for avoiding such a matte surface, a higher moisture content may be tolerated along with a possible loss of but a small fraction of the water-solubles.

In so consolidating air-laid felts of the character described, namely, those containing fibers having water-solubles in natural proportion, or in augmented proportion where limited steaming of the wood substance has been practiced, the pressing conditions used heretofore have been such that staining of the matte face or faces to an undesirable extent has resulted. Small sized felts, for example, may be consolidated without staining when using a procedure which effects staining of larger sized felts. Such staining is a serious problem encountered in the commercial manufacture of a consolidated product of conventional four-foot width. As will appear hereinafter, the factors causing or permitting stain include distance inwardly from exposed edges of a felt in the process of consolidation. Increasing the moisture content of the felt increases the tendency to stain, other factors remaining constant. One means used by board manufacturers to minimize staining where steam treatment of the wood substance has been employed to facilitate preparation of the fiber from wood, has been so to control and limit the steaming that creation of water-solubles in the felt is minimized.

It has also been observed that increasing the total moisture content of felts, in addition to effecting stain, may be carried out in such a way and to such an extent that it not only increases the stained area but changes the unstained matte areas to a smooth glazed surface if a smooth platen or caul face is employed.

There is considerable evidence to indicate that both the staining and the glazing result from the presence in the felt being pressed of an aqueous solution of the water-soluble material. The surface glazing is desirable, but surface staining is undesirable.

The present application is a continuation-in-part of my prior application Serial No. 391,392, filed November 10, 1953, now abandoned.

In the copending application of G. B. Matter, Jr., Serial No. 391,381, filed November 10, 1953, now abandoned, and in a continuation-in-part thereof, Serial No. 467,625, filed November 8, 1954, there is described a method of avoiding the staining of the surface when using air-laid moist felts. It aims to minimize or prevent loss of water-solubles by minimizing or obviating the expressing of liquid from the felt during hot-pressing, and to this end prescribes a total moisture content not over 40%. When the air-laid felt is formed so as to have a uniform moisture content of about 15%, the surface is matte and may be stained unless the method of the applications above referred to is employed. Increasing the uniform moisture content of said air-laid felts to over 40% increases the tendency to stain, but when the increase is such as to give also the desirable glaze, too much water is expressible in the pressing operation with an undesirable loss of water-solubles.

The present invention is directed to the production of glaze on one or both faces of a consolidated felt having

densities upwardly from about 50 lbs. per cu. ft. Practically, the invention may not be carried out under all conditions with disregard of staining. The steps taken to effect glaze include retention and augmentation of water-solubles deriving from the wood, increase in total moisture content, and localization of free water at a face to be glazed. These steps enhance the tendency to stain, as does increase of size of the felt such as to increase the distance inwardly from exposed edges of the felt. Accordingly, the invention in its broadest aspect may be practiced to produce unstained glazed areas, with or without continuity with stained glazed areas. In its more specific aspect to produce consolidate products of relatively large size with a glazed face or faces entirely free from stain, it is practiced in combination with the invention set forth in said Serial No. 391,381 and its continuation-in-part.

It is a general object of this invention to effect an improved face on a consolidated felt by pressing the fibers thereof while wet with water as a plasticizer and lubricant of the fibers in consolidation.

It is the general object of the present invention to employ for consolidation a felt of fibers which contain water-solubles, to effect the consolidation without loss of an effective quantity of water-solubles to produce glaze on one or both faces, with or without staining of interior portions of the face of the product.

It is a specific object of the invention to employ for consolidation a felt of fibers which contain water-solubles, a substantially non-expressible amount of water for a particular consolidating process, and a localization of part of that water as free water at a surface to be glazed, and to employ a consolidating procedure as to time, temperature and mechanical pressure which is dictated by the dimensions of the felt so that the glaze-inducing factors do not result in staining the glazed face.

It is a particular object of the invention to employ air-laid felts having as formed a uniform moisture content in a range well below 40%, and to increase the total moisture content toward said upper limit of 40% by adding water to the face or faces of the felt which are to be glazed faces, and then while said water actually wets the fibers at the treated face, consolidating the felt in a hot press in a manner to avoid staining.

It is a particular object of the invention to use air-laid felts of whole wood fiber containing water-solubles of wood origin which are natural to the wood, and permissibly to augment said material amount by action of steam to assist in forming a glaze coat and so to conduct the hot-pressing operation that staining of the glazed face is avoided.

It is a particular object of the invention to use air-laid felts of wood fibers containing substantially all the organic material of the wood from which the fibers are derived, which felts are so limited in total moisture content that in the compression for consolidation, substantially no water is expressed, whereby substantially all the water-soluble content deriving from said wood is preserved for its bonding function in the consolidation, and in part for forming a glaze coat.

It is still another object of the invention to use such air-laid felts of which the interior is moist with capacity for holding more moisture without becoming wet, and in which a surface selected to become a quality face is wetted by controlled addition of water just before the hot-pressing.

Various other and ancillary objects and advantages of the invention will appear from the following description and explanation.

The preferred and commercial practice of the present invention to prevent staining. Since both the stain and the glaze result from aqueous solution in the felt being consolidated, deriving in part at least from moisture in the fibers with or without added water and from the water-soluble content of the fibers employed, both inventions are herein explained together.

In brief, the practice to prevent staining involves the use of controlled times and pressures in a hot press, to effect loss of water content as vapor, thereby to avoid heating any pocketed solution to its boiling point where the consequent pocketed steam pressure pushes solution through the felt with resultant staining.

