

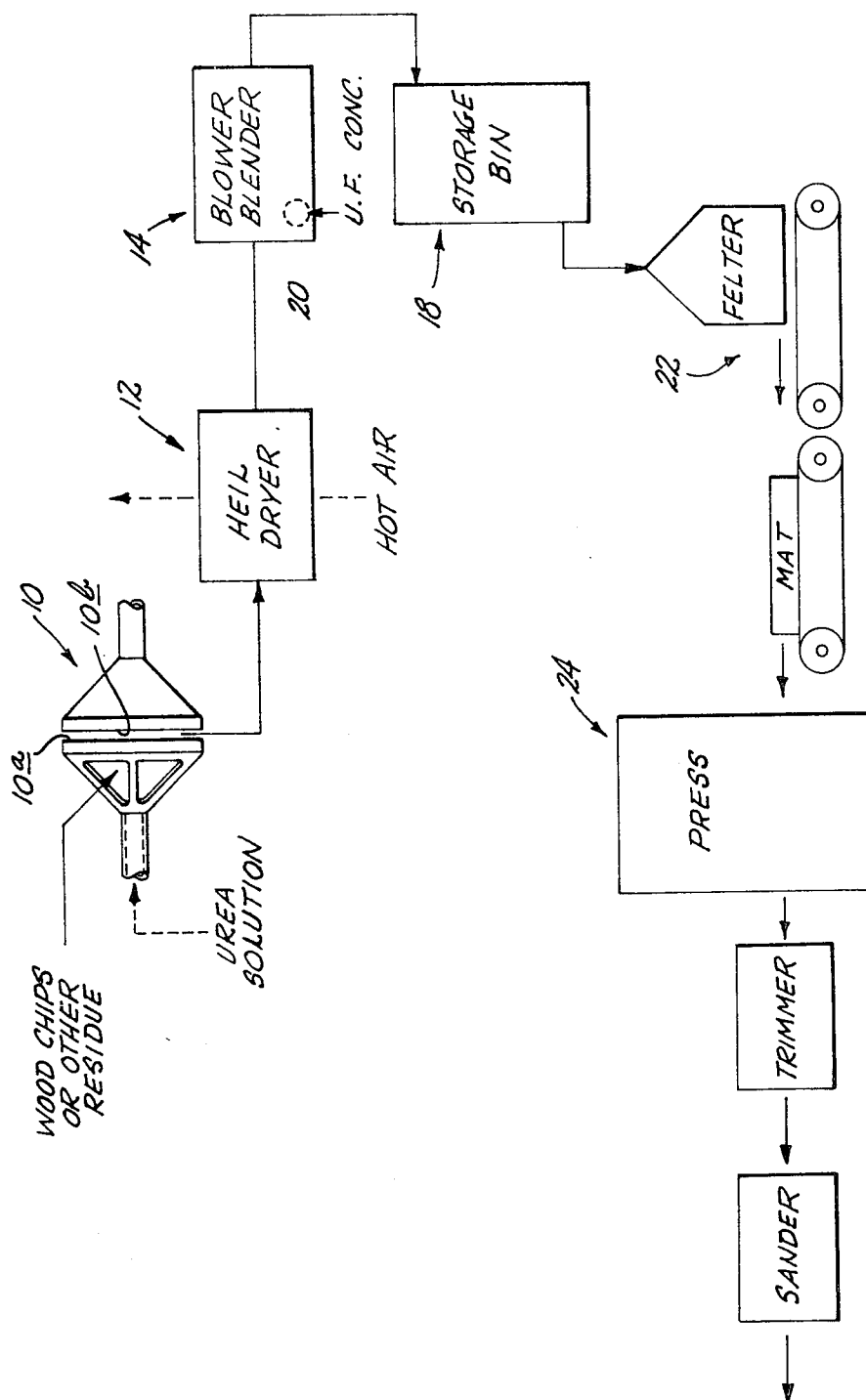
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MANUFACTURE OF PRODUCTS FROM COMMINUTED WOOD

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MANUFACTURE OF PRODUCTS FROM COMMUNUTED WOOD

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ABSTRACT OF THE DISCLOSURE

A process for preparing a wood mixture comprising comminuted wood having urea and a urea-formaldehyde concentrate incorporated with the comminuted wood at two stages. The urea is added to the comminuted wood first, and the resulting wood mass is dried prior to the distribution in the wood mass of the urea-formaldehyde concentrate. The making of a consolidated product by heating and pressing such a wood mixture containing urea-formaldehyde concentrate, with resinification occurring during such heating and pressing to form a urea resin binder.

This invention relates to the production of products from comminuted wood. The invention contemplates a method of preparing a urea-formaldehyde resin which binds the wood together in the final product, featuring the two-stage addition of components that condense when heat and pressure are applied to form in situ the urea-formaldehyde resin.

In the making of consolidated products from comminuted wood, a urea-formaldehyde resin suggests itself as the binder for holding the wood particles together, since the material is comparatively inexpensive and under proper conditions can produce good bonds with a relatively fast press cycle. Such a urea resin has not been employed in the manufacture of many kinds of products, however, because of certain difficulties, including the fact that it is hard properly to mix the resin with the wood material, and handling problems are experienced after mixing. Procedures have been proposed wherein components combinable to produce a resin are mixed with the wood material, but these generally have been of a rather specialized nature, and have not proved adaptable to large scale commercial production.

A general object of the present invention is to provide an improved process for forming products from comminuted wood, which results in the final production in the consolidated product of a urea-formaldehyde resin binder, such forming, in situ, during the application of heat and pressure from separate components added earlier at two different stages.

More specifically, the invention features the production, as one stage of the process, of a mass of comminuted wood having urea distributed therein, the subsequent drying of this wood material, and after such drying the distribution in the mass of comminuted wood of a concentrated, urea-stabilized, formaldehyde solution. The wood mixture so produced is then subjected to heat and pressure, with the in situ formation of a urea-formaldehyde resin.

With the process contemplated, a resin results which produces good internal bonds in a product prepared from the comminuted wood. Apparently a significant factor in producing such bonds is that the formaldehyde contributed by the urea-formaldehyde solution is sufficiently tied and appropriately positioned in the wood mixture to be available for reaction with the urea contributed from two sources to produce the type of condensation resulting in good bonds. The concentrate when added to the

comminuted wood introduces little water, requiring no further drying of the furnish after the addition. The urea initially incorporated with the comminuted wood prior to the drying, becomes well distributed, and this urea is in no way adversely affected by subsequent drying to bring the moisture content of the wood mass down to requisite levels.

The invention has many applications, but it is particularly useful in the production of consolidated products from comminuted wood where the products have relatively high density, and it is desired to minimize blows, i.e., rupture of the board resulting from the internal generation of steam during the press cycle. This is a phenomenon, for instance, which occurs in the manufacture of hardboard using a conventional dry process, where heat and pressure are applied with a steam-heated press. With this type of process, the wood mixture from which the board is prepared must have a moisture within controlled limits to minimize the chance of blows. The invention enables such a wood mixture to be prepared, without having to excessively dry the wood as a step in the preparation of the wood mixture (which introduces an explosion hazard), and with the elimination of other problems normally associated with its preparation.

These and other objects and advantages will become more fully apparent as the following description is read in conjunction with the accompanying drawing, which is a flow diagram illustrating a typical process carried out as contemplated herein.

Explaining the invention in connection with the manufacture of hardboard using a dry process, which exemplifies a type of manufacture where the invention might be utilized with the obtaining of advantageous results, difficulties have been encountered when a conventional urea-formaldehyde resin is utilized as the binder, by reason of moisture conditions present during various stages of the process. To further explain, when making hardboard, the final wood fiber mixture which is air felted to prepare a mat should have a moisture content of no more than about 18% (based on the dry weight of the wood), and preferably less than about 10%. With a greater moisture, and using a conventional steam-heated platen press, blows tend to occur during the press cycle. These may be described as a rupturing of the panel by reason of steam generated internally, the product being so dense that steam cannot escape readily. Because obtaining proper moisture levels has not been practical using a urea resin, generally a phenolic resin has been employed as the binder, with such being added to raw wood residue which is subsequently defibered and further processed to produce the furnish.

Further explaining, urea-formaldehyde resin tends to be a tacky substance, and is more sensitive to heat and moisture than a phenolic resin. Water is used as a vehicle for introducing the resin, which means that when a urea resin is added to raw material, the moisture content of the material rises. As a consequence, when a urea resin is mixed with wood material, and particularly when the latter is in fiber form, a moist and somewhat tacky fiber mass results, that is difficult to handle by reason of its tendency to ball up and to adhere to the equipment processing it. If such is then dried, the resin material in the material becomes unsuitable as a binder in the final consolidated product. If the wood raw material is forced dried at elevated temperature to a very low moisture content prior to the addition of the urea resin, a product with acceptable moisture content directly after urea resin addition might be produced, but such extreme drying introduces a danger of explosion.

As contemplated by the invention a urea resin constitutes the binder in the final consolidated product, but such is formed in situ from urea and a urea-formaldehyde

hyde concentrate earlier incorporated with the wood material at two different stages.

The urea is incorporated with the wood material prior to final drying, and preferably, in the case of manufacture of hardboard, during the defibering of wood chips or residue whereby it becomes intermixed with the fiber product. Wood chips during defibering typically are relatively moist, and may have, for instance, a moisture content ranging from about 40–200% (based on the dry weight of wood). With the wood chips being wet, dry urea may be fed into a refiner together with the wood chips with the urea solubilizing in the moisture of the wood and the refining action being operable to distribute the solubilized urea completely throughout the wood material. Alternatively, a urea solution may be incorporated at this point, with the refining action again being operable to produce complete distribution of the solution. The urea becomes distributed on the surfaces of the wood fibers produced by the refining.

With the urea distributed in the comminuted wood, the wood may be dried to a moisture content which is lower than the level of the moisture desired in the final wood moisture but not as low as would be the case were a conventional urea-formaldehyde resin employed. This is because, as contemplated by this invention, the amount of water added at a later stage is relatively small. The drying of the comminuted wood, therefore, need not be done to such a low level as to introduce explosion problems in the plant. The urea itself is not adversely affected by the drying step.

After drying of the comminuted wood including the urea, a urea-formaldehyde concentrate is distributed in the comminuted wood, i.e., fiber in the case of hardboard, as by spraying it on the wood with tumbling of the wood as it passes through a spray zone. The concentrate introduces the formaldehyde necessary for condensation with the urea in the production of a final urea-formaldehyde resin. Being a concentrate, very little water is added at this stage, which, as already indicated, makes further drying unnecessary.

Formaldehyde, as is well known, is a gas at ordinary temperatures, and soluble to a limited degree in water. Formaldehyde tends to build up polymers in an aqueous solution, which precipitate out at low temperatures, particularly a problem as the concentration of a solution is increased. Methanol has been incorporated in formaldehyde solutions to inhibit polymer formation, but even with the inclusion of methanol, with the higher concentrations, precipitation may occur unless a solution is stored at an elevated temperature. It is to be noted that the usual methanol-inhibited formaldehyde solutions are not suitable for the practice of the instant invention, for the reason that the amount of water added to the comminuted wood by such solutions tends to be excessive, and there is apparently an effective loss of formaldehyde during the final heating and pressing cycle which results in the production of consolidated products of inferior quality.

It has been discovered that unexpected and superior results are obtained if the formaldehyde which is incorporated with the comminuted wood takes the form of what is known as a urea-formaldehyde, or UF concentrate. These comprise urea-stabilized, concentrated, formaldehyde solutions, containing from 60–90% solids. They are true solutions, with urea and formaldehyde only slightly reacted, not to form a resin, but maintained in such a state that they are essentially the chemical equivalents of urea and formaldehyde, insofar as their ability to form resins when suitably treated is concerned. The mold ratio of formaldehyde to urea in such solutions normally ranges from about 4.4–7.3 moles formaldehyde for each mole of urea. The preparation of such UF concentrates is more fully described in such prior art patents as 2,652,377 and 2,946,403.

With the inclusion of the urea-formaldehyde concentrate with the comminuted wood, the urea which

stabilizes the formaldehyde in the solution constitutes a further addition of urea to the wood mass. The amount of urea, therefore, that is incorporated with the wood initially, for instance, during the defibering of wood chips, is selected so that after the addition of the urea-formaldehyde concentrate, the mole ratio of urea to formaldehyde becomes adjusted to the mole ratio desired in the final product. In this connection, the usual resin binder which forms in the ultimate consolidated product will have a mole ratio of urea to formaldehyde ranging from about 1:1 to 1:2. The amounts of urea and urea-formaldehyde concentrate mixed with the wood are selected so as to give in the final consolidated product the usual proportion of resin to wood which, in the case of hardboard, ordinarily ranges from about one to 10 parts resin for each 100 parts wood (here and elsewhere in the application, wood parts are on a dry basis unless otherwise indicated).

With a wood mixture containing urea-formaldehyde concentrate prepared as contemplated, and when such is consolidated by the application of heat and pressure, the initially incorporated urea which collects on the surface of the comminuted wood material and the urea and formaldehyde incorporated by the urea-formaldehyde concentrate addition come into intimate contact and quickly condense to form, in situ, a urea-formaldehyde resin binder. Prior to the application of heat and pressure, there is insignificant interaction between the materials, which means that the wood mixture prepared has good storage stability.

