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The present invention relates to the hot-pressing of a mixture of comminuted wood and binder material to panel form, and in particular to improvements in the method of pressing.

Considerable experience has been acquired in hot-pressing a mixture of wood sawdust and phenolic-formaldehyde resin to form panels. The ideal objectives are to produce panels of uniform thickness, uniform density, uniform surface texture and uniform interior. In part, the attainment of these objectives depends upon formation of a layer of the mixture to be molded, such that each unit area of the layer contains the same quantity of the binder resin. This is best accomplished by proper preparation of a loose granular mixture and by laying the latter at a uniform density and uniform thickness, whereby only compression and heating of the layer are required to integrate it to panel form.

Among the known methods of pressing there are two commonly used in the art. One involves placing the layer of particles into the mold and the latter slowly under constant pressure until a predetermined thickness is attained in a time period sufficient to set the binder. This is herein referred to as "follow-up pressing" because as the layer is compressed and heated the platens follow the material. By this method the characteristics of the material predetermine the thickness of the panel for any predetermined platen pressure.

A second known method is to close the platens on the layer to a predetermined spacing by use of mechanical stops onto which the platens are closed during the pressing. This is known by the art as "pressing to stops." In this method the characteristics of the material predetermine the density of the panel for each thickness predetermined by the stops.

There are practical disadvantages of these two methods as applied to mixtures of comminuted wood and thermosetting binder. In the follow-up pressing there are particles in constant motion until final thickness is achieved. The surface layers set before final thickness is reached and hence this constant motion of the particles can interfere with proper bonding. Also the surface particles are dried and embrittled, and the embrittled particle does not spread out to fill voids; it may split; and it acts as a solid to localize within the layer the pressure from the platens. Voids are thus produced. To some extent these difficulties are minimized by wetting with water the surface particles, while the interior ones are dry. This plastifies the surface particles, delays the drying and embrittlement, and delays the attainment of thermosetting temperature. The follow-up pressure method gives no control of thickness, and in production runs, there are over-thick and under-thick panels.

In the method of pressing to stops many of the foregoing disadvantages are eliminated, but other practical disadvantages are introduced. With granular or a loose granular mixture, especially a dry mixture predominating in wood sawdust, a low-density load in a large press has particles blown off the face of the load by the rush of air escaping from over the load and from the edges of the load by the escape of air from within the mixture, as the platen closes. These particles land on the stops and thus negate the stops. In general, the vicinity of such a press during production operation is contaminated with settled and flying particles of material from unpressed loads, and also from pressed panels on which salvage fragments are unavoidable. These conditions make it difficult to keep the stops clean.

In addition, the provision of stops takes away some of the platen area which could otherwise be used for panels. Stops, therefore, result in lower production by inefficient use of platen area.

Another disadvantage of stops is the necessity to change them to vary the thickness of the panel. In a multi-opening press, which is the conventional commercial press, this difficulty is multiplied.

Still another disadvantage of stops is the extensive area of stop needed for the high pressures used in making adequately dense panels. Under certain conditions the back pressure from the material being pressed reduces to zero or to very low amounts during the cure, in which case the stops must absorb the entire pressure. This requires an area for the stops sufficient to absorb the full applied pressure and a platen thickness sufficient to prevent deflection of the platen. This situation calls for more expensive equipment and higher capital investment.

The present invention involves a method of pressing which overcomes all the above disadvantages of pressing to stops, which retains all the advantages of pressing to stops, and which offers new advantages not available in either of the two methods discussed above.

It is the general object of the invention to press initially to final thickness while substantially all of the mass is mobile, and to exert all the pressure on the material being pressed.

It is a further object of the invention, after initially pressing to final thickness to release the applied pressure as the back pressure from the material diminishes.

Various other and ancillary objects and advantages of the invention will become apparent from the following description and from the drawings, which set forth in connection with the accompanying detailed description, showing a graph relating pressure and thickness in carrying out the invention.

The process is carried out by loading a tray or carrier sheet uniformly over each unit area with the same amount of a uniform mixture. Preferably, by suitable means and controls, this is accomplished by loading a flat bottomed tray to a uniform depth with the material at a uniform density. The density is preferably that of the free-flowing mixture, as it settles by gravity in a layer which may vary in depth due to the width range, for example from 1.5 to 2.5 inches for a quarter inch thick panel of about 60 lbs. per cu. ft. However the range may vary to include 8 inches and even 1/16 inch, depending on many factors. The density of such a layer may vary to include a range from 8 to 14 lbs. per cu. ft., depending upon the particle sizes of the comminuted wood, moisture content, and other factors.