The invention has been more completely practiced with fibers of Douglas fir and of white fir (*Abies concolor*) prepared in the Asplund defibrator by the process of U. S. Patent No. 2,008,892, which involves the presence of steam and incidentally the generation of water-solubles in amount generally increasing as the time or temperature or both, of the exposure to steam increases. It has also been practiced on fiber prepared mechanically from raw wood with no treatment to increase its content of water-solubles above the natural content. In both cases, the water-solubles have an interfiber bonding effect which is pronounced. The degree of interfiber bonding may be further increased if desirable by use of added binders, such as thermosetting resins. Such added binders are expensive. However, usage of such added binder may be appreciably minimized by special endeavor to increase the content of water-solubles deriving from the wood itself and by preserving the same with the fibers for use in the consolidation. Heretofore, water-solubles in the fiber mat have been minimized to avoid surface staining which they cause as a result of consolidation by hot-pressing.

The steaming time in the normal Asplund defibration is relatively short. In this process as it is commercially practiced to produce fiber economically from Douglas fir, for example, the steam pressure is in the range from 50 to 200 p. s. i. g. (pounds per square inch gauge pressure) and the wood substance is exposed to it for a time usually of about one minute, but permissibly from 6 to 0.5 minutes, respectively, but not over 2 minutes at 200 p. s. i. g. In the Asplund process wood chips are fed into a high pressure steam chamber wherein the chips are quickly softened, and wherein the softened chips are mechanically rubbed to fiber by relatively rotating disks. From the periphery of these disks the fiber is discharged to a gaseous atmosphere of low steam pressure or to the atmosphere.

The time and temperature of the steaming in the said defibrator advantageously may be each or both increased in order to increase the water-solubles deriving from the wood itself, being careful, however, to shorten the maximum time as temperature increases so as to avoid at 200 p. s. i. g. (388° F.) an exposure of over 2 minutes. These are about the critical conditions for gasifying and losing wood substance by generation of furfural and other non-bonding chemical substances, which conditions also lead to dark colored fiber. Neither the sequence nor concurrency of steaming and defibering is critical. One may follow the other, but the Asplund process is preferred.

Such fibers are then air-laid to a felt by any suitable process, with moisture control at any appropriate stage to yield mats having a uniform moisture content in the range from 8% to 35% by weight. The lower limit is imposed arbitrarily to facilitate felting and to eliminate deleterious effects such as those caused by static electricity. The upper limit is imposed to permit increase of total moisture content by wetting one or both faces for hot-pressing to produce glaze. When the total moisture content exceeds 40%, it is very difficult to consolidate the felt by heat and pressure and retain sufficient water-solubles to effect glaze, because the amount of water lost by expression carries off too large an amount of the water-solubles. However, when the total moisture content is not over an amount in the range from about 24% to about 28%, and sometimes 30%, no water is lost from an assembly in a practical cycle of hot-pressing to form a board of about 64 lbs. per cu. ft. density, when the felt is located between a smooth caul and a wire

screen. So many factors are involved in determining that critical content of moisture at which water is expressed from the mat in hot-pressing, that it is not possible to specify a universal maximum.

By allowing a small loss of water-solubles as a result of some expression of water from the mat, a maximum of 40% moisture content is generally applicable. In fact, experience has shown that by wetting the fibers at a face to be glazed, the wetting being essential, loss of some water by expressing it from the assembly is difficult to avoid when a satisfactory glaze is produced. In practice for assemblies having a screen at one face and a smooth caul at the other, the total moisture content of the felt varies from 30% to 40%, in making boards having a density of 64 lbs. per cu. ft. The amount of water-solubles lost is generally of the order of 10% or less of the total content of water-solubles. By increasing the steaming action on wood by which water-solubles are created, the loss, even if greater, is easily compensated for.

Whether or not a felt contains "expressible water" in hot-pressing depends among other factors upon the total moisture content, upon its distribution, and also, importantly, upon the density and temperature of the felt at the critical point where expressibility comes into existence. The density and the temperature vary with the pressing cycle as to time, mechanical pressure, temperature, and rate of supplying heat. In addition to these factors, is the character of the assembly, such for example, as the presence or absence of a screen-facing against the felt being pressed. The particle-size-distribution of the felt contents is also important in controlling the volume ratio of capillary spaces to total volume. The previous history of the fibers, and the presence or absence of additives, such as water-resisting agents, affect the capacity of the fibers to hold water, and also the rates of absorbing it and of yielding it.

When a felt has a uniform distribution of its moisture content, the pressing process first heats the faces before heating the interior, with the result that volatilization of water from the faces increases the capacity of the face layers to take up water which might actually be expressed from the cooler interior. Such a felt as a whole may therefore contain an inexpressible content of water for a particular pressing cycle, even though the central layer thereof, if isolated, might lose water by expressing it therefrom. In the case where only one face of the felt lies against a screen and the other face is confined against a smooth caul, expressible water is lost earlier in a given pressing cycle (i. e., at a lower effective mechanical pressure) than in the case of an assembly of the same felt wherein both faces are confined against smooth cauls.

In the present invention wherein one or both of the face layers are sprayed so as actually to wet the fibers, a reduction of water content of the mat is likely first to take place at the wet face layer against a smooth caul. Generation of steam pressure at the more highly heated face layers tends to drive at least some of any locally expressed water toward the interior. Such water will move into the capillary spaces and also will be absorbed by the fibers which have capacity to absorb more water. Accordingly, the pressing cycle should be carried out sufficiently slowly to avoid reducing the capillary volume so fast that it cannot hold such water as may be expressed from wetted face layers against smooth cauls.

Each felt has a maximum capacity to hold water for each type of assembly and for each combination of mat density and temperature, but in a pressing cycle of the type herein employed, the mat temperature is not uniform as the density is changing. In every pressing cycle lacking the expression of water, all the water removed from the felt is lost as vapor. The pressing cycle must be carried out with regard to the variable factors in the mat assembly such as the screen face, the total moisture content and its distribution. These adjustments of conditions in a commercially practicable pressing cycle for limiting the loss of water for the purposes desired may be readily effected when the total moisture content does not exceed 40% by weight; and avoiding loss of water may be effected in such a cycle using assemblies with one screen and a wet face against a smooth caul and platen temperature of 360° F., when the total moisture content lies in the approximate range of 24% to 28%, and sometimes 30%, but such limitation does not mean that this range is an absolute criterion of inexpressible water for every possible pressing cycle.

For the highest quality of product it is important that the mat have substantially the same amount of wood substance at every unit area. This may be achieved by forming a mat substantially uniform in thickness, in density, and in moisture content. Variation in these factors within a mat, when conventional continuous hot-pressing technique is used easily leads to staining by forming in the press local areas of relatively higher resistance to flow of vapor through the mat. However, by practice of the present invention substantial deviations from uniformity may be permitted without resulting in staining, especially of the glazed face.

A typical mat ready for pressing has, for example, a uniform oven-dry fiber density of 3 pounds per cubic foot, is 2.6 inches thick, and has a uniform moisture content of 25%. Its fibers consist of whole wood substantially all in the form of ultimate fibers and opened up aggregates of ultimate fibers, as may be produced by the said defibrator process, with or without some additional size reduction of any content of larger sizes which may be so produced along with the ultimate fibers. Such a felt may be placed with one or both faces against smooth caul plates or heated platens for consolidation to produce one or two smooth faces in the resulting product.

Experience has shown that when these faces in panels having a density upwardly from 50 lbs. per cu. ft., which faces are so intended to be smooth, are made actually wet, as by spraying with water just before pressing, a desirable glaze is produced when using a smooth platen or caul plate. Otherwise, in mats not so wetted the face is duller, more matte in appearance and of a fibrous texture. The presence of free water among the surface fibers on initiating consolidation plasticizes the fibers and lubricates them to invite better meshing and consolidation to a molded face which is complementary to the contacting face acting thereon. In a pressing cycle of conventional continuous pressing, such a glazed face, and even such a matte face, is stained with areas of dark color and with much darker edges of the stained area. The stain is more extensive at wetted faces. The stained areas are located remotely from the edges. The said conventional practice involves heated platens having a temperature in the range from 300° to 450° F., preferably 400° F. In the practice of the present invention, the transmission of heat to the mat is controlled. This may be done by using insulated platen faces, or where the platen face is not insulated from its source of heat, imposing insulation between it and the felt being consolidated. The reasons for this will appear in connection with the explanation which follows.

A certain press having uninsulated smooth faced platens at 400° F. is operated on an horizontal assembly consisting upwardly of: carrying caul, insulating fiber sheet, metal caul plate, wire mesh screen, the typical mat above described with its top face wetted to provide a total moisture content for the mat to not over 40% by weight, smooth caul plate, and insulating fiber sheet. Every press has mechanical limitations which limit its flexibility. The press referred to will produce staining on the described assembly when operated to produce a board having a

density of 64 pounds per cubic ft. by the following time cycle:

Time to close onto an assembly, up to	15 seconds.
Time to compress assembly to reach 48 p. s. i.	5 to 10 seconds.
Time to compress at 48 p. s. i.	20 seconds.
Time to reach 750 p. s. i.	15 to 25 seconds.
Time to hold for cure at 750 p. s. i.	2 minutes.
Time to open press and remove assembly	Not significant.

The removed product in general will show a perimetric area at the facial edges of the panel (4 feet square) of excellent appearance having a glazed surface which is free from stain. Around the central area of the glazed face may be one or more small or large islands of stain, dark in appearance against the lighter edges, and much darker on the shores of the islands. The stain commonly extends from face to face, but not uniformly. Analysis shows the unstained glaze to be water-soluble, and the stained area to be higher in water-solubles than unstained area. It also shows the concentration of the water-solubles to be heaviest in the face layer of the stained area and decreasing inwardly. Studies of the conditions, and experiments to overcome such staining in arriving at the present invention, have led to a probable theory as to the mechanism of glazing and staining.

The following explanation is offered without any intention to become committed to it or that it be a limitation to be imposed on the present invention:

In the presence of moisture in the felt, the applied mechanical pressure and the retarded transmission of heat work together initially to change conditions in the mat. The pressure compacts the felt to a body of low porosity and of high resistance to flow of gas (air and steam) through it, as the heat slowly raises the temperature of the water content. The moisture and the free water of spraying are in part vaporized to steam within the previously compressed body, some vapor escaping through the edges, and much of it being partially confined within the body at increasing water-vapor pressure in directions inwardly from the edges. As the pressing continues, both vapor and aqueous liquid exist within the compressed body at increasingly higher temperatures as the distance inwardly from the edges increases, the liquid being increasingly solvent of material in the body as the temperature increases. The mat temperatures continue to build up after maximum mechanical pressure and minimum mat thickness have been achieved. As the temperatures build up, the vapor pressure at the areas near the edges is lower than centrally because of loss of steam edgewise and because of inwardly increasing resistance to loss of steam from the interior. Liquid in the edge areas may evaporate as fast as it acquires heat. However, centrally this is not so and the partially confined liquid becomes hotter at higher vapor pressure as the distance increases inwardly from the edges. When the boiling point is reached a steam pocket forms by boiling of the liquid, a condition indicated by a rapid but slight fall in temperature, as may be observed by an implanted thermocouple. The steam pocket tends to force surrounding liquid in all directions away from the pocket, and of course it moves further in the directions of least resistance. Why it goes to the smooth caul plate is next explained.

While the press is held closed to effect the cure, water vapor gradually escapes, evidenced by the fact that the high moisture or water content is drastically reduced and generally to less than 1% by weight in the case of high density boards of 60 to 70 pounds per cu. ft. There are three avenues of escape, namely, the exposed edges of the body, the body face on the screen, and the body face against the smooth caul plate. The evidence supports the statement that there is some facewise loss of vapor toward the smooth caul plate and a resulting escaping interfacial layer of water vapor between the caul plate and the compressed body. When a vapor pocket forms some liquid moves toward the smooth caul plate and into the interfacial vapor layer with outward spreading within said interface toward the edges, while most of it moves within the mat toward the edges and downwardly toward the screen. Because of the greater evaporation at the screen face, the interstitial bodies of fluid in the mat are more concentrated in solids toward that face, and hence less fluid. The water content of the moved fluid vaporizes more freely at the interface, being nearer the source of heat, and thus concentrates the solids therein as an area of stain. The edges of the liquid at the interface also vaporize water into the interface, drawing more of the liquid to replace it, thus leaving more residue to form the darker edges of the stain as described.

The vaporization at the smooth caul face takes place initially from the solution of water-solubles resulting from wetting the face. The wet face in drying draws more solution from within. Thus, a layer of solids deposited from a syrupy liquid of high solids content, forms at the face and finally dries as a film coat, which as a glaze mirrors the texture of the smooth caul.

In the preferred practice of the present invention, the assembly may be as above described, but as soon as the press has been closed to establish a density in the vicinity of final density, and preferably substantially final density and thickness, and before the mat has become uniformly heated throughout, the pressure is relaxed to a value such that the internal vapor pressure, highest in the generally stainable area, is relieved facewise from the mat toward the caul plate, where it escapes as the interfacial layer described. Sufficient water is thus removed from the body so that substantially no migrating quantity of interstitial fluid body remains. The required time and extent of such relief or reduction in mechanical pressure varies with numerous variable factors, such as board density, particle size, amount and kind of additives, and are readily determined by instruments or by cut-and-try methods for any set of fixed conditions. The release of water vapor need not be effected in a single continuous step, and may consist of a series of intermittent steps. Avoidance of a boiling condition internally prevents the staining and provides a uniform facial appearance on both sides, including the glazed face. By this procedure, deposited water-solubles remain in situ uniformly over the surface and do not migrate as a solution laterally in the interface.

Given any set of fixed conditions the time required to generate the said coercive steam pocket is readily to be found by use of an imbedded thermocouple. The described slight drop in temperature which results from its adiabatic expansion marks the critical time. Prior to this critical time, but after compressing the mat substantially to final density, the pressure is relaxed a predetermined amount but not wholly released for a time or times to bleed out excess vapor and to obviate flow of solution in the body.

Numerous factors predetermine the rate at which heat from the platens should be conducted to the mat. This may be controlled by insulation between the mat and the source of heat in the platen. Where a caul plate is used to control the texture of a mat face, transfer of heat to the mat must be delayed. This may be done by use of a cold thick caul, or an insulator, such as a wire screen, may lie between the caul plate and the source of heat. When there is a screen between the mat and the caul plate it functions also to facilitate removal of water vapor from the mat, and thus shortens the pressing cycle, but this assistance to exit of water vapor is not sufficient under conditions of continuous pressing to prevent staining on the opposite side against a caul plate, even in consolidated products only ⅛ inch thick.

In production practice the building of insulated assem-

blies to be pressed is avoided by incorporating insulation into the press. Thus, on a platen face directly heated from its interior, there is placed, for example, a wire mesh screen of chosen porosity and resistance to deformation in use, and this is capped by a suitably thick metal sheet, preferably smooth, which becomes the platen face which contacts the mat. Upper and lower platens may be insulated to the same degree or different degrees, according to the assembly to be used. With such insulated platens, the asssembly may be of at least two kinds. A board having but one smooth face (S–1–S meaning smooth on one side) is made from an assembly consisting vertically of supporting caul plate, wire mesh screen, and moist mat. A board having two smooth faces (S–2–S meaning smooth on two sides) is made from an assembly consisting vertically of supporting smooth caul plate and moist mat, presupposing in each case the upper insulated platen face to be smooth.

The following examples are suitable cycles for assemblies 52 inches square containing insulating sheets for the specific press above referred to, to change the result from a staining to a non-staining operation. The size of the assembly is given as it predetermines timing in the cycle, by predetermining the distance from the most remote point to an edge. The fibers are whole wood Douglas fir defibered in the Asplund defibrator at 160 p. s. i. g. in about 60 seconds, with added binder of about 1 part of phenol-formaldehyde resin solids per 100 parts of oven-dry fiber.

As is well known in the art, the heating in the press performs two functions among others. The primary function is to consolidate the mat. The second function is to reduce the moisture content. The final moisture content must be such that on opening the press the vapor pressure within the consolidated product will not rupture or blister the structure. In high density boards, the final moisture content must be lower than in similarly bonded boards of lower density. However, the kind and degree of bonding at each density of product predetermines the critical moisture content at which rupture or blistering may occur.

Although the following examples are based upon use of insulation in the press, the invention is not so limited. The idea is to retard the initial transmission of heat to the felt. Use of insulation between already heated platens and a felt between them, with or without relatively thin cauls, is merely a practical measure. Another expedient, eliminating insulation, is to place the mat between much thicker and cold metal cauls and then subject such assembly to compression between between already heated platens. The cold cauls must first be heated before the mat is effectively heated. The caul material, thickness and initial temperature are factors for regulation of heat transfer as desired. Another factor of like function is the addition, within limits as to quantity, of water at the face or faces of the mat. Another factor, related to both insulation and cauls having predetermined heat capacity to be satisfied, is the speed with which press platens act on the mat in reaching substantially the final thickness of intended consolidation. A less practical method is to compress directly between initially cold platens and then control the rates of heating of the platens and delivery of heat therefrom to the mat.

It is to be understood that it is not necessary for each face of the mat to be identically heated. For example, in a continuously used batch-type multi-opening press, the upper platen may be insulated, and the mat may enter upon a cold, thick metal carrying-caul.