The mechanisms of the reaction which takes place during the application of heat and pressure, whereby resinification occurs, are felt to include the combining of the formaldehyde with urea produced upon the application of heat, and the dissolving of the urea and formaldehyde in available heated water, with subsequent condensation. While the urea-formaldehyde concentrate which initially is added may have a pH ranging from about 7–9.5, at the elevated temperatures employed (normally 250–350° F.) acidic conditions occur in the wood mixture which are the result of natural wood acids, or added acid catalyst, catalyzing the condensation whereby it proceeds at a very rapid rate. By using the urea-formaldehyde concentrate as the source of formaldehyde, the formaldehyde remains sufficiently tied in place and properly positioned adjacent the surfaces of the wood particles, during the condensation, to prevent the same from being effectively lost, as by penetrating into the wood or escaping as a gas without forming a condensation product. The resin bond desired is between the surface of the wood particles, or fragments, and this type of result is apparently obtained with the urea-formaldehyde concentrate as the donor of the formaldehyde. It has been noted that with relatively high density materials, i.e., having a density of 40 pounds per cubic foot and over (such characterizing hardboards and certain types of particle board) internal bonds can be produced exceeding 100 pounds per square inch.

Describing the preparation of a specific product using the invention, hardboard was prepared, by a dry process, by introducing wood chips or other residue into a refiner such as a double-disk Bauer refiner. Such is indicated schematically in the drawing at 10, and includes opposed disks bounded by working surfaces 10a, 10b in counter relative rotational motion with respect to each other. The chips were moist when fed into the refiner. Simultaneously with feeding of the chips, an aqueous urea solution was fed into the refiner, as by feeding such through an internal passage in one of the shafts supporting one of the Bauer disks. The refiner defibered the chips while simultaneously mixing the urea with the fiber product. In a specific example, 100 parts wood (on a dry basis) were fed into the refiner, with the simultaneous feeding of 17.2 parts of a 25% concentration aqueous urea solution. The product coming from the refiner had a 90% moisture content, i.e., 90 parts water for 100 parts dry wood.

Comminuted wood, i.e., fiber, passing from the refiner was then fed through a Heil dryer, which is a drum-type dryer with hot air circulated therethrough. Such is shown in the drawing at 12. In the case of the specific panel being described, such dryer had an air inlet temperature of 450° F. In the dryer water was removed by evaporation from the wood material, to reduce the moisture content of the fiber to 5.2% (with these and other figures given herein, a rounding to the first decimal has been done for reasons of simplicity). The temperature of the air leaving the dryer was approximately 160° F.

On leaving the dryer, the wood fiber was transported using a blower into a storage bin. The blower and storage bin are shown in the drawing at 14 and 18, respectively. At the intake to the blower, a urea-formaldehyde concentrate was sprayed onto the fiber material through a sprayer forming a spray zone. There was a tumbling of the wood fiber produced by air flow on passing such spray zone. By reason of this tumbling, and the spraying of the concentrate, the concentrate became well distributed. The spray zone in the drawing is indicated in the box representing the blower by the dotted circle 20, depicting the nozzle device used to spray the concentrate.

The concentrate used was UF 20/51 distributed by the Borden Chemical Company, and had the following specification:

formaldehyde—50–51%
urea—20–21%
pH—6.8–7.2
specific gravity—25°/25° above 1260
viscosity (50–70°)—250 cps.

In the specific example being described, 9.6 parts of concentrate were introduced for every 100 parts comminuted wood. This resulted in the introduction of about 2.8 parts water for every 100 parts wood, whereby the comminuted wood had a moisture content on leaving the spray zone of about 8%, which is well below the 18% moisture ordinarily felt to be the most permitted in a dry process of making hardboard using steamheated platens. The wood mixture contained, expressed as parts per 100 parts dry wood, 6.3 parts urea and 4.9 parts formaldehyde.

Such wood mixture was felted onto a screen using a vacuum former, as illustrated in the diagram at 22. The mat prepared was divided into lengths and then transported into press 24 where panels or boards were prepared, using a temperature of 325° F., a pressing pressure of 700 p.s.i., and a seven-minute press cycle (boards of $\frac{3}{8}$ inch thickness). Polished caul plates bounded each side of each mat while being pressed. Subsequently, these boards were trimmed and sanded in the usual manner. The moisture content of the boards on leaving the press was about 4–5%.

The panels, or boards, produced had smooth faces on opposite sides, by reason of the use of polished caul plates. The bond between wood fibers was good throughout, including over face regions. The boards had a density of 62 pounds per cubic foot. When tested, and using ASTM procedures, the boards demonstrated an internal bond averaging 250 p.s.i.

Further illustrating the invention in connection with the manufacture of particle board, green planer shavings were removed from a storage bin, and a 25% aqueous urea solution sprayed onto the shavings. The urea solution was introduced to the shavings at a rate of 4.3 parts of urea for 100 parts wood, on a dry weight basis. After drying of the shavings to a moisture content of about 10%, a urea-formaldehyde concentrate having the specifications above indicated was sprayed onto the shavings and the shavings then passed through a blender. 9.5 parts of concentrate were introduced for every 100 parts wood. The material leaving the blender was felted to prepare a mat which was subsequently pressed at 300° F. and a maximum press pressure of 700 p.s.i., for 5½ minutes, to a thickness of 0.625 inch.

Particle board produced in this manner had a density of 42.2 pounds per cubic foot, a modulus of rupture of 1,815 p.s.i., and an internal bond of 130 p.s.i.

In yet another application of the invention, hardboard was prepared with a wood flour overlay included to reduce the soak characteristic of the hardboard. In the preparation of this product, a mat was dry felted from a comminuted wood mixture prepared as described in connection with the example above set forth illustrating hardboard manufacture. A layer of wood flour was dusted over the surface of this mat, with the wood flour in the final mat representing about 3% of the total weight of the wood in the mat. The wood flour, comprising comminuted wood material passing through an 80 mesh screen, was prepared through the steps of spraying urea solution onto wood chips, reducing the wood chips to flour of proper particle size, drying of the product, and then blending with the product a urea-formaldehyde concentrate. The urea was introduced at the rate of 4.3 parts urea per 100 parts wood, and the concentrate was introduced at the rate of 9.5 parts concentrate per 100 parts wood, as described in the example above relating to particle board manufacture.

The composite mat produced was placed in a press and pressed for 5½ minutes at 280° F., using a maximum press pressure of 700 p.s.i. A hardboard was produced having a thickness of 0.250 inch, a density of 64.3 pounds per cubic foot, and an internal bond of 235 p.s.i. The machinability of the product was extremely good, and paint holdout in comparison to a similar dry process board prepared without the wood flour overlay was excellent.

In this connection, and in the preparation of wood flour for dusting over the mat, balling of the flour during its processing and prior to preparing the mat can be quite a problem, the problem being overcome with the two-stage addition of urea and urea-formaldehyde concentrate as contemplated by this invention.

A comminuted wood mixture prepared as contemplated may have other uses than the production of panels, and consolidation of the wood mixture may be done in other ways, as by using radio frequency for heating, or by applying pressure using dies or extrusion techniques.

Simultaneously with the addition of urea, waxes, either in a solid state or an emulsion, may be added to the wood material. These waxes serve as sizing, and reduce water absorption in the finished product. By way of example, and using the process just outlined, wax was incorporated with the comminuted wood by introducing an emulsion of wax at a rate sufficient to include 0.5 part wax for 100 parts wood (dry basis) into the Bauer refiner.

In other types of manufacture, of course, the defibering may be done using additional treatment than merely mechanically refining the wood residue. For instance, the wood residue may be subjected to a preliminary cooking treatment, which serves to heat the wood and additionally to soften it, whereby defibering later with the refiner is promoted.

It should also be noted that various forms of comminuted wood may be employed. For instance, the comminuted wood in the wood mixture might include such materials as wood flakes, slivers, chips, etc. The addition of catalysts to the mixture, or buffers, to speed up or slow down the cure, either throughout or in selected regions of the mat prepared, is also possible according to the invention.

Generally summarizing various advantages realized by the invention, a procedure is contemplated which permits the production of a comminuted wood mixture with a moisture content within a prescribed range, without having to dry the wood mixture after the formaldehyde is present, and without having to dry the wood mixture excessively at any given time, whereby to introduce the hazard of explosions. Moisture contents are obtainable in the final wood mixture that are below 10%, whereby the problems of blows, etc. during the press cycle are minimized. The latter is a particularly important consideration when man-

ufacturing relatively dense products, where it is difficult for steam to escape from the article being pressed. It is practicable with the invention to obtain a wood mixture within acceptable moisture limits, while still including a relatively large amount of binder forming materials.

The comminuted wood mixture produced has a relatively low tack level, inhibiting problems of balling in the mixing machinery, and the build-up of resinous deposits on various manufacturing components. Further, with a low tack level, uniform dry felting of the wood mixture is made easier.

The storage life of the wood mixture produced is significantly better than that of material produced using regular procedures. A conventional wood mixture prepared with a urea-formaldehyde resin will slowly cure at room conditions, particularly in the presence of the acidic wood material. A comminuted wood mixture including the urea and the concentrate as described has excellent stability, which exceeds 24 hours.

The invention makes possible the use of a urea-formaldehyde type resin as a binder in the final product, in articles which heretofore have not been made satisfactorily with such type binder. As a consequence, faster cure times at lower temperatures may be used than are possible with a phenolic type resin. This permits, as a corollary, an increase in the output capacity of any given plant. Reduced press temperatures also permit higher out of press moisture contents in products produced, eliminating or reducing the need for subsequent humidification treatment of the product. The use of lower press temperatures is also a factor in inhibiting explosion dangers. Furthermore, urea-formaldehyde type resin binders are more susceptible to being modified by the inclusion of a fire retardant such as a borate, a procedure not usually recommended with phenolic systems because of interference that the borate produces. In certain applications as where surface abrasion resistance, hardness and machinability are desired, the use of a urea-formaldehyde condensate is superior to a phenolic system.

While a particular embodiment of the invention has been described, obviously variations and modifications are possible, and it is not intended by this disclosure to be limited in all respects to the specific details hereinabove enumerated.

It is claimed and desired to secure by Letters Patent:

1. In the preparation of a product from comminuted wood, the method comprising preparing a mass of comminuted wood having urea mixed therewith to be distributed therein, drying the mass to reduce the moisture content thereof, after such drying forming a mixture containing urea-stabilized formaldehyde concentrate by distributing in the dried mass a urea-stabilized formaldehyde concentrate containing the equivalent of urea and formaldehyde combinable with the urea in the originally prepared mass to produce a urea-formaldehyde resin, and with the application of heat and pressure consolidating the wood mixture to form the product, the urea and urea-formaldehyde concentrate condensing during such application of heat and pressure to form in situ a urea-formaldehyde resin binding together the comminuted wood in the product formed.

2. The method of claim 1, wherein the comminuted wood comprises defibred wood, and the mass of comminuted wood having urea distributed is prepared by passing wood chips through a refiner to produce the defibred wood while simultaneously feeding urea into the refiner.

3. The method of claim 2, wherein the urea which is fed into the refiner comprises an aqueous solution,

4. The method of claim 1, wherein the product produced comprises a board with a density greater than about 40 pounds per cubic foot, the comminuted wood comprises defibred wood, and drying of the wood mass reduces the moisture content thereof sufficiently to produce in the wood mixture containing urea-formaldehyde concentrate a moisture content no greater than about 18%.

5. The method of claim 1, wherein the product produced comprises a panel with a density greater than about 40 pounds per cubic foot, the comminuted wood comprises defibred wood, the mass of comminuted wood with urea distributed therein is prepared by passing moist wood particles through a refiner to produce defibred wood while simultaneously feeding urea into the refiner, and the drying of the wood mass reduces the moisture content thereof sufficiently to produce in the wood mixture containing urea-formaldehyde concentrate a moisture content no greater than about 18%.

6. The process of claim 1, wherein the distribution of the urea-formaldehyde concentrate is performed by spraying the concentrate onto the dried wood mass in a spray zone and while the wood mass is moved with tumbling through such spray zone.

7. The process of claim 5, wherein the application of heat and pressure is performed with opposed polished plates, to produce a board having smooth faces on opposite sides.

8. The process for preparing a difibred wood mixture suitable for dry felting of a mat in the preparation of hardboard comprising passing wood through a refiner simultaneously with the introduction into the refiner of urea to produce a mass of defibred wood having the urea mixed therewith with such typically having a moisture content ranging from about 40-200%, then drying the defibred wood to remove water therefrom thus to reduce the moisture content of the defibred wood, and after such drying forming a defibred wood mixture containing urea-formaldehyde stabilized concentrate by passing the defibred wood through a spray zone where a urea-stabilized formaldehyde concentrate is sprayed onto the defibred wood with tumbling of the defibred wood in such spray zone, the drying of the defibred wood reducing the moisture content thereof to a low enough level whereby there is produced after distribution of the concentrate a furnish having a moisture content no greater than 18%.

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