The initial load may be compressed to any density greater than said free-flowing density before the heat is applied under molding pressure, in order to effect a reduction in the amount of air trapped in the load and to minimize the effect of air escaping from between the platens on the load surface. In hot-molding loads from conventional mill waste, panels free from voids may be made by compressing to a density of at least 50 lbs. per cu. ft. Higher densities may be obtained, the range from 50 to 65 lbs. per cu. ft. being readily achieved by conventional equipment. Densities as high as the maximum compressibility of wood are possible, which varies slightly with the kind of wood and content of resin. In general this is near 80 pounds per cu. ft.

The mixture may have a variable moisture content. It may be uniformly dry, and sawdust having moisture to 55% by weight of moisture is considered dry at ordinary room temperatures. The loaded mixture may be non-uniform in moisture content, having a dry interior and wet facial layers as above referred to.

For the preferred practice of the present pressing method, such wet faces are not needed. However, when the pressing cycle is unduly long and the platen temperature unduly high, as may be the case, insulated panels are molded, or if the wood particles are relatively coarse, wet faces are advantageous to delay the quick rise in temperature of the facial layers.

The initial mixture should have a moisture content of...
at least 6% by weight. Otherwise the sawdust particles will be too dry and brittle, and in the initial and a suitably quick compression will fracture and interfere with the forming and inter-meshing one with another to eliminate voids.

Where thermosetting resin powder is used as the binder, such as glass fiber showing normally solid powder of a condensation product of phenol and formalddehyde, the mixture may have from 4 to 25 parts of such binder per 100 parts of wood (on the oven-dry basis). For conventional milling from into synthetic lumber of a density of about 55 pounds per cu. ft., a small amount of such resin is suitable, for example, 6 to 8 parts by weight per 100 parts of wood (oven-dry basis).

In operation of commercial presses, it is not practicable to secure substantially instantaneous positioning of the platens. The pressure on the platens and their relative movement are accomplished gradually, and hence movement is slow or fast according to the operation or limitations of the hydraulic system.

In a commercial press with reference to which this invention is described, it takes about one to one and one-half minutes to move the platens from full opening (at which the load is inserted) to full closure to final thickness of the panel. The moving time depends upon the load to the panel, temperature, and materials, the final density of the panel having little influence in the method of this invention. In short, the present invention calls for compressed air to lead to final thickness, as relatively as quickly as the mechanical limitations of the press permit, considering also the limitations imposed by air over and in the fill being so compressed. The time should be such that substantially the top material of the fill is unset and mobile during the compression.

In Fig. 1 there is shown a plot of a pressing in which the time from starting closure of the platens to release of the formed panel is 5.25 minutes, as plotted on the horizontal axis 10. The left hand vertical axis 11 is graduated in pressure of pounds per square inch (p. s. i.) exerted by the platens. Thus 12 is graduated in inches for the thickness of the material from load to panel. By recording pressure and thickness during the pressing, and plotting said pressure against time, the relationship is plotted as pressure curve 14 and thickness curve 15. In the operation the load in a tray to a depth of $\frac{1}{5}$ inches at a density of 100% pounds per cu. ft. is placed on a lower plate at a temperature of 350°F. which is moved up against an upper plate at a like temperature. At 15 seconds, pressure and thickness are first measured, the material having been already slightly compressed. The pressure is shown at point 16 as being 500 p. s. i. and the thickness, $\frac{1}{2}$ inch. The aim is to press to a final thickness of 0.01 inch and have the platens withdrawn before the predetermined separation at which movement is arrested. This may be done by positioning an electric switch so as to close at the exact moment. The switch may be a signal to an operator, or it may automatically operate to hold the platens at that position.