Example 1 (S–1–S)

The assembly comprises a mat having a density of 3 lbs. oven-dry fiber per cu. ft. at 2.6 inches thickness, initially formed with 25% moisture content, and additionally sprayed on the face to be smooth with 155 ounces of water per 100 sq. ft., giving a total moisture content of 37.5%. The assembly consists of a carrying caul, a fiber insulating sheet, a bottom caul plate, a wire mesh screen, said mat, a smooth caul plate, and a fiber insulating sheet. The platens have a temperature of 400° F. The press has two rams, a light one to move it and a heavy one to exert the greater pressure. In operation the pressing is:

	Seconds
To eliminate open space between platens and assembly	15
To reach 48 p. s. i. with the light ram	5 to 10
To compress at 48 p. s. i	15 to 25
To increase pressure 750 p. s. i. with the heavy ram	20
To hold at 750 p. s. i	45
To relax pressure from 750 to 48 p. s. i	30
To hold at 48 p. s. i	30
To increase to 60 p. s. i	30
To increase to 80 p. s. i	30
To increase to 750 p. s. i	15
To hold at 750 p. s. i	45
To open and relieve all pressure	30

The product is a panel ⅛ inch thick having a density of 64 pounds per cu. ft. and having one glazed face free from stain.

Example 2 (S–2–S)

A panel similar to that of Example 1, but smooth and stain-free on two sides is made as follows:

Assembly: Transport caul, fiber insulating sheet, bottom smooth caul plate—mat 2.6 inches thick at 3 lbs. oven-dry fiber per cu. ft. with uniform mat moisture of 24% by weight and an additional spray on each face of 85 ounces of water per 100 sq. ft., giving a total of 36% moisture—smooth caul plate, and fiber insulating sheet. Platen temperature 400° F.

	Seconds
To eliminate open space between platens	15
To reach 48 p. s. i	5 to 10
To compress at 48 p. s. i	15 to 25
To increase pressure to 750 p. s. i	15
To hold at 750 p. s. i	60 to 150
To reduce pressure to 30 p. s. i	120
To hold pressure at 30 p. s. i	360
To increase pressure to 750 p. s. i	15
To hold pressure at 750 p. s. i	45
To open and relieve all pressure	30

The product is an S–2–S panel ⅛ inch thick at 64 lbs. per cu. ft.

Example 3 (S–1–S)

A panel thinner and more dense than that of Example 1 is made by using the same assembly and mat as in Example 1, the mat being formed with 25% by weight of moisture, and using a spray of water in the amount of 130 ounces per 100 sq. ft., giving a total moisture content of 31.4%. A suitable pressing schedule with platens at 400° F. is:

	Seconds
To eliminate open space between platens	15
To reach 48 p. s. i	5 to 10
To compress at 48 p. s. i	10 to 15
To reach 750 p. s. i	15 to 20
To hold at 750 p. s. i	30
To reduce to 48 p. s. i	15
To increase to 60 p. s. i	10
To hold at 60 p. s. i	10
To reach and hold 80 p. s. i	10
To reach 750 p. s. i	10 to 15
To hold at 750 p. s. i	105 to 110
To open and relieve all pressure	30

The product is an S–1–S panel 1/10 inch thick at 68 lbs. per cu. ft.

Example 4 (S–1–S)

A panel thicker and less dense than that of Example 1 is made by using the same type of assembly as in Example

1, but a mat 4 inches thick at 2.4 lbs. oven-dry fiber per cu. ft., and an initial moisture content of 25% by weight with a spray of water on one face at 180 ounces per 100 sq. ft., giving a total moisture content of 32%. A suitable pressing schedule with platens at 400° F. is:

	Seconds
To eliminate open space between platens	15
To reach 48 p. s. i.	15 to 20
To hold at 48 p. s. i.	25 to 30
To reach 560 p. s. i.	10 to 15
To hold at 560 p. s. i.	5
To reduce to 30 p. s. i.	30
To hold at 30 p. s. i.	540
To reach 100 p. s. i.	15
To open and relieve all pressure	15

The product is an S–1–S panel ¼ inch thick at 55 lbs. per cu. ft.

Example 5 (S–2–S)

A glazed S–2–S panel similar to that of Example 1 is made using the assembly of Example 2 and a mat as in Example 1, but of lower moisture content, namely, 12% by weight with a spray of water on each face at 21 ounces per 100 sq. ft., giving a total moisture content of 15%. A suitable schedule with platens at 400° F. is:

	Seconds
To eliminate open space between platens	15
To reach 48 p. s. i.	5 to 10
To hold at 48 p. s. i.	40 to 60
To reduce to 30 p. s. i.	90
To reach 750 p. s. i.	15
To hold at 750 p. s. i.	45
To reduce to 80 p. s. i.	30
To hold at 80 p. s. i.	30
To open and relieve all pressure	30

The product is an S–2–S panel having unstained glazed faces, ⅛ inch thick at 64 pounds per cu. ft.

The following examples relate to use of a different press operating with different controls and with different assemblies. The mat is carried into the press on a caul which retains heat from a prior use in the press in a process duplicating the respective examples given below, and having a temperature ranging upwardly from room temperature to one under 150° F. The upper caul is secured to the upper platen and therefore is always heated as it approaches and meets the mat. Both platens have an internal temperature of 360° F. In the case of S–1–S boards a wire screen is interposed between the carrying caul and the mat. The screen facilitates loss of water which attends the conditions necessary to produce an S–1–S board with glaze on the upper face as a result of wetting the upper layer of the mat.

Example 6 (S–1–S)

A fiber felt is formed having an average of 14% moisture content and varying generally in the range from 12% to 16%. The mat unit to be pressed weighs 48.06 lbs. to form a board 4 ft. x 16 ft. x ⅛ inch. The mat is sprayed on both faces with a total of 18 lbs. of water, distributed in the amounts of 3 ozs. and 1.5 ozs. per sq. ft., respectively, on the top and bottom faces of the mat, sufficiently prior to entry into the press, so that the faces remain wet. This provides a total moisture content of 37.4%.

The mat is pressed with the following cycle:

	Seconds
At 500 p. s. i.	30
Release to 50 p. s. i.	30
At 50 p. s. i.	90 to 120
At 500 p. s. i.	60

In the pressing, a slight amount of water is lost largely through the screen facing including some of the free water adjacent the same. The smooth upper caul and the cycle effect unstained glaze on the top face of the board, which has a density of 62 lbs. per cu. ft.

Example 7 (S–2–S)

A fiber felt is formed having an average moisture content of 11% ± 1%. The mat unit to be pressed weighs 46.44 lbs. to form a board 4 ft. x 16 ft. x ⅛ inch. The top is sprayed with 5 pounds of water distributed in the amount of 1.25 ozs. per sq. ft., thus raising the total moisture content to 19.6%. The mat resting on a smooth caul is promptly pressed without loss of water in the following cycle:

	Seconds
At 250 p. s. i.	30
Release to 30 p. s. i.	30
At 30 p. s. i.	300
At 750 p. s. i.	60

The resulting board is ⅛ inch thick with a density of 62 lbs. per cu. ft., and it presents a high quality hard glaze on the top face.

From the foregoing description it appears that panels with a glazed face may be made from felts which are either free from stain or are stained generally in the middle areas. The broad objective of the present invention is to produce the glazed surface, and this object is achieved even in a stained panel. In many uses of the product a large panel as manufactured is cut to smaller sizes. Thus, unstained glazed areas may be cut from a manufactured stained panel to provide such smaller sizes as products of the invention. Accordingly, the invention in its broadest aspect is independent of the non-staining consolidation procedure, but in its preferred and commercial application it is joined with said procedure to form panels with an unstained glazed face.

I claim:

1. The method which comprises forming a felt of wood fibers of substantially uniform content of fiber material per unit area, said fibers consisting of substantially all the substance of the wood from which the fibers are derived and being substantially all in the form of ultimate fibers and opened-up aggregates of ultimate fibers, the said substance of said fibers including water-soluble content, the felt having in substantially uniform distribution a moisture content in the range from 8% to 35% by weight; wetting at least one face of said felt by applying water substantially uniformly thereto in amount to increase the resulting total content of water to not over 40% by weigh, the said water at the wet face serving to plasticize and lubrictae the fibers and as solvent for water-solubles to form a coating fluid at said face during the hereinafter mentioned pressing; exposing the edges of said felt to the atmosphere and during said exposure applying mechanical pressure to said felt between imperforate surfaces of which at least one is in direct contact with a wet face of the felt; simultaneously transmitting heat through said surfaces toward the faces of said felt during said compression from heat sources having temperatures in the range from 300° to 450° F.; and continuing said heating and pressing for a time to consolidate the body and to reduce the moisture content to a value permitting opening of the press without rupture of the consolidated body, whereby a solution of water-solubles in water from the initial water content of the felt forms a coat of dried water-solubles at the said wetted face.

2. The method which comprises forming a felt of wood fibers of substantially uniform content of fiber material per unit area, said fibers consisting of substantially all the substance of the wood from which the fibers are derived and being substantially all in the form of ultimate fibers and opened-up aggregates of ultimate fibers, the said substance of said fibers including water-soluble content, the felt having in substantially uniform distribution a moisture content in the range from 8% to 35% by weight; wetting both faces of said felt by applying water substantially uniformly thereto in amount to increase the resulting total content of water to not over 40% by weight, the said water at the wet face serving to plasticize and lubricate the fibers and as solvent for water-solubles

to form a coating fluid at said face during the hereinafter mentioned pressing; exposing the edges of said felt to the atmosphere and during said exposure applying mechanical pressure to said felt between imperforate surfaces each of which is in direct contact with a wet face of the felt; simultaneously transmitting heat through said surfaces toward the faces of said felt during said compression from heat sources having temperatures in the range from 300° to 450° F.; and continuing said heating and pressing for a time to consolidate the body and to reduce the moisture content to a value permitting opening of the press without rupture of the consolidated body, whereby a solution of water-solubles in water from the initial water content of the felt forms a coat of dried water-solubles at the said wetted face.

3. The method which comprises forming a felt of wood fibers of substantially uniform content of fiber material per unit area, said fibers consisting of substantially all the substance of the wood from which the fibers are derived and being substantially all in the form of ultimate fibers and opened-up aggregates of ultimate fibers, the said substance of said fibers including water-soluble content, the felt having in substantially uniform distribution a moisture content in the range from 8% to 35% by weight; wetting at least one face of said felt by applying water substantially uniformly thereto in amount to increase the resulting total content of water to not over 40% by weight, the said water at the wet face serving to plasticize and lubricate the fibers and as solvent for water-solubles to form a coating fluid at said face during the hereinafter mentioned pressing; exposing the edges of said felt to the atmosphere and during said exposure applying mechanical pressure to said felt between imperforate surfaces of which at least one is in direct contact with a wet face of the felt and thereby effecting a thickness which is substantially the thickness at which the felt is to be finally consolidated, simultaneously transmitting heat through said surfaces toward the faces of said felt during said compression from heat sources having temperatures in the range from 300° to 450° F., said thickness being attained prior to the time the felt becomes uniformly heated throughout; holding said mechanical pressure for a short time while generated water vapor escapes from the felt toward and then facewise along said surfaces and also at the exposed edges of the felt, and the water-vapor pressure within the felt increases inwardly from the edges in the presence of a correspondingly increasing proportion of interstitial fluid consisting substantially of water and dissolved water-solubles, during which said short time the temperature of said fluid increases in the directions inwardly from the edges of the felt; lowering the applied mechanical pressure prior to the attainment of the boiling point of the hottest portion of said fluid, whereby to permit increased rates of vaporization of water from the faces of the felt and edgewise of the felt with deposition of said water-solubles in situ as a residue, thereby avoiding movement and migration of said fluid as would occur when partially confined bodies thereof reach the boiling point, and boil to form steam in pressure pockets causing such migration, the said lowering of mechanical pressure also accelerating the vaporization of water from the surface liquid; and when volatilization of water is substantially completed with a resulting deposition of solute in situ for use as binder solids, increasing the mechanical pressure to attain and maintain final thickness to bond the fibers to a consolidated body in part at least by said residue of water-solubles, to dry the surface-located residue to a surface coat with a facial character as molded by the said contacting surface, and to reduce the moisture content to a value permitting full release of said pressure without rupture of the resulting consolidated body.

4. The process of claim 3 in which the fibers of the felt contain water-soluble content deriving from the wood by the action of steam.

5. The process of claim 3 in which the fibers are mechanically produced from wood in an environment of steam whereby the water-soluble content of the wood substance is increased by the action of the steam.

6. The method which comprises forming a felt of wood fibers of substantially uniform content of fiber material and of thermosetting resin binder per unit area, said fibers consisting of substantially all the substance of the wood from which the fibers are derived and being substantially all in the form of ultimate fibers and opened-up aggregates of ultimate fibers, the said substance of said fibers including water-soluble content, the felt having in substantially uniform distribution a moisture content in the range from 8% to 35% by weight; wetting at least one face of said felt by applying water substantially uniformly thereto in amount to increase the resulting total content of water to not over 40% by weight, the said water at the wet face serving to plasticize and lubricate the fibers and as solvent for water-solubles to form a coating fluid at said face during the hereinafter mentioned pressing; exposing the edges of said felt to the atmosphere and during said exposure applying mechanical pressure to said felt between imperforate surfaces of which at least one is in direct contact with a wet face of the felt and thereby effecting a thickness which is substantially the thickness at which the felt is to be finally consolidated, simultaneously transmitting heat through said surfaces toward the faces of said felt during said compression from heat sources having temperatures in the range from 300° to 450° F., said thickness being attained prior to the time the felt becomes uniformly heated throughout; holding said mechanical pressure for a short time while generated water vapor escapes from the felt toward and then facewise along said surfaces and also at the exposed edges of the felt, and the water-vapor pressure within the felt increases inwardly from the edges in the presence of a correspondingly increasing proportion of interstitial fluid consisting substantially of water and dissolved water-solubles, during which said short time the temperature of said fluid increases in the directions inwardly from the edges of the felt; lowering the applied mechanical pressure prior to the attainment of the boiling point of the hottest portion of said fluid, whereby to permit increased rates of vaporization of water from the faces of the felt and edgewise of the felt with deposition of said water-solubles in situ as a residue, thereby avoiding movement and migration of said fluid as would occur when partially confined bodies thereof reach the boiling point, and boil to form steam in pressure pockets causing such migration, the said lowering of mechanical pressure also accelerating the vaporization of water from the surface liquid, and when volatilization of water is substantially completed with a resulting deposition of solute in situ for use as binder solids, increasing the mechanical pressure to attain and maintain final thickness to bond the fibers to a consolidated body in part at least by said residue of water-solubles and in part by said thermosetting resin, to dry the surface-located residue to a surface coat with a facial character as molded by the said contacting surface, and to reduce the moisture content to a value permitting full release of said pressure without rupture of the resulting consolidated body.

7. The process of claim 6 in which the fibers of the felt contain water-soluble content deriving from the wood by the action of steam.

8. The process of claim 6 in which the fibers are mechanically produced from wood in an environment of steam whereby the water-soluble content of the wood substance is increased by the action of the steam.

9. The method which comprises forming a felt of wood fibers of substantially uniform content of fiber material per unit area, said fibers consisting of substantially all the substance of the wood from which the fibers are derived and being substantially all in the form of ultimate fibers and opened-up aggregates of ultimate fibers, the said substance of said fibers including water-soluble content, the felt having in substantially uniform distribution

a moisture content in the range from 8% to 35% by weight; wetting at least one face of said felt by applying water substantially uniformly thereto in amount to increase the resulting total content of water to not over 40% by weight, the said water at the wet face serving to plasticize and lubricate the fibers and as solvent for water-solubles to form a coating fluid at said face during the hereinafter mentioned pressing; exposing the edges of said felt to the atmosphere and during said exposure applying mechanical pressure to said felt between imperforate surfaces of which one is in direct contact with a wet face of the felt and between the other of which and said felt is a wire-mesh screen, and thereby effecting a thickness which is substantially the thickness at which the felt is to be finally consolidated, simultaneously transmitting heat through said surfaces toward the faces of said felt during said compression from heat sources having temperatures in the range from 300° to 450° F., said thickness being attained prior to the time the felt becomes uniformly heated throughout; holding said mechanical pressure for a short time while generated water vapor escapes from the felt toward and then facewise along said surfaces and also at the exposed edges of the felt, and the water-vapor pressure within the felt increases inwardly from the edges in the presence of a correspondingly increasing proportion of interstitial fluid consisting substantially of water and dissolved water-solubles, during which said short time the temperature of said fluid increases in the directions inwardly from the edges of the felt; lowering the applied mechanical pressure prior to the attainment of the boiling point of the hottest portion of said fluid, whereby to permit increased rates of vaporization of water from the faces of the felt and edgewise of the felt with deposition of said water-solubles in situ as a residue, thereby avoiding movement and migration of said fluid as would occur when partially confined bodies thereof reach the boiling point, and boil to form steam in pressure pockets causing such migration, the said lowering of mechanical pressure also accelerating the vaporization of water from the surface liquid; and when volatilization of water is substantially completed with a resulting deposition of solute in situ for use as binder solids, increasing the mechanical pressure to attain and maintain final thickness to bond the fibers to a consolidated body in part at least by said residue of water-solubles, to dry the surface-located residue to a surface coat with a facial character as molded by the said contacting surface, and to reduce the moisture content to a value permitting full release of said pressure without rupture of the resulting consolidated body.

10. The process of claim 9 in which the fibers of the felt contain water-soluble content deriving from the wood by the action of steam.

11. The process of claim 9 in which the fibers are mechanically produced from wood in an environment of steam whereby the water-soluble content of the wood substance is increased by the action of the steam.

12. The process of claim 9 in which thermosetting resin binder is distributed uniformly among the fibers of the felt.

13. The process of claim 12 in which the fibers of the felt contain water-soluble content deriving from the wood by the action of steam.

14. The process of claim 12 in which the fibers are mechanically produced from wood in an environment of steam whereby the water-soluble content of the wood substance is increased by the action of the steam.

15. The method which comprises forming a felt of wood fibers of substantially uniform content of fiber material per unit area, said fibers consisting of substantially all the substance of the wood from which the fibers are derived and being substantially all in the form of ultimate fibers and opened-up aggregates of ultimate fibers, the said substance of said fibers including water-soluble content, the felt having in substantially uniform distribution a moisture content in the range from 8% to 35% by weight; wetting both faces of said felt by applying water substantially uniformly thereto in amount to increase the resulting total content of water to not over 40% by weight, the said water at the wet face serving to plasticize and lubricate the fibers and as solvent for water-solubles to form a coating fluid at said face during the hereinafter mentioned pressing; exposing the edges of said felt to the atmosphere and during said exposure applying mechanical pressure to said felt between imperforate surfaces both of which are in direct contact with a wet face of the felt and thereby effecting a thickness which is substantially the thickness at which the felt is to be finally consolidated, simultaneously transmitting heat through said surfaces toward the faces of said felt during said compression from heat sources having temperatures in the range from 300° to 450° F., said thickness being attained prior to the time the felt becomes uniformly heated throughout; holding said mechanical pressure for a short time while generated water vapor escapes from the felt toward and then facewise along said surfaces and also at the exposed edges of the felt, and the water-vapor pressure within the felt increases inwardly from the edges in the presence of a correspondingly increasing proportion of interstitial fluid consisting substantially of water and dissolved water-solubles, during which said short time the temperature of said fluid increases in the directions inwardly from the edges of the felt; lowering the applied mechanical pressure prior to the attainment of the boiling point of the hottest portion of said fluid, whereby to permit increased rates of vaporization of water from the faces of the felt and edgewise of the felt with deposition of said water-solubles in situ as a residue, thereby avoiding movement and migration of said fluid as would occur when partially confined bodies thereof reach the boiling point, and boil to form steam in pressure pockets causing such migration, the said lowering of mechanical pressure also accelerating the vaporization of water from the surface liquid; and when volatilization of water is substantially completed with a resulting deposition of solute in situ for use as binder solids, increasing the mechanical pressure to attain and maintain final thickness to bond the fibers to a consolidated body in part at least by said residue of water-solubles, to dry the surface-located residue to a surface coat with a facial character as molded by the said contacting surface, and to reduce the moisture content to a value permitting full release of said pressure without rupture of the resulting consolidated body.

16. The process of claim 15 in which the fibers of the felt contain water-soluble content deriving from the wood by the action of steam.

17. The process of claim 15 in which the fibers are mechanically produced from wood in an environment of steam whereby the water-soluble content of the wood substance is increased by the action of steam.

18. The process of claim 15 in which thermosetting resin binder is distributed uniformly among the fibers of the felt.

19. The process of claim 18 in which the fibers of the felt contain water-soluble content deriving from the wood by the action of steam.

20. The process of claim 18 in which the fibers are mechanically produced from wood in an environment of steam whereby the water-soluble content of the wood substance is increased by the action of the steam.

21. A consolidated fibrous panel of whole wood fibers containing substantially all the substance of the wood from which the fibers are derived including water-soluble material derived from said wood, said product having thermoset phenol-formaldehyde resin binder in amount of about 1 part per 100 parts of oven-dry wood substance, having a density of at least 50 lbs. per cu. ft., and having at one face a film-like coat comprising some of said water-soluble material.

22. A consolidated fibrous panel of whole wood fibers

containing substantially all the substance of the wood from which the fibers are derived including water-soluble material derived from said wood, said product having thermoset phenol-formaldehyde resin binder in amount of about 1 part per 100 parts of oven-dry wood substance, having a density of at least 50 lbs. per cu. ft., and having at one face a film-like coat comprising some of said water-soluble material, said coat being in the form of a glaze.

23. A consolidated fibrous panel of whole wood fibers containing substantially all the substance of the wood from which the fibers are derived including water-soluble material derived from said wood, said product having thermoset phenol-formaldehyde resin binder in amount of about 1 part per 100 parts of oven-dry wood substance, having a density of at least 50 lbs. per cu. ft., and having at both faces a film-like coat comprising some of said water-soluble material.

24. A consolidated fibrous panel of whole wood fibers

containing substantially all the substance of the wood from which the fibers are derived including water-soluble material derived from said wood, said product having thermoset phenol-formaldehyde resin binder in amount of about 1 part per 100 parts of oven-dry wood substance, having a density of at least 50 lbs. per cu. ft., and having at both faces a film-like coat comprising some of said water-soluble material, at least one such coat being in the form of a glaze.

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