CONTINUOUS HARDBOARD PRODUCTION

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ABSTRACT
A thin resin-bonded hardboard is produced by forming from a practically dry starting material containing a major part of defibrated ligno-cellulose plant substances and only a small percentage of synthetic resin binders a continuous, porously felted fiber mat which is continuously passed between a pair of cooperating hot press rollers under such conditions that the thickness of the mat is reduced to only a small fraction of the original one and the fibers are bonded together partly by the aid of the lignin and partly by the added binder in at least the surface layers of the rolled web. The web may be press-rolled to substantially its final thickness at once between the hot press rollers or be further treated in a hot plate press operating stepwise.

3 Claims, 4 Drawing Figures
CONTINUOUS HARDBOARD PRODUCTION

This invention is concerned with the production of resinbonded hardboard having a thickness of between approximately 0.15 and 3.0 millimeters from a starting material containing a major part of defibrated ligno-cellulose plant substances and an admixture of resinous binding agents. The term "hardboard" as used in this specification refers to a fiber board product having a density about 750 kilograms per cubic meter.

Hardboard is in itself a well known material nowadays consumed in great quantities, for instance within the packing industry and for building and interior fitting purposes. Its production requires a combined high pressure and high temperature treatment of porous felted fiber mats which so far has been successfully carried out only in flat plate presses, usually of the multiple opening type. Accordingly, hardboard has been available only in sheets or panels, the maximum size of which depends on the size of the flat plate press equipment used in the factory. For several obvious reasons this is highly objectionable. In order to overcome this deficiency considerable effort has been spent on finding out ways for splicing together hardboard sheets or panels, but this is, of course, no favorable solution of the basic problem.

Accordingly, it is an object of the present invention to teach a practically useful method for production of thin hardboard of the kind defined hereinbefore in the form of a continuous web.

In accordance with the present invention a thin, continuous web is produced from a starting material containing at least a major part of defibrated ligno-cellulose plant substances and an admixture of resinous binding agents amounting to at most 10 % of the weight of the final product by first causing said starting material to form a continuous, porously felted fiber mat having a certain but low moisture content, by subsequently feeding in said fiber mat between a pair of cooperating nip-forming press rollers, both of which have a hard surface and at least approximately the same diameter and both of which are heated to a minimum temperature of 160°C, at least within the envelope surface portions thereof engaging the fiber mat, said two press rollers being held together with such a high pressure that the thickness of the porously felted fiber mat, when the latter is passing between said rollers, is reduced to only a fraction of its original thickness, whereby most of the steam generated from the moisture contents of the fiber mat as a result of the latter being heated between the press rollers will be forced to seek its way out through the fiber mat in a direction opposite to the infeed direction of the latter, and by otherwise maintaining such conditions during the pressing operation that both the admixture of resinous binding agents and the lignin content of the defibrated ligno-cellulose substances will partake in at least a partial binding of the fibers of the pressed web. Afterwards the continuous web thus produced may be subjected to further treatment in order to obtain the required properties.

It has been found that, during the process just described, the porously felted fiber mat entering between the hot press rollers will primarily become heated to a temperature at which the small but still active and sufficient amount of water in the mat will evaporate and, by being forced out backwards, will steam and soften the fibers so as to prepare them in a very favorable manner for the subsequent pressing operation. Thereafter, closer to the press roller nip, the temperature of the fiber mat, now already considerably compressed, will be further increased, whereby the added resinous binding agents will become liquid and the lignin will be at least partly expelled from the ligno-cellulose fibers so as to distribute properly in the compressed mat and smear the softened fibers thereof, when the press roller nip is eventually reached.

Although a certain low moisture content is thus required in the fiber mat entering between the press rollers, this content should at least be kept within the range of 2 and 10 %, and preferably between 3 and 5 %. Such small water quantities in the mat can be rapidly evaporated between the press rollers with a reasonably low power consumption. On the other hand, with such a low moisture content in the mat the fibers are dry from a practical point of view. Therefore, it is preferred to prepare the starting material from dry-defibrated ligno-cellulose substances and, in any event, to cause it to form the porously felted fiber mat in a dry way by depositing it from a gaseous suspension medium. A preferred manner and apparatus for effecting this is described in U.S. Pat. No. 3,792,943.

In order to permit a further reduction of the heating power to be supplied through the press rollers to the fiber mat, the latter may be pre-heated before its entrance between the press rollers to a temperature of less than 100°C, preferably to between 30 and 80°C. Suitably, such pre-heating of the fiber mat is combined with a simultaneous adjustment of the moisture contents of the mat by passing the same through a chamber in which both the temperature and the atmospheric humidity may be controlled as required.

As already mentioned the admixture of resinous binding agents should amount to at most 10 % of the weight of the final product. In practice, however, it has been found that half that percentage or even less is sufficient in most cases. Thermosetting synthetic resin binders on a phenol, urea and/or isocyanide basis are preferred.

In addition to ligno-cellulose fibers and resinous binders the starting material may include up to one third of other kinds of fibers, such as mineral fibers, e.g., asbestos, glass and rockwool fibers; animal textile fibers, e.g., wool, cowhair and real silk; vegetable textile fibers, e.g., cotton and cellulose wadding; artificial fibers, e.g., rayon and other synthetic fibers; or mixtures of such other kinds of fibers. If desired, a certain small amount, up to 10 % by weight, of a filler serving as a pigment, such as chalk, kaolin or coloring matter, may also be included. In most cases it is further recommendable to impregnate the fibers included in the starting material with small amounts of moisture repellants, hydrophobic agents, fire retarders, fungicides, insect repellants and/or insecticides before the pressing operation.

As already pointed out, it is important that the two press rollers have at least approximately the same diameter and the latter must be many times greater than the thickness of the porously felted fiber mat to be pressed. As a general rule, the larger the diameter of the press rollers, the more can the speed of the fiber mat be increased, when all other factors are the same. This is explained by the fact that the roller diameter and the original thickness of the fiber mat are both fac-
tors determining the length of the path at the inlet side of the two press rollers where the fiber mat is subject to the heat and pressure from the latter.

Further, it has been found important for a successful accomplishment of the process that such gases which are possibly formed, for instance by partial evaporation of the lignin or the resinous binding agents or by chemical reactions during the last high-temperature stage of the pressing operation, are permitted to leave the pressed web substantially unimpeded immediately after the pressed web has left the press roller nip, because this will improve the quality of the product.

The surface temperature of the press rollers is another important factor. Although 160°C is a minimum temperature, it is in most cases advantageous to use higher temperatures, such as between 180° and 350°C, because higher temperatures generally permit a higher production speed. However, temperatures above the range just mentioned may easily cause burning of the web and should, therefore, be avoided. A top temperature of between 250° and 300°C is preferred.

The two press rollers, which preferably should be made of metal, such as steel, should be held together with a resilient pressure of at least 20 kilograms per centimeter active axial roller length. In some cases a roller pressure of approximately between 30 and 50 kilograms per centimeter active roller length has been found satisfactory, viz. when the pressed web is subsequently subjected to a further compression in a hot plate press, as will be described in the following, but in other cases it will be necessary to use roller pressures up to 250 kilograms per centimeter active roller length.

It is preferred to bring the fiber mat fed in between the two hot press rollers into immediate contact with both said rollers, because this will improve the heat transfer from the rollers to the mat. When this is objectionable for the one reason or the other, the fiber mat may pass the press rollers resting on a thin wire cloth forming an endless conveyor.

As already indicated, there are two different ways of completing the production of the continuous hardboard web. The first one is to reduce, at once between the hot press rollers, the thickness of the fiber mat to at least the very close vicinity of that of the final product. In such a case it is usually advantageous to let the pressed web, while still hot, pass one or more pairs of cooperating smoothing and calibrating rollers having a surface temperature, at least within their active envelope, of between 150° and 200°C, in order to obtain a satisfactory product. The second possibility is to impart to the fiber mat during its passage between the press rollers a reduced thickness exceeding that of the final product and to subsequently subject the continuous web thus formed and pre-pressed to a further, calibrating thickness reduction in at least one flat plate press having heated press plates, said press being operated stepwise to subject one longitudinal portion after the other of the pre-pressed web leaving the press rollers to a high flat pressure and simultaneously to such an increased temperature that a complete binding of the fibers throughout the product by means of the lignin and other binding constituents of the web is achieved.