Fig. 1 shows that as the platens close, the pressure rises and falls, but the thickness diminishes. In this particular press, the limit of pressure which may be applied is 800 p. s. i., which limit is reflected in the plotted curve 14. At 30 seconds point 17 shows the maximum pressure at 800 p. s. i. and point 18 shows the thickness to be $\frac{1}{2}$ inch. At 45 seconds, point 19 shows continuation of the maximum pressure to 800 p. s. i. and point 20 shows the thickness to be $\frac{1}{2}$ inch. The dotted pressure line 21 indicates maximum pressure which could prevail until something happens in the fill to lessen the back pressure. Experience with the operation has taught that as soon as the resin begins to set the back pressure rapidly and almost momentarily diminishes. As a consequence there is achieved a sudden drop in back pressure. To maintain the maximum pressure inflection in back pressure, which is the pressure which corresponds to the reduction in back pressure which results in the movement of the platens. The operating pressure and the back pressure must balance each other to maintain a fixed spacing. Accordingly, the tendencies of the platens to move reflect the changes in the back pressure and hence the progress of the setting.

When the pressure is controlled either manually or automatically by an operator on controlled materials in production runs, an operator acquires a "feel" or has an indication by which he knows the conditions in the press. When the expected feel or indication is not encountered the operator is instantly aware of something amiss. The point is that the platens have already attained their predetermined "panel separation." However, it is apparent that the critical change occurs for between 45 and 70°F. The critical time at which the platens have been rearranging themselves and fitting together, under the applied force of the closing platens. Less and less pressure is required to hold the platens in this range. Fig. 5 shows the pressure at 45°F. and at 40°F. The pressure at 25°F. reached a time at between 45 and 60 seconds. Point 25 shows the pressure at 400 p. s. i. at 60 seconds, having dropped from 800 at the critical point somewhat between 45 and 60 seconds. As soon as the pressure at the fixed location, the pressure in the second minute of the operation reduces to 300 p. s. i. as shown at 26. As the third, fourth and fifth minutes the pressure is constant at 280 p. s. i. shown at 27, 28 and 29. As binder sets the panels are fixed and back pressure lessens. This is part of the "feel." At the end of the fourth minute, the platens are opened; the pressure drops to zero as shown at 30, and the panel expands to a thickness of $\frac{1}{2}$ inch. In principle, the control of the platens is such as to maintain the plate opening exactly at the predetermined final thickness of the panel (allowing for expansion on release). Practically, this control may be effected by visual indicating means observed by an operator who controls the hydraulic pressure which moves the platens in the hydraulic field, if the hydraulic signal is used, it has been found practical to use two switches, one to indicate a minimum plate spacing, on which signal pressure is released, and one to indicate a maximum spacing, on which such pressure is increased. By this bleeding pressure in and out, the platens oscillate over a very small range of 0.06 inch per panel in a 10-opening press.

By the technique of an operator with experience can determine trends in the variable characteristics of the material being pressed and thereby establish the corrective steps necessary to maintain specification density and vertical thickness.

Where the said two limit switches are employed they have been operated to light red and green signal lamps, to which the operator is quickly alerted by the said lamp being lighted, thus giving an indication of the location of the platens and moving the plate away from the pressure area to the desirable zone indicating that the plate is ready for further pressing or further movement to cause said platens on said layer by pressure acting only against the resistance of said layer and thereby compressing said layer at a minimum spacing of the platens corresponding to a predetermined minimum thickness of an integrated panel to be formed from said mixture, said closing of the platens on the layer being effected while the integrating action is incomplete in substantially every part of the layer, whereby the binder is thereafter fully activated to integral the layer while the particles are substantially fixedly positioned in said compressed layer, and immediately after so closing the platens regulating the said applied pressure. Also, the signal circuit have been made to operate relays which control a reversible motor, arranged to increase and decrease the hydraulic pressure, thereby respectively to move the platens in closing or opening directions.

I claim:

1. The method which comprises forming a substantially uniform and dense layer of a heat-activated binder which has a moisture content of less than 6 parts by weight per 100 parts of the mixture and having a moisture content of less than 10 parts dry basis weight of wood, placing said layer between spaced-apart heated platens having a temperature in the range from 250°F. to 400°F., placing said layer between spaced-apart heated platens having a temperature in the range from 250°F. to 400°F., promptly thereafter initiating movement to close said platens on said layer by pressure acting or
only against the resistance of said layer and thereby compressing said layer at a minimum spacing of the platen corresponding to a predetermined minimum thickness of an integrated panel to be formed from said mixture, said closing of the platens on the layer being effected while the integrating action is substantially incomplete in every part of the layer, whereby the binder is thereafter fully activated to integrate the layer while the particles are substantially fixedly positioned in said compressed layer, and immediately after so closing the platens regