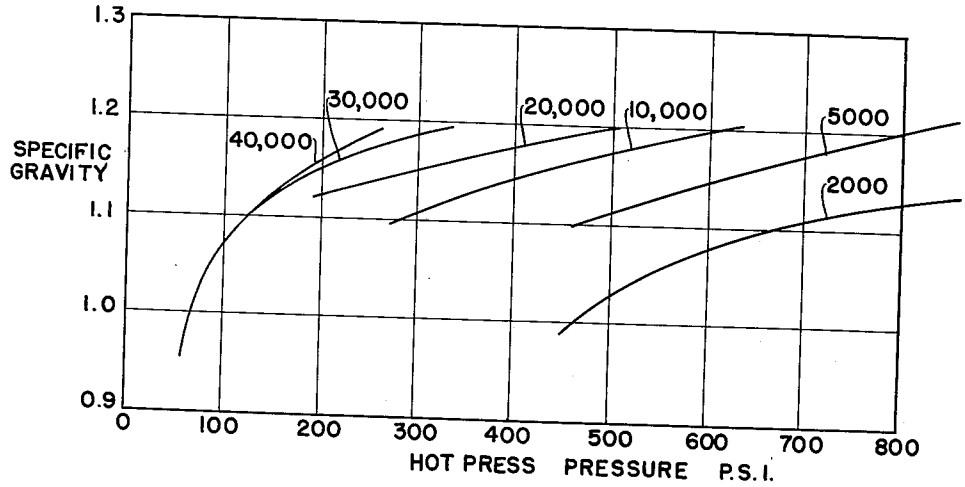
Feb. 13, 1962 J. G. MEILER 3,021,244

PROCESS FOR PRODUCING HIGH DENSITY HARDBOARD

Filed Dec. 23, 1955

FIG. 1



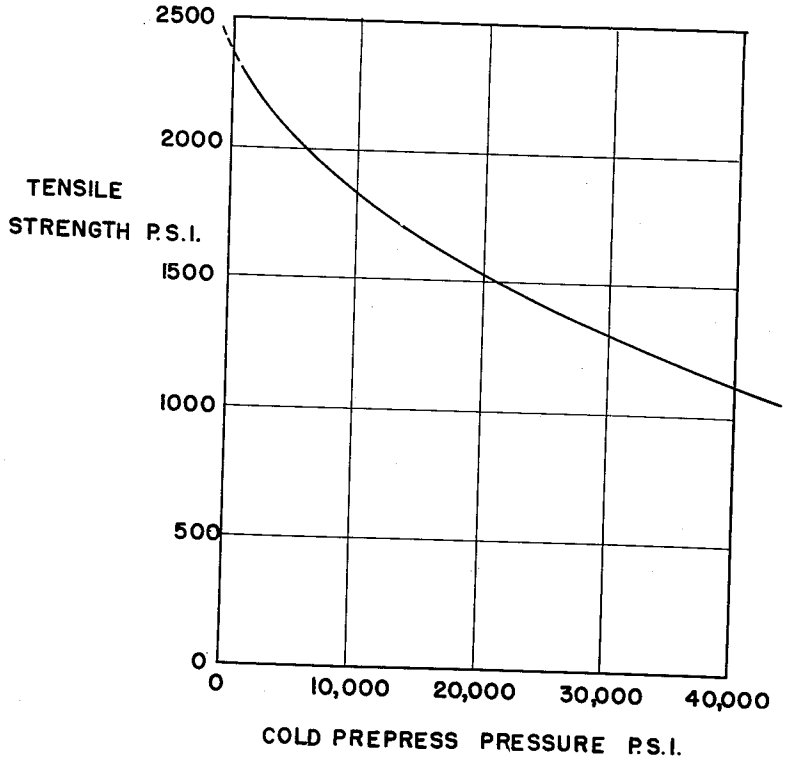


FIG. 2

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PROCESS FOR PRODUCING HIGH DENSITY HARDBOARD

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This invention relates to the production of high density hardboard, a product formed by the compression of lignocellulose particles, such as particles of wood, bagasse, straw and like plant materials, into dense, hard sheets, and has for its object the provision of an improved process for this purpose. The invention is based on my discovery that lignocellulose particles which had been converted into the desired particle of suitable size and steamed, and when in a moist condition, can be pressed at very high pressures and at normal room temperatures into a dense sheet, advantageously to a density while under pressure greater than the final density of the finished hardboard. The compacted sheet thus formed can then be cured or set at higher temperatures and at much lower rolling pressure into a hardboard having its final density and thickness. I have found that the high pressures necessary to attain the desired results can be efficiently and practically accomplished by passing a relatively loose mat of lignocellulose particles containing the required amount of moisture and at normal room temperatures between one or more sets of high pressure nip rolls.

To simplify the description of the invention it will be described hereinafter with reference to wood particles, it being understood the process is also applicable to equivalent lignocellulose particles. The wood particles formed into hardboard in the process of my invention can be of any suitable size and shape. For example, the wood particles can be in the form of pulp fibers, chips or shavings. The fibers may be formed from steamed wood chips which are passed through an attrition mill, and the shavings may be formed by cutting the wood across the grain so as to make their cut surfaces nearly parallel to the grain to minimize curling. The invention is applicable to the treatment of any suitably subdivided wood or wood-like material.

It is the present common practice in forming hardboard of compressed wood particles to form the wood particles into a loose mat, then to heat the mat and compress it into a dense sheet. There are a number of different methods in common use or described in the literature for preparing hardboards. In general, however, each of them includes some method of forming a suitable uniform mat of wood or wood-like particles (either with or without resin binder and water repellent) which is then pressed and cured in a press capable of applying extremely high total pressure, but low unit area pressure, and a high temperature. The pressure and temperature in said presses are maintained until the desired board density and hardness are attained and the resin (if any) is cured. Pressures ranging upward from 500 pounds per square inch are required, and the flat bed presses used for this purpose are of necessity huge, costly and cumbersome. A total pressure of about 2,304,000 pounds is required to apply a pressure of only 500 pounds per square inch to an ordinary 4 feet by 8 feet sheet of hardboard, such as are used in the industry at this time. As a result, these presses constitute one of the major items of expense in manufacturing hardboard and, furthermore, because the mat is in an expanded form when placed in such presses, their capacity is seriously limited, thereby raising unit costs.

In its preferred and more complete aspect the process

of my invention comprises steaming the wood particles at such temperatures and for such a time as to soften the fibers, drying them to the required moisture content, if necessary, forming the particles into a mat (with or without added resin binder or water repellent), passing the mat at normal room temperatures quickly to a very high pressure unit as between the nip of opposed rolls to compress the sheet momentarily under very high pressure to at least final density, and then curing the sheet at a much lower pressure and at an elevated temperature to final density. It was a surprising feature of my invention that the mat could be compressed to even more than final density at room temperature without noticeable fiber injury so that it could be easily and readily cured in an ordinary relatively simple and inexpensive low pressure flat-bed press, or in a continuous type low pressure belt press. This cold prepressing step has the surprising effect of lowering substantially the time needed for the curing stage. Furthermore, "spring-back" after the high pressure prepressing is small and, if flat bed low pressure presses are used for "curing" the hardboard, maximum press loadings can be obtained. The high density hardboard produced by my process is equal or superior to the hardboards produced by present practices. Not only does my process require a much less expensive plant, reduce unit costs and speed up overall production, but it can be carried out on mats of continuous or indefinite lengths to produce dense sheets in lengths not heretofore attainable.

