May 21, 1968 J. R. ASH 3,384,137

HOT PRESS PLYWOOD

Filed July 8, 1963

Fig. 1.

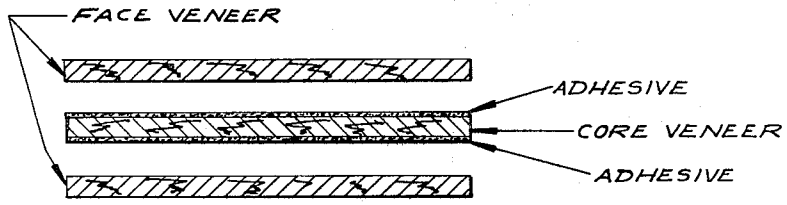


Fig. 2.

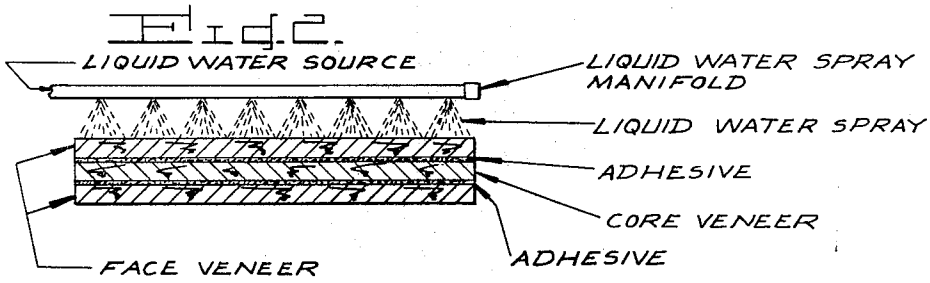


Fig. 3.

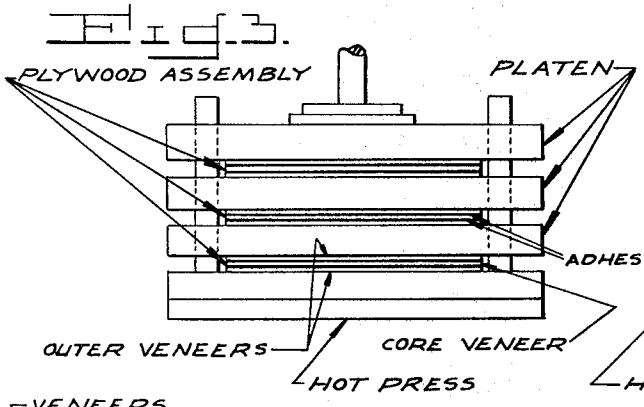
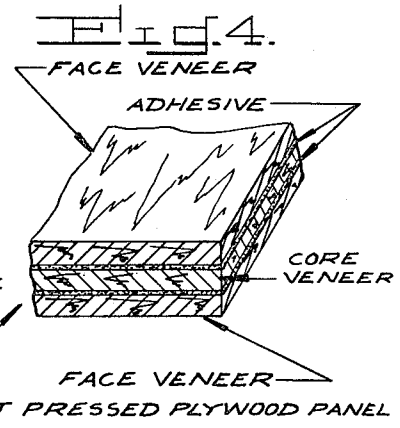


Fig. 4.



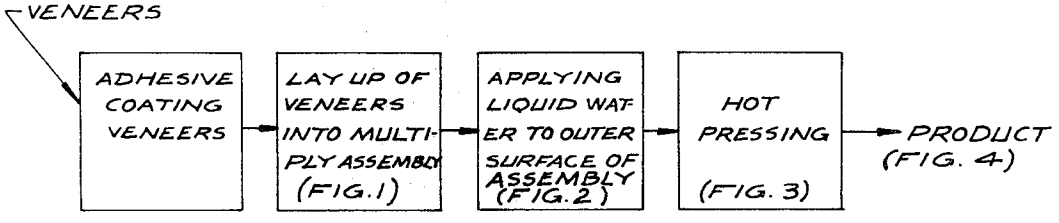


Fig. 5.

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HOT PRESS PLYWOOD

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This invention relates to the manufacture of plywood. More particularly this invention relates to certain improvements in the hot press manufacture of plywood enabling shorter press cycles.

At the present time, plywood mills are seeking means to increase their output which do not require significant modifications in their manufacturing operation. One of the more significant restrictions on the rate of manufacture is the requisite dwell time of the assembled stacks of plywood panels in the hot press. This dwell time varies, of course, with the nature of the adhesive, the press temperature, and the thickness of the intended plywood panel. In general proteinaceous adhesives require a 3 to 5 minute hot press cycle while phenolic adhesives may require anywhere from a 4 to 9 minute or more hot press cycle depending on the speed of cure of the phenolic adhesive used. In actual practice, the particular adhesive employed is normally dictated by the intended application of the finished plywood panel. Thus, it is not always possible to effect a significant reduction in press time through the use of a more reactive adhesive.

It has, therefore, become necessary to search for an expedient by which the requisite press time may be reduced irrespective of the nature of the plywood adhesive used.

It is an object of this invention to provide a novel process enabling a significant reduction in the press cycle required for the manufacture of plywood by hot press processes.

This and other objects are attained in the manufacture of plywood by conventional hot press techniques through the improvement which comprises applying water to at least one of the outer surfaces of plywood pre-press assemblies immediately prior to the hot pressing thereof. By the term "plywood pre-press assemblies" is meant an assembled but not yet consolidated plurality of adhesive coated wood veneers laid-up one upon the other in the form of a multi-ply panel.

This invention will now be described in more detail with reference to the drawing where FIGURE 1 is an expanded view showing the arrangement or lay up of the component parts of a plywood assembly; FIGURE 2 is a view illustrating the application of liquid water to the outer surface of a plywood assembly in accordance with this invention; FIGURE 3 is an illustration of the general features of a plywood press and shows the manner in which a plurality of plywood assemblies may be placed in a press; FIGURE 4 is a fragmentary perspective view of a portion of a plywood panel; and FIGURE 5 illustrates the various steps of the process of this invention for producing plywood panels.

In FIGURE 1 there is illustrated a typical lay up for a three-ply, plywood panel. The lay up or assembly includes a core veneer sandwiched between a pair of face veneers with the grain in the face veneers running at right angles to the grain in the core veneer, as is conventional in plywood manufacture. A suitable glue or adhesive material is applied to the faces of the core veneer. However, the glue or adhesive may be applied to the backs of the face veneer or to both the core veneer and face veneers.

In FIGURE 2 there is illustrated suitable means shown as a length of pipe with a plurality of openings therein and connected to a source of water providing a manifold for spraying liquid water onto the surface of a plywood

assembly. The manifold if a single length of pipe may move across the surface of the assembly or the assembly may travel under the manifold. Of course the means for applying water to the surface of the plywood assemblies may be other than as illustrated in FIGURE 2 for accomplishing the practice of this invention.

In FIGURE 3 there is illustrated a plywood hot press wherein the surface wet plywood assemblies are positioned between the platens of the press and as shown when the press is filled, it is operated to press the lay up assemblies together under suitable pressure, temperature supplied through the platens, and time to effect curing and setting the resin in the adhesive and joining the core and face veneers.

In FIGURE 4 there is illustrated a consolidated plywood assembly showing the core veneer joined to the face veneers by the adhesive which is cured during the hot press operation.

In FIGURE 5 there is illustrated the process of this invention wherein suitable wood veneers are first coated with an adhesive, then laid up into multi-ply veneer assemblies as illustrated in FIGURE 1, then liquid water is applied to the surface of the assemblies by suitable means such as seen in FIGURE 2, and then hot pressed to produce a plywood panel.

The following examples illustrate the dramatic reduction in press cycle resulting from wetting the surfaces of plywood pre-press assemblies prior to hot pressing. A variety of thermosetting and proteinaceous adhesive formulations are portrayed in these examples which are presented in illustration of this invention and are not intended as limitations on the scope thereof. Where parts are mentioned, they are parts by weight.

Example I

This example illustrates the advantages of practice of this invention using a typical 4 minute hot press phenolic glue formulation.

A stainless steel kettle equipped with heating and cooling means and an agitator is charged with 395 parts (circa 4.3 mols) of phenol, 900 parts (circa 11.1 mols) of a 37% aqueous formaldehyde solution, 430 parts of water and 135 parts (circa 1.7 mols) of a 50% aqueous sodium hydroxide solution. The mixture is heated to and maintained at about 150° F. for 4 hours. Then 40 parts (circa 0.4 mol) of phenol are added and the mixture is heated at about 200° F. for an additional 20 minutes. The reaction mixture is then cooled to about 165–170° F. and bodied thereat until a 70° F. viscosity of about 150 on the MacMichael #26 scale is attained. 100 parts (circa 1.25 mols) of a 50% aqueous sodium hydroxide solution are then added and the reaction mixture is rapidly cooled to about room temperature. The resulting liquid phenolic resin has a 70° F. viscosity of about 15–25 on the MacMichael #26d scale.

A 4 minute plywood glue formulation is then prepared, combining 245 parts of water, 360 parts of the liquid phenolic resin prepared above in this Example I, 200 parts of Furafil 100s extender and 55 parts of wheat flour in a mixer. This is mixed for 2 minutes, 110 parts of a 50% aqueous sodium hydroxide solution are added and mixing is continued another 2 minutes. 55 parts of soda ash are then added followed by a 15 minute mix. Finally, another 1140 parts of the liquid phenolic resin prepared above in this Example I and 120 parts of a 50% aqueous resorcinol solution are added and the mixture is mixed until smooth.

Six 5-ply $1\frac{3}{16}$" Douglas fir plywood panels are then laid up using a glue spread of 60 pounds per 1000 square feet of double glue line (MDGL) and an assembly time of 10 minutes in each instance. The surfaces of three of

these plywood prepress assemblies are sprayed with water in amount of 16.5 pounds per 1000 square feet of face surface just prior to pressing. Duplicate pairs of wet vs. dry assemblies are then hot pressed at 325° F. and 175 p.s.i. at press cycles of 4.0, 3.5 and 3.0 minutes, respectively. Each panel is then tested for dry, wet and boil shear strength, measuring the percent wood failure in each instance.

Specimens for shear strength evaluation are prepared by first cutting a 3⅛" x 10" section from each panel; each section being cut so that the grain of the face plies is oriented parallel to the long axis. Each section is then grooved along a line 1 inch from the long axis, and parallel thereto, to a depth extending ⅔ through the center ply. A second and similar groove is cut parallel thereto upon the opposite face of each section such that the distance between the grooves is exactly 1 inch. After grooving, each section is cut across the long axis to yield a number of specimens measuring 1" x 3⅛" and having a shear area of one square inch located in the center. For each of the dry, wet and boil shear tests six of the specimens cut from each section are broken on the Hydraulic Plywood Testing Machine #HC–455, manufactured by I. F. Laucks, Inc. and the average breaking load and percent failure for each set of 6 specimens is determined.

The specimens to be tested for dry shear strength require no pretreatment. Those to be tested for wet shear strength are pretreated by soaking them in water at room temperature for 48 hours and are then broken while still wet. The specimens to be tested for boil shear strength are pretreated by immersing them in boiling water for 4 hours, drying them in a forced air oven at 145° F. for 20 hours, and finally immersing them in boiling water for another 4 hours. These specimens are also broken while still wet.

The test results for each press cycle are summarized in Table A. In interpreting these results, a wood failure of 0% indicates that failure occurs entirely within the glue-line. Conversely, a wood failure of 100% indicates that the glue-line is uniformly stronger than the wood within the shear area of the center ply. Obviously, a plywood adhesive should show a high wood failure, at least on dry shear. Similarly, a water-resistant plywood adhesive should show appreciable wood failure on wet shear.

TABLE A

Press Cycle (minutes)	Wet Surface	Percent Wood Failure		
		Dry Shear	Wet Shear	Boil Shear
4.0	Yes	98	97	95
4.0	No	97	95	92
3.5	Yes	98	95	97
3.5	No	83	73	75
3.0	Yes	15	10	7
3.0	No	(1)		

[1] Delaminates.

Table A clearly demonstrates that the use of pre-wet plywood pre-press assemblies enables the use of shorter hot press cycles. In this instance, using a 4 minute phenolic glue, conventional plywood techniques provide only a weak glue-line bond at a 3.5 minute press cycle and fail to provide a self-supporting plywood panel at a 3 minute press cycle. The water sprayed assemblies, on the other hand, need be hot pressed for only 3.5 minutes to obtain full development of the bond strength. Even at a 3 minute hot press cycle, the panel obtained, though undesirable, is self-supporting and presents a modicum of bond strength. Thus, a 10–15% reduction in press cycle is afforded through practice of this invention.

Example II

This example illustrates the advantages of practice of this invention using a typical 7¼ minute hot press phenolic glue formulation.

A stainless steel kettle equipped with heating, cooling and reflux means and an agitator is charged with 100 parts (circa 1.0 mol) of phenol, 175 parts (circa 2.1 mol) of a 37% aqueous formaldehyde solution, 15 parts (circa 0.2 mol) of a 50% aqueous sodium hydroxide solution and 85 parts of water. The mixture is refluxed (circa 215° F.) for about 40 minutes and then cooled to and maintained at about 180° F. until a 70° F. viscosity of about 300 on the MacMichael #26 scale is attained. Then another 25 parts (circa 0.3 mol) of the 50% aqueous sodium hydroxide solution are added and heating is continued at about 180° F. until a 70° F. viscosity of about 75 on the MacMichael #26 scale is attained. Finally, another 25 parts (circa 0.3 mol) of the 50% aqueous sodium hydroxide solution are added and the reaction mixture is rapidly cooled to about room temperature. The resulting liquid phenolic resin has a 70° F. viscosity of about 30–35 on the MacMichael #26d scale.

A 7¼ minute plywood glue formulation is then prepared, combining 240 parts of water, 100 parts of Furafil 100s extender and 25 parts of wheat flour in a pot. This mixture is mixed for 2 minutes, 50 parts of a 50% aqueous sodium hydroxide solution are added and the mixture is mixed for another 2 minutes. 25 parts of soda ash are then added followed by a 15 minute mix. Finally, 835 parts of the liquid phenolic resin prepared above in this Example II are added and the mixture is mixed until smooth.

Twelve 5-ply 13/16" Douglas fir plywood panels are then prepared and evaluated as described in Example I except that hot press cycles of 7.5, 7.0, 6.5, 6.0, 5.5 and 5.0 minutes are used. The results are summarized in Table B.

TABLE B

Press Cycle (minutes)	Wet Surface	Percent Wood Failure		
		Dry Shear	Wet Shear	Boil Shear
7.5	Yes	100	98	95
7.5	No	100	90	92
7.0	Yes	97	95	96
7.0	No	93	97	97
6.5	Yes	93	93	92
6.5	No	97	85	95
6.0	Yes	98	90	92
6.0	No	50	40	20
5.5	Yes	85	85	77
5.5	No	(1)		
5.0	Yes	80	65	55
5.0	No	(1)		

[1] Delaminates.

Table B clearly shows that use of a 7¼ minute phenolic glue in the conventional manner requires at least a 6.5 minute press cycle to provide acceptable plywood panels whereas use of the same glue under the same process conditions, but using the pre-wetting expedient of this invention enables the production of acceptable plywood panels at press cycles of as low as 5 minutes. Note that at 5 and even 5.5 minutes press cycles without prewetting, self supporting panels are not obtained.

EXAMPLE III

This example illustrates the advantages of the practice of this invention using a typical hot press protein glue formulation prepared as follows: 300 parts of water and 210 parts of a dry glue mix comprising, on a weight basis, 55% of water-soluble spray dried blood, 30% soybean flour, 12% Furafil 100s extender and 3% of a defoamer are mixed in a pot until smooth. Another 870 parts of water are then added slowly followed by a 2 minute mix. Then, in succession are added 35 parts of a 33% aqueous lime solution followed by a 1 minute mix, 110 parts of "N" brand sodium silicate followed by a 1 minute mix and finally 30 parts of a 50% aqueous sodium hydroxide solution followed by a 5 minute mix.

Twelve 5-ply 13/16" Douglas fir plywood panels are then laid up using a glue spread of 90 pounds per 1000 square feet of double glue line (MDGL) and an assembly time of 10 minutes in each instance. The surfaces of six of these plywood pre-press assemblies are sprayed with water in amount of 16.5 pounds per 1000 square feet of face surface just prior to pressing. Duplicate pairs of wet vs.

dry assemblies are then hot pressed at 260° F. and 175 p.s.i. at press cycles of 3.5, 3.0, 2.5, 2.0, 1.5, and 1.0 minutes, respectively. Each panel is then tested for dry and wet shear according to the procedure set forth in Example I. The results are summarized in Table C.

TABLE C

Press Cycle (minutes)	Wet Surface	Percent Wood Failure	
		Dry Shear	Wet Shear
3.5	Yes	100	83
3.5	No	100	85
3.0	Yes	100	87
3.0	No	100	90
2.5	Yes	90	81
2.5	No	85	52
2.0	Yes	92	70
2.0	No	30	15
1.5	Yes	60	46
1.5	No	(1)	(1)
1.0	Yes	12	3
1.0	No	(1)	(1)

[1] Delaminates.

Table C again clearly shows the dramatic reduction in press cycle realizable by the practice of this invention. Using the protein glue, conventional practice requires at least a 2.5 minute press cycle to obtain adequate panels. The pre-wetting expedient of this invention, on the other hand, enables the manufacture of satisfactory panels at press cycles of less than 2 minutes. Note that through the pre-wetting expedient, self-supporting panels are obtained at a 1 minute press cycle whereas conventional techniques fail to provide self-supporting panels at even a 1.5 minute press cycle.

EXAMPLE IV

This examples illustrates the advantages of the practice of this invention using a typical hot press urea glue formulation prepared as follows: The urea-formaldehyde resin employed is one containing about 1.9 mols of formaldehyde per mol of urea.

80 parts of water and 2 parts of ammonium chloride are mixed together in a pot for 1 minute. 5 parts of pine oil and 100 parts of wheat flour are then added and the mixture is mixed until smooth. Finally, 400 parts of the urea-formaldehyde resin are added and the mixture is mixed until smooth.

Ten 5-ply 13/16" Douglas fir plywood panels are then prepared and evaluated as described in Example III except that a glue spread of 60 pounds per 1000 square feet of double glue line (MDGL) is used and with the further exception that press cycles of 6.0, 5.5, 5.0, 4.5, and 4.0 minutes, respectively, are used. The results are summarized in Table D.

TABLE D

Press Cycle (minutes)	Wet Surface	Percent Wood Failure	
		Dry Shear	Wet Shear
6.0	Yes	100	100
6.0	No	100	100
5.5	Yes	100	100
5.5	No	100	100
5.0	Yes	100	92
5.0	No	95	83
4.5	Yes	100	96
4.5	No	62	10
4.0	Yes	78	36
4.0	No	(1)	(1)

[1] Delaminates.

Again, Table D demonstrates the effectiveness of the process of this invention in reducing hot press cycles in the manufacture of plywood panels, this time using a urea glue. Note that conventional techniques are shown to require at least a 5 minute press cycle to obtain good panels; inferior panels being obtained at a 4.5 minute press cycle and no panel at all being formed at a 4 minute cycle. The pre-wetting expedient of this invention, however, enables the manufacture of good panels at a 4.5 minute press cycle and, in fact, at a 4 minute cycle provides a better panel than is obtained at a 4.5 minute cycle using conventional techniques.

In the typical process for the hot press manufacture of plywood, wood veneers which have been coated with the prescribed amount of a suitable adhesive formulation are laid-up, i.e., assembled, into panels comprising a plurality of such veneers; generally arranged cross-grained to one another in successive plies. These plywood pre-press assemblies, generally comprising 3, 5 or 7 plies, are then placed in a hot press where consolidation of the panels is effected.

In the practice of this invention, such a conventional process is modified to the extent that after the assmbly of each panel, but prior to hot pressing, water is applied to the surfaces of said plywood pre-press assemblies. Upon subsequent hot pressing, the water is driven from the surface into the veneer and toward the center of the panel so as to secure more efficient heat transfer into the panel and accordingly effect a significant reduction in the required press cycle.

The foregoing examples illustrate application of the principle of this invention in the manufacture of plywood panels made using phenolic resins of two different press cycle requirements, urea-formaldehyde resins and proteinaceous adhesives. In each instance, it is observed that press cycle reductions of 25% or more are realized through the practice of this invention.

As an auxiliary advantage, it has been found that the surfaces of the resulting plywood panels are much smoother and require less sanding in finishing than the corresponding conventionally manufactured panels. It is therefore apparent that while significant reductions in press cycle may not be obtained by applying water to just one surface of the plywood pre-press assembly, this expedient would reduce the, e.g., sanding and cost of preparing plywood panels having one finish face.

It has been observed that the amount of water required in the practice of this invention varies with the nature of the wood used. When Douglas fir veneer is used, at least about 5 pounds of water should be applied per 1000 square feet of surface area of the plywood pre-press assembly in order to obtain significant reductions in hot press cycle. However, in the broader scope of this invention, where more or less porous wood veneers than Douglas fir are employed, this minimum water requirement will vary accordingly. Therefore, in the broader aspect, at least about 2 pounds of water per 1000 square feet of surface area should be used. There is no practical upper limit to the proportion of water applied obviously, since excessive amounts of water will merely tend to flow off of the assembly surface, thus automatically limiting, within rough bounds, the quantity of water present at the time of press. It may, however, be stated that in the case of Douglas fir, application of more than about 20 pounds of water per 1000 square feet of surface area (and about 30 pounds per 1000 square feet in other instances) does not appear to provide significant further reduction of press cycle.

Any conventional method may be employed to apply the water to the surfaces of the plywood pre-press assembly, e.g., spraying, roll coating, etc.

Normal hot press temperatures and pressures may be used in the practice of this invention. However, it has been found most advantageous to effect the hot pressing at temperatures in the order of 500° F. enabling press cycles so rapid as to be continuous in nature. The scorching which one would normally expect at such high temperatures is not observed, probably because of the presence of steam.

It is obvious that many variations may be set forth in the products and processes set forth above without departing from the spirit and scope of this invention.

What is claimed is:

1. In a process for the manufacture of plywood which

comprises the assembly of a plurality of adhesive coated wood veneers and subsequent consolidation of said assembly under heat and pressure, the improvement which comprises applying liquid water to at least one of the outer surfaces of said assembly just prior to hot pressing in a proportion of at least about 3 pounds per 1000 square feet of surface area.

2. A process as in claim 1 wherein liquid water is applied to both outer surfaces of said assembly.

3. In a process for the manufacture of plywood which comprises the assembly of a plurality of adhesive coated Douglas fir veneers and subsequent consolidation of said assembly under heat and pressure, the improvement which comprises applying liquid water to at least one of the outer surfaces of said assembly just prior to hot pressing in a proportion of at least 5 pounds per 1000 square feet of surface area.

4. A process as in claim 3 wherein liquid water is applied to both outer surfaces of said assembly.

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