The first one of these two ways is simple but power-consuming because of the required roller pressure, which is between 100 and 250 kilograms per centimeter active roller length. Furthermore, it requires a very large roller diameter, commonly up to 2 meters or more, if a high production speed is desired. This is true, because for completing the web already between the hot press rollers it is imperative that the temperature also in the middle of the web is increased to at least 160°C within the region of the press roller nip. Now, the minimum temperature in the middle of the web depends on several factors, viz. the web thickness, or, more exactly, the size of the press roller nip, the period of time during which each portion of the fiber mat will remain in contact with the hot press rollers, and the surface temperature of said rollers, and all these factors must thus be carefully interrelated. On the other hand, the period of time during which the fiber mat is in contact with the hot press rollers is dependent on the rate at which the thickness reduction of the fiber mat is effected, and this rate is determined by the circumferential speed as well as by the diameter of the two press rollers. As mentioned before, there are limits for the temperature of the press rollers and, consequently, a high speed production requires a large roller diameter.

The second way is slightly more complicated and requires the use of an additional flat plate press but is still an attractive alternative because less power is consumed and the diameter of the press rollers may be kept within more moderate limits, commonly between 40 and 100 centimeters. In this case the pressure used for holding together the two press rollers may be reduced to between 20 and 80 kilograms per centimeter active roller length. A surprising fact is that, in spite of the stepwise treatment of the continuous web in the plate press, no marks or weakness zones will indicate this on the final product. The reason for this is probably that the prepressing operation prepares the surface layers of the web by creating a kind of pre-bound skins on both sides of a softer, still only poorly bound core which is then caused to integrate with the skins in the subsequent compression step carried out in the plate press.

When the second way is used, it is preferred to let each portion of the pre-pressed fiber web stay in the flat plate press for at least 2 seconds, and preferably for about 5 seconds, the most appropriate stay time being mainly dependent on the thickness of the final product and the temperature of the press plates. The active surface portions of the press plates should be kept at a temperature of between 180° and 200°C, preferably at about 250°C, and it has been found adequate to subject the pre-pressed web to a pressure of between 20 and 100 kilograms per square centimeter.

As can be readily understood, the fact that the web entering the hot plate press has been pre-pressed to a substantially fixed thickness, which is small in comparison with the original thickness of the porously felted fiber mat and only about twice the thickness of the final product, is very advantageous, because the movements or strokes of the press plates in the hot plate press may then be very small, whereby the working pace of the plate press may be kept fairly high or, in other words, the time needed for opening and closing the press at each operating cycle may be reduced to a minimum. At the same time, through-heating of the web takes only a short time, which fact also contributes to a high capacity of the plate press.

After having been given its final thickness the continuous hardboard web is preferably conditioned and/or
coated, and in accordance with this invention such conditioning or coating takes place while the web is still hot. Conditioning may, for instance, include a controlled increase of the moisture content of the web, and coating may, for instance, also include facing or laminating the web, on one or both sides, with a layer of plastics, veneer, fabric or even metal foil. Also, the continuous hardboard web received from the press station may be impregnated with a liquid impregnating agent, while it is still hot and preferably, within an interval of time after the pressing operation when the temperature of the web is just sinking past 100°C, because it has been found that the web at that very moment has a pronounced sucking ability. The impregnating agent may be any known preparation and especially, bitumen or tar. Also fire retardants, fungicides and insecticides may be added to the final web by such subsequent impregnation instead of being included in the starting material, as indicated hereinafter.

Whenever the fiber mat or the pre-pressed web is brought into immediate contact with hot press roller or press plate surfaces, the latter must, of course, be coated with a suitable releasing agent capable of withstanding the prevailing heat and preventing sticking of the mat or web to the metal surfaces. Such releasing agent may also be used on any wire cloth accompanying the mat or web.

For further elucidation of the invention reference will now be had to the accompanying drawings, in connection with which certain preferred examples of the process embodying the invention will be described. In the drawings, where all the figures are only diagrammatic.

FIG. 1 illustrates a first form of plant for the production of a continuous hardboard web.

FIG. 2 illustrates on an enlarged scale the pressing procedure proper taking place between the press rollers in FIG. 1.

FIG. 3 illustrates a first modification of the production plant in FIG. 1, and

FIG. 4 illustrates a second modification of the same.

Referring first to FIGS. 1 and 2, numeral 1 designates an endless wire screen running over suitable conducting and driving rollers 2 and passing first through a fiber distributing apparatus 3, in which prepared dry fibers in air suspension are fed in at 4 and caused to deposit on top of the wire screen 1 so as to form thereon a porous felted fiber mat 5 of a predetermined thickness. The apparatus 3 is preferably of the kind more closely described in U.S. Pat. No. 3,792,943. For the purpose of illustration it may be assumed that the mat 5 has an approximate thickness of 25 millimeters and a weight of about 950 grams per square meter when leaving the apparatus 3, and that the fibers deposited on the wire screen 1 are dry-diffibrated and subsequently further disintegrated fibers of a ligno-cellulose plant substance such as redwood or birch, to which has been added 4% by weight of phenol resin glue and 2% by weight of a hydrophobic agent in the form of a wax-paraffin-emulsion. The fiber mat 5 has, when leaving the apparatus 3, an approximate moisture content of 6 to 8%. Resting on the wire screen 1 the porously felted fiber mat 5 is then passed through a pre-heating chamber 6, through which dried hot air having a temperature of about 70°C is blown, whereby the moisture content of the mat will be reduced to about 4% and the temperature of the mat will be increased to the temperature level within the chamber 6.

Immediately after having left the chamber 6 the wire screen 1 is deflected for return, whereas the fiber mat 5 continues forwardly over a sliding plate 7 located immediately in front of the entrance to the nip between a pair of cooperating press rollers 8 and 9. The lower one 9 of these press rollers is stationary mounted and driven with a circumferential speed of about 15 meters per minute, which was also the running speed of the wire screen 1. The upper roller 8 is loaded with an elastically yieldable pressure corresponding to about 200 kilograms per centimeter of active roller length. By means of overheated steam or electricity the surface temperature of the two press rollers 8 and 9 is kept at about 270°C, at least within those envelope surface portions thereof which engage the mat 5. As can be seen from FIG. 1, the distance between the outlet end of the pre-heating chambers 6 and the press rollers 8, 9 is relatively short, so that the temperature and moisture content of the mat 5 will not significantly change before the mat enters between the press rollers which both have a diameter of 2 meters.

The distance between the envelope surfaces of the two press rollers 8 and 9 in the nip between them will be almost exactly 1.0 millimeter, which means that the mat 5 is subjected to a very extensive thickness reduction between the press rollers and, in fact, comes out with a thickness very close to that of the final product.

On the other hand a certain swelling or expansion of the pressed web will take place at the outlet from the press roller nip so that the thickness of the pressed web will be about 11 millimeters a small distance behind the press roller nip. This swelling is believed to result from the fact that certain gases are formed in the web when the latter is passing the press roller nip and these gases probably force their way out from the interior of the pressed web immediately after the press roller nip.

After having been pressed between the rollers 8 and 9 the web 5' is smoothed and calibrated to its final thickness by being passed through two pairs of cooperating rollers 10 having a diameter of 40 centimeters. The rollers 10 are all heated to a surface temperature of about 175°C and are kept together with a pressure of about 25 kilograms per centimeter active roller length, i.e., web width. The pre-sheared rolled hardboard 5 will subsequently pass through a conditioning chamber 11 where a suitable moisture content of the web is restored. Alternatively, the web 5'' may, as previously mentioned, be coated or impregnated. Such treatment may also take place before the web is passed between the pairs of rollers 10.

As appears from FIG. 2 the preheated, porously felted fiber mat 5 will leave the sliding plate 7 and come into contact with the two hot press rollers 8 and 9 already a good distance in front of the press roller nip at 12 so as to be heated from said rollers during a progressive compression which takes a certain time, because the fiber mat 5 is very much thicker than the pressed web 5'. Between the two rollers 8, 9 it will pass through a preparatory heating zone A and then enter into a pressing zone B. Already well before the end of the heating zone A, the fiber mat is supposed to have reached such a high temperature that its water contents has almost completely evaporated, and the steam thus formed will obviously be driven out backwards towards the left in FIG. 2 with the result that
the fibers in the mat are steamed and softened. At the inner end of the heating zone A the temperature throughout the compressed fiber mat has reached such a level that the added resinous binding agents and also the lignin of the starting material are in a liquid state and become properly distributed. Then in the pressing zone B the final binding of the fibers takes place.

Referring now to FIGS. 3 and 4, it may be assumed also in these two cases that the porously felted fiber mat 5 is obtained in the same manner as described in connection with FIG. 1. The fiber mat 5 is then passed through a pre-heating chamber 6 and between a pair of heated press rollers 8' and 9'. In both FIG. 3 and FIG. 4 the hot press rollers 8' and 9' have a diameter of 65 centimeters and are held together with an elastic pressure corresponding to about 35 kilograms per centimeter active roller length, or width of mat. They are both heated in a temperature of about 170°C, and their circumferential speed and, accordingly, the speed of the fiber mat, is kept at about 10 meters per minute. Under these conditions, the porously felted fiber mat 5 having an original thickness of approximately 25 millimeters will be compressed between the press rollers to about twice the thickness of the final product, i.e., to about 2 millimeters.

In FIG. 3 there is on the outlet side of the press rollers arranged a running track 15 for a plate press 16 that is movable back and forth in the feeding direction of the pre-pressed web 5a leaving the press rollers 8' and 9'. The active surfaces of the plates of the press 16 are kept at a temperature of about 250°C. The press plates are hydraulically operated with a sufficient closing force to subject the portion of the pre-pressed web received between them to a pressure of about 80 kilograms per square centimeter. The plate press moves towards the left when opened and towards the right when closed, in such a manner that the one longitudinal portion after the other of the pre-pressed web 5b is subjected to pressure and heat treatment during a period of about 5 seconds. From a practical point of view this means that the plate press must have a length of 1.5 to 3.0 meters. The resulting product 5b leaves in this case the plant while moving continuously and with the same speed as the pre-pressed web 5a leaves the press rollers.

In FIG. 4 a stationary plate press 20 is used and placed at such a distance from the press rollers 8' and 9' that the pre-pressed web 5a can form a loop therebetween as indicated at 21. This is required because in this case the web 5a is fed stepwise through the plate press and out of the plant. Otherwise the pressing conditions in the plate press are the same as in FIG. 3. Furthermore, FIG. 4 shows, how the fiber mat passing between the hot press rollers 8' and 9' may be supported on a thin wire cloth 22 which is also used to carry the pre-pressed web in the loop 21 and through the plate press 20. The wire cloth 22 forms an endless conveyor and is separated from the final product 5b immediately behind the plate press in order to return. Such a wire cloth may, of course, be used also in the example shown in FIG. 3.

Instead of using only one plate press for the final treatment of the pre-pressed web, two or more such presses may be used and be passed by the web in succession during stepwise advance, for example. In such a case the web may in the first plate press be subjected to a high initial pressure and in the following press or presses be hardened under a more moderate pressure but still at a high temperature.

If it is desirable to obtain a corrugated or ondulated hardboard product, the ready-pressed web may be passed through a roller dyke having two longitudinal or transverse corrugations. Preferably such additional treatment is carried out while the web is still at a high temperature, e.g., above 100°C. As an alternative the pressing rollers 8 and 9 themselves may be shaped to corrugate the web during the pressing procedure proper.

I claim:
1. An improved process for manufacturing a continuous flexible web of resin-bonded hardboard within the thickness range of between 0.15 and 3.0 millimeters which comprises
   a. providing an air suspension of a fiber-binder mixture containing a major part of defibrated lignocellulose plant substances and less than 10% of a thermosetting synthetic resin binder,
   b. feeding said air suspended fiber-binder mixture into a fluffy continuous mat having a moisture content between 2 and 10%,
   c. preheating said mat to a temperature between about 30°C and 80°C,
   d. supporting said preheated mat upon a belt of thin wire cloth,
   e. feeding said supported mat continuously into a nip formed by cooperating press rollers at 40 - 100 centimeters and heated to a temperature of between 180°C and 250°C while subjecting it to a pressure of about 20 and 250 kilograms per centimeter in said nip so as to:
      1. compact it to about twice the thickness of the final product,
      2. to convert a substantial part of its moisture content into steam which is driven out backwards through the mat, and
      3. to activate the added binder as well as part of the lignin content of the fibers themselves,
   f. sequentially transferring unseparated segments of the continuous supported and pre-pressed mat to a stationary flat plate press having its press plates heated to a temperature of 180°C - 300°C, and
   g. sequentially subjecting each unseparated segment of the pre-pressed mat to a pressure of about 20 - 100 kilograms per square centimeter for a short period of time while it is in said flat plate press to thus achieve the final thickness of the mat, and
   h. removing from the flat plate press a continuous flexible web of hardboard of 0.15 - 3.0 mm thickness and separating therefrom said belt of thin wire cloth.

2. An improved process for manufacturing a continuous flexible web of resin-bonded hardboard within the thickness range of between 0.15 and 3.0 millimeters which comprises
   a. providing an air suspension of a fiber-binder mixture containing a major part of defibrated lignocellulose plant substances and less than 10% of a thermosetting synthetic resin binder,
   b. feeding said air suspended fiber-binder mixture into a fluffy continuous mat having a moisture content between 2 and 10%,
   c. supporting said mat upon a thin wire cloth,
   d. feeding said supported mat continuously into a nip formed by cooperating press rollers that are heated
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to a temperature of between 160°C and 350°C while subjecting it to a pressure of at least 20 kilograms per centimeter in said nip so as 5 to compact it to a reduced thickness exceeding that of the final product.

2. to convert a substantial part of its moisture content into steam which is driven out backwards through the mat, and

3. to activate the added binder as well as part of the lignin content of the fibers themselves.

e. sequentially transferring unseparated segments of the continuous supported and pre-pressed mat to a stationary flat plate press having its press plates heated to a temperature of 180° – 300°C, and

f. sequentially subjecting each unseparated segment of the pre-pressed mat to a pressure of about 20 – 100 kilograms per square centimeter for a short period of time while it is in said flat plate press to thus achieve the final thickness of the mat, and

g. removing from the flat plate press a continuous flexible web of hardboard of 0.15 – 3.0 mm thickness and separating therefrom said belt of thin wire cloth.

3. An improved process for manufacturing a continuous flexible web of resin-bonded hardboard within the thickness range of between 0.15 and 3.0 millimeters which comprises

a. providing an air suspension of a fiber-binder mixture containing a major part of defibrated cellulose plant substances and less than 10% of a thermosetting synthetic resin binder,
b. felting said air suspended fiber-binder mixture into a fluffy continuous mat having a moisture content between 2 and 10%,
c. feeding said mat continuously into a nip formed by cooperating press rollers heated to a temperature above 160°C while subjecting it to a pressure of at least 20 kilograms per centimeter in said nip, so as to compact it to about twice the thickness of the final product, to convert a substantial part of its moisture content into steam which is driven out backwards through the mat, and to activate the added binder as well as part of the lignin content of the fibers themselves,
d. sequentially transferring unseparated segments of the continuous pre-pressed mat into a stationary flat plate press having its press plates heated to at least 180°C, and

e. sequentially subjecting each segment of pre-pressed mat to a pressure of about 80 kilograms per square centimeter for a short period of time while it is in said still unbroken mat step-by-step through the flat plate press to thus achieve final thickness of the mat, and

f. removing from the flat plate press a continuous flexible web of hardboard of 0.15 – 3.0 mm thickness.

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