In carrying out a process of my invention it is important to control the pressure, temperature and moisture content of the particles in order to achieve satisfactory results. The compacted mat is passed between the rolls at nip pressures varying from 1000 to 5000 p.l.i. (pressure per lineal inch), the minimum pressure being necessary to obtain final density and the maximum pressure being the limit above which there is a weakening of the final product. It is necessary also to have some moisture in the wood particles, say from 2 to 25%, preferably from 5 to 15%, of the bone dry weight of the wood. The high pressure prepressing is most advantageously done during a very short time and under conditions which do not change the moisture content of the mat materially thereby retaining sufficient moisture to permit the prepressed sheet thereafter to be successfully pressed under heat and low pressure into the final product having the desired properties and specific gravity. In the final curing a temperature of from 150° C. to 250° C. and a pressure of from 25 to 300 p.s.i. are satisfactory and these must take into consideration whether a resin binder has been used and its thermoplastic or thermosetting properties.

In accordance with a complete process of my invention the mat may be formed of any suitable wood particles and by any of the methods commonly used. The wood particles may be formed from wood of different species of trees, both coniferous species such as pine, cedar, hemlock and Douglas fir, and deciduous species such as beech, birch and maple. The logs may be barked or the barking may be partly or entirely eliminated as when the wood particles are used in the middle of a multi-layer hardboard. In forming wood fibers, the logs are run through a conventional chipper as is common practice in the wood pulping industry, and the chips are softened by steaming in direct contact with steam under suitable conditions. Atmospheric conditions of steaming can be used, but preferably the chips are steamed at pressures of 25 pounds per square inch and higher for periods of 4 minutes or less. The softened chips must be subdivided with a minimum damage to the individual fibers. The fiber production may be accomplished effectively by passing the steamed chips through a double disc attrition mill

such as a Bauer refiner, in which the discs are set not too close together. The subdivided chips can then be dried gently to avoid fiber damage, as with a current of air to a moisture content of from 2–25%, based on the bone dry weight of the fiber. Preferably, a binder is added which may be in solution, in an emulsion or as a dry powder. Likewise, a waterproofing agent such as a hydrocarbon wax, may be added as a liquid, solution or an emulsion by means of spraying to apply a uniform coating on the fibers.

The binder may be either a thermosetting or thermoplastic type. The use of the low pressures in the final hot pressing prevents the usual "blowing" of the product which occurs when non-thermosetting resins are used. However, for most operations, the phenol-formaldehyde and urea formaldehyde thermosetting resins are very effective for the purpose of this invention. The amount of resin used is only enough to bind the fibers together and impart the required strength to the board under its conditions of use. The strength of the board increases with increasing resin content, however, the increase in strength beyond a certain value does not justify the increased cost of the additional resin. Consequently, the amount of resin used is generally limited to an amount below 10%. However, the resistance of the product to the action of water generally requires the use of some resin, but the amount may be very low; thus, 0.5% resin shows a decided improvement in some types over products with no resin.

A suitable water repellent is hydrocarbon wax, for it is extremely effective in small percentages when used under proper conditions of acidity. The hydrocarbon waxes and petrolatums are effective in the range of 0.4 to 1½% and usually no greater effect is obtained with higher percentages. However, up to 3% has been used to overcome non-uniformity in coating and distribution of the wax. Other waterproofing agents such as rosin, rosin size and various bitumens can be used. In the case of the bitumens, they may be used as thermoplastic binders as well as waterproofing agents. Likewise, the binders may improve the water resistance of these products.

In carrying out one type of complete operation of this invention a mass of fibrous wood particles coated with a thermosetting resin and petrolatum is formed into a continuous mat by any suitable method commonly used in this art. For example, the mat may be made by forming one or more layers of the fibers on a moving screen or belt, shaving each layer with a rotary brush to a uniform thickness before forming the succeeding one. The height of the single layer or layers or the total height of all of the layers determines the thickness of the final hardboard. The resin content of the individual layers can be varied as desired. This loose continuous mat is then advantageously compacted as by passing it between belts supported on rolls to a thickness which gives the mat a specific gravity of about 0.10. The compacted continuous mat of wood fibers having the desired moisture content varying from 2.0 to 25%, preferably between 5 and 15%, and containing resin and wax, is passed continuously into the high pressure stage for prepressing between rolls.

The high pressure stage of the invention comprises running the mat between high pressure rolls at from 1000 to 5000 p.l.i. (pounds per linear inch) at a speed which synchronizes with the speed of the required production and which may be as high as 150 ft. per minute. The important condition in the operation of this high pressure stage is that the pressure be as low as practical to give the desired low pressure and pressing time in the final hot pressing operation. Since the p.s.i. (pounds per square inch) which is exerted by a given p.l.i. depends on several factors, e.g., diameter of the rolls, thickness of the mat, thickness of the steel belts, when used, an exact range of p.l.i. is not easily ascertained. However, it is undesirable to use too high a pressure since excessive

pressure reduces the strength of the final pressed hardboard. A measure of the required pressure needed in the high pressure prepressing is obtained from the fact that the mat is to be compressed to a thickness not greater, and preferably less than, the desired thickness of the final hardboard. The time to achieve the desired compression can be exceedingly short, as shown by obtaining of the desired result by passing the mat under a pair of rolls at a speed of about 25 to 28 ft. per minute, which can be exceeded very appreciably, if desired. As a result of the peculiar properties imparted to the fibers, a dense sheet is obtained. One of the objects of this invention is the obtaining of this dense, relatively strong sheet, which, because of its strength, can be handled in the subsequent operations in pressing in a conventional flat bed press without the use of cauls. This, in itself, is a decided advantage in the production of hardboard because the use of these cauls is a source of difficulty and requires a great deal of maintenance. The important property imparted to this dense sheet is that it can be pressed and set into a uniform, hard, strong, high density product at relatively low pressures when treated in the final hot pressing stage.

It is important in this prepressing stage of the process to regulate the pressure conditions so as to minimize any injury that may be caused by excessive pressures and to prevent the loss of moisture which could not be compensated for without resorting to a high final molding pressure. Thus, by passing a mat with a moisture content of from 2 to 25% between the rolls at speeds up to 150 ft. per minute at pressure equivalent to the effect of 1000 p.l.i. to 5000 p.l.i., a web which has higher densities and greatly improved strength is produced as a continuous sheet which can be subsequently pressed under heat and relatively low pressures into a product having the required properties of high strength, water resistance and excellent surfaces. Thus, the high pressure prepressing permits the elimination of the large high pressure presses commonly used in producing hardboard.

The final stage of the process of this invention is accomplished by pressing and prepressed sheet at temperatures from 150 to 250° C. and at the relatively lower pressures of from 25 to 300 p.s.i. for a relatively shorter time than is normally used in pressing hardboard in commercial production. An important feature of this invention is that the final pressing to the required final density can be accomplished at such low pressures that an ordinary plywood press can be used. Therefore, this sheet can be used to replace the face veneer in the conventional plywood process and be pressed to its final density in the same pressing operation used to consolidate the veneer into plywood. When the sheet is to be so used, a thermosetting phenolic binder, such as a phenol-formaldehyde adhesive resin, preferably is incorporated in the compact mat of wood particles, and the mat is then passed through the rolls at a nip pressure of from 1000 to 5000 p.l.i. This prepressed mat or sheet is now used to replace the face and back veneer in the normal plywood process. One such prepressed mat is used as the back of the normal plywood instead of the veneer back. The cross band which has been coated with a phenolic plywood adhesive in the normal way is placed on this prepressed mat. The core veneer is then placed on the cross band. Another cross band veneer coated wih phenolic resin on both sides is placed on the core. The second prepressed mat is then placed on this coated cross band and serves as the face or top layer of the plywood. This entire sandwich of veneer and prepressed mats are consolidated into a single product under the same condition used to make plywood to form a composite product with hardboard faces and back and veneer core.

The temperature in the final stage should be high enough to permit the proper consolidation of the mat to the required density and to set the phenolic resin, i

used, but should not be so high that the product will be burned; the time of pressing varies with the thickness of the hardboard. Due to the highly prepressed sheet, and the low pressure required in the final stage a much more rapid production cycle can be used. The pressing times, therefore, are from a few seconds for thin hardboard to 15 minutes for the thicker hardboard.

The description of the process as being continuous comprehends and defines both the completely continuous operation of forming a continuous mat and sheet of indefinite length and the modified operation in which the sheet from the high pressure stage is cut into sections for final curing in a flat bed press, the importance and characteristic feature being that the sheet produced in the high pressure stage is capable of being pressed in the final stages at lower pressures and faster times than are now used.

In the production of a shaving type board, specially prepared shavings are made by shaving wood generally in the form of blocks or logs into particles which are distinguished from other particles in being thin, about 0.005" to 0.060" in thickness, about ¼" to 2" in length and from about 1/64" to 2" in width due to the breaking along the grain. Their important characteristic is that they are cut across the grain to make their faces as nearly as possible parallel to the grain of the wood to minimize the curling of the shavings and damage to the fiber. These shavings are produced on machines which are now in use. The binder, water and waterproofing agents used are similar to those used in forming the hardboards of the fiber products although the amounts may not be the same. The mixing is accomplished in the various manners known to the art. The mat may be formed as a single or a multiple layer mat. The formation may be done in several ways for instance, a predetermined rate of flow of shavings mixed with water, binder and waterproofing agent is deposited uniformly on a moving conveyor which may be a moving belt or screen or a vibrating conveyor of any of the known types. The shavings are displaced from the belt by brushing or by projection beyond the end of the conveyor, and they may be given additional momentum by a rotating prong on a shaft or allowed to gently float down in a box. Each layer may be leveled and excessive material removed by a shaver such as a rotating brush, a pronged rotor or by a screw which moves the shavings in both directions from the midpoint of the upper face of the mat. The material may be compacted either before or after the mat formation by vibration to give more uniform density and leveling. The mat is given a preliminary compressing in a continuous low pressure press such as a belt press. The slightly compressed mat is then prepressed continuously under high pressure. This prepressing technique follows that used with the fiber particles, but the equipment used may be varied to meet the requirements of the mats formed of shavings. While hardboards with specific gravities of 1.00 may be produced from shavings, the major use for these products is in lower densisty boards, below 0.8 specific gravity and down to 0.3 specific gravity. For this reason, the high pressure prepressing pressures used may be lower and the final pressing pressure also may be lower than used in making fiber type hardboard. However, the basic advantages of the invention, that is, the reduction of the pressure and time required in the final low pressure and high temperature stage can be obtained by the prepressing of the mat under pressure high enough to reduce its thickness to at least no greater than its final thickness and preferably less.

The mats used in preparing the data listed in Tables I, II, III and IV were prepared from chips of hemlock, cedar, and Douglas fir wood, respectively. These chips were steamed at pressures of 25 p.s.i. for approximately 4 minutes and while hot passed through a Bauer double disc refiner without the addition of water to produce a fiber. The fiber was partially dried in a hot air stream in a gentle manner. A binder and waterproofing agent may or may not be added. However, in these operations the binder used was an aqueous solution of phenol-formaldehyde resin and the waterproofing agent was a molten hydrocarbon wax. A wax emulsion may be used. The water content was now reduced to the amounts given in the examples by a further drying with hot air. The fiber was formed into a mat by blowing the fiber onto a screen having a partially evacuated air space beneath the screen. The excess material was shaved off with a brush to give mats of the required uniform thickness. The mats were then given a preliminary pressing which produces a mat having a specific gravity of approximately 0.1. The mats described in Tables I and II were prepressed in a flat press and then hot pressed under the conditions listed in Table I. The effect of increasing the prepressing pressure on decreasing the final pressure required to give a product with a fixed specific gravity is shown in the curves and in Table I. Thus, in order to obtain a product having a specific gravity of 1.00, a mat prepressed at 2000 p.s.i., requires a final pressure of approximately 470 p.s.i. while a mat prepressed at 40,000 p.s.i. requires only 60 p.s.i. However, the application of pressures up to about 2000 p.s.i. have only a slight effect on the reduction of the final pressing pressures. One of the important features of this invention lies in the fact that the prepressing can be done almost instantaneously and consequently this high pressure need only be applied over a short area such as between a pair of rolls. Consequently, the application of the high pressures required are easily obtained mechanically. Thus, a pair of rolls which operate at a pressure of 2500 p.l.i. can exert pressures in excess of 25,000 p.s.i. There are many existing machines which operate at pressures of 2500 p.l.i. and higher.

TABLE I

Cold Pressing, p.s.i.	Hot Pressing, p.s.i.	Sp. g.
2,000	470	1.00
2,000	600	1.08
2,000	700	1.11
2,000	800	1.13
5,000	470	1.11
5,000	600	1.13
5,000	700	1.15
5,000	850	1.21
10,000	300	1.10
10,000	400	1.15
10,000	500	1.16
10,000	600	1.19
20,000	200	1.12
20,000	300	1.14
20,000	400	1.19
20,000	500	1.18
30,000	100	1.08
30,000	150	1.09
30,000	200	1.15
30,000	300	1.18
40,000	60	0.94
40,000	100	1.07
40,000	150	1.12
40,000	200	1.16
40,000	250	1.13

The prepressing pressures should not be excessive since the data in Table II which is plotted in FIGURE 2 shows that increasing the prepressing pressures decreases the final strength of the product. However, several factors influence this relation such as the diameter of the roll, the stiffness of the belt which relate to the severity of the stress between sections infinitely close and in the nip of the rolls and factors which might be thought of as relieving the strain such as thickness of the board and mat. Thus the 1/10 inch thick board shows less effect on the prepressing pressure on the strength of the pressed products as indicated in subsequent data.

TABLE II

Cold Pressing, p.s.i.	Tensile at 1.1 sp. g.
2,000	2,250
5,000	1,820
10,000	1,790
20,000	1,570
30,000	1,430
40,000	1,140

Another series of tests were made which show both the effect of the prepressing pressures in p.l.i. as compared to no roll prepressing and the effect of final pressing pressures. The fiber used was obtained from cedar and contained 6% of a thermosetting phenolic resin, 2% of a petrolatum and 8.7% water. The final boards were 0.030" to 0.040" in thickness. The roll prepressing was done between steel rolls 22" in diameter at the p.l.i. indicated. The speed of the mat passing thru the rolls was 28.8 ft. per minute. The final pressing was done in a flat bed press of the conventional type. The results of these tests are shown in Table III.

TABLE III

Properties of pressed boards

Rolling Pressure, p.l.i.	Final Pressing Conditions											
	60 p.s.i.			90 p.s.i.			120 p.s.i.			150 p.s.i.		
	Sp. Gr.	Tensile Strength		Sp. Gr.	Tensile Strength		Sp. Gr.	Tensile Strength		Sp. Gr.	Tensile Strength	
		Dry	Wet		Dry	Wet		Dry	Wet		Dry	Wet
0	0.61	600	200	0.79	1,400	400	.84	1,800	800	0.95	3,000	1,400
2,500	0.89	1,500	600	0.95	2,200	1,200	1.01	3,000	1,200	1.03	3,400	1,700
5,000	0.91	1,600	700	0.99	2,100	1,100	.95	2,600	1,000	1.09	2,700	1,300
7,500	0.92	1,800	700	1.03	2,600	800	1.01	2,200	800	1.05	3,100	900

NOTE.—Pressing condition 1 minute at 180° C. at pressure given above.

The fact that thicker (1/10 inch) boards can be pressed at very short pressing time and that the water resistance of the board can be improved by baking as shown in the data given below.

Table IV gives the results of making pressed boards on commercial flat bed press equipment under the conditions listed.

TABLE IV

Properties of pressed boards

Rolling Pressure, p.l.i.	Pressing Time, Min.	Final Pressing Conditions								
		60 p.s.i.			90 p.s.i.			120 p.s.i.		
		Sp. Gr.	Flexural Strength		Sp. Gr.	Flexural Strength		Sp. Gr.	Flexural Strength	
			Dry	Wet		Dry	Wet		Dry	Wet
0	1				0.67	750	0	0.71	1,200	0
5,000	1	0.91	2,900	1,100	0.97	4,200	1,400	1.00	5,400	1,700
5,000 [2]	1	0.98	3,500	1,700	1.02	4,400	1,900	1.09	4,900	1,800
5,000 [2]	1½	1.01	3,000	2,600	1.00	3,800	1,800	1.01	4,800	3,000

[1] Pressing at 206° C. followed by baking at 206° C.
[2] 5 passes through the rolls at 5,000 p.l.i.
NOTE.—Temperature of final pressing 180° C. except as noted.

The mats used in forming the hard boards of Table IV contained 2½% of a phenolic resin (Monsanto PF594) and 1½% of petroleum hydrocarbon wax. The fiber was made from old growth Douglas fir. These mats were felted on commercial equipment. In another test, the same fibers used in Table IV were pressed into a hardboard on a commercial flat bed press for 15 seconds at 750 p.s.i., vented, and then pressed at 150 p.s.i. for 4 minutes which results in a board 0.100 inch thick, having a sp. gr. of 1.01, flexural strength when dry of 5500 p.s.i. and when wet of 2800 p.s.i. It is evident that the roll pressed samples have properties similar to the commercial product made on conventional flat bed pressing equipment.

The pair of experimental rolls used in producing the hardboard described in Table III and IV were relatively small in diameter. The variability of the results are due to relatively narrow pressing area in the nip of these small rolls and uncertain operation of the steel cauls used experimentally instead of continuous belts. However, the results do show that the high pressure rolling permits the use of shorter times and lower pressures in the final pressing operation, and that subsequent baking has increased the wet flexural strength without lowering the dry strength.

It is further shown in the following test that very desirable hardboard can be made from wood fiber in the absence of either resin or wax. Fiber obtained from hemlock and containing 22.5% water was formed into a mat and run through the rolls at 5000 p.l.i. and was given a final pressing for one minute at 180° C. at 100 p.s.i. The resulting hardboard had a tensile strength when dry of 3600 p.s.i. and when wet of 1000 p.s.i., a specific gravity of 1.27, and a thickness of approximately 0.040 inch. The flexural strengths could not be determined satisfactorily on the thin (0.040") samples and the tensile strength was determined. A rough correlation of the tensile strength to the flexural strength is 1:2.

The effect of the high pressure prepressing is shown on hardboards made from different shaped particles. Thus, a hardboard made from specifically prepared shavings approximately 0.010" thick and ¾" long and from 1/16" to ¾" wide which were cut across grain from a cedar block and coated with 4% of phenolic resin and 2% wax was made into mats. The mats were prepressed under the pressures listed in Table V and the final pressing conditions were for 7½ minutes at 180° C. The specific grav-

ity of the product increased with increasing prepressing pressure, as shown in Table V.

Table V

Prepress Pressure, p.s.i.	Final Pressing Pressure, p.s.i.	Specific Gravity
2,000	160	0.805
4,000	160	0.915
6,000	160	0.96
8,000	160	0.99

The hardboard was approximately 3/8" thick.

In the accompanying drawings:

FIG. 1, is a set of curves derived from Table I.

These curves show the effect of increasing the prepressing pressure on the final pressure required to give a hardboard with a desired specific gravity.

FIG. 2, is a curve derived from the data of Table II. This curve shows that prepressing pressures should not be excessive, otherwise there is a resulting decrease in the final strength of the hardboard.

The thicknes of the final hardboard and its final density when hot pressed are factors which govern the decrease in thickness resulting from prepressing. The controlling factors which determine the extent of the decrease in thickness occurring in this high pressure prepressing are the use of prepressing pressure which must not be so high as to appreciably decrease the strength of the final product, but which will be high enough to reduce the required final hot pressing pressure which in some cases may approach zero. Increasing the thickness of the mat decreases the deleterious effect of the high pressure prepressing.

I can prepress a fibrous material made from wood under high pressure, without using resin or wax, and mold it into a high density product by pressing it under heat at relatively low pressure. The invention, accordingly, is applicable to the treatment of paper and other fibrous mats and comprehends the use with the fibers of all types of resins, for example, lignin as in wood, and added resins which bind the fibers.

I claim:

1. In the production of high density hardboard, the improvement which comprises incorporating in a mass of lignocellulose particles containing from 5 to 15% of moisture based on the bone dry weight of the lignocellulose a resinous binding material, compacting said mass of particles into a compact mat, while said compact mat is at normal room temperature subjecting it to a pressure of from 1000 to 5000 p.l.i. to at least final density, and then curing the resultant sheet at a pressure from 25 to 300 p.s.i. at an elevated temperature to final density.

2. The process of claim 1 in which said mat is compressed to a final density in excess of 0.5.

3. The process of claim 1 which comprises passing the mat between the nip of pressure rolls at a speed of at least 25 feet per minute.

4. The process of claim 1 which comprises providing a compact mat formed of presteamed wood fibers.

5. The process of claim 1 which comprises providing a compact mat formed of wood shavings.

6. The process for producing high density hardboard which comprises steaming wood particles, forming the wood particles and a resinous binding material into a compact mat having a moisture content of from 5 to 15% based on the bone dry weight of the wood, passing the mat at normal room temperature between at least one pair of pressure rolls at a nip pressure of from 1000 to 5000 p.l.i. to compress the mat to at least final density, then subjecting the resulting dense sheet to a pressure up to 300 p.s.i. and at an elevated temperature to cure the sheet at final density.

7. The process of claim 6 which comprises passing a web of indefinite length continuously between the rolls at a speed of at least 25 feet per minute.

8. The process of claim 6 which comprises applying to the mat a water repellent prior to curing the resin at the low pressure and at the elevated pressure.

9. The process of claim 6 which comprises cutting the dense sheet into shorter lengths and compressing them in a flat bed press at a pressure of from 25 to 300 p.s.i. and at a temperature of from 150° to 250° C.

10. The process of claim 6 which comprises passing the dense sheet from the rolls through an endless belt press to apply a pressure of at least 25 p.s.i. and at a temperature of from 150° to 250° C. to compress the sheet to final density and cure it.

11. In the production of a composite high density hardboard and plywood, the improved process which comprises forming a compact mat of wood particles having from 5 to 15% of moisture and a thermosetting phenolic binder, passing the mat between rolls at a nip pressure of from 1000 to 5000 p.l.i. to form a sheet having a least final density, connecting the sheet adhesively to at least one sheet of plywood by means of a thermosetting phenolic adhesive, and compressing the sheet and plywood under a pressure below said nip pressure and at an elevated temperature to set the binder and the adhesive forming a composite sheet of hardboard and plywood.

12. The process of claim 11 which comprises admixing a phenol-formaldehyde adhesive resin with the wood particles as the binder, and applying a phenol-formaldehyde adhesive resin to the dense sheet and the plywood, and, after the sheet and plywood are joined, heating the composite product to a sufficient temperature to set the resin.

13. The process of claim 11 in which the mat of wood particles is compressed to a specific gravity of at least 1.0.

14. In the production of high density hardboard, the improvement which comprises incorporating in a mass of lignocellulose particles containing from 5 to 15% of moisture based on the bone dry weight of the lignocellulose a resinous binding material, compacting said mass of particles into a compact mat, while said compact mat is at normal room temperature passing it between a pair of rolls at a nip pressure of from 1000 to 5000 p.l.i. and compressing the mat to at least final density, and then curing the resultant hardboard sheet at a pressure from 25 to 300 p.s.i. at a temperature of 150° to 250° C. to form a hardboard having a specific gravity of at least 1.0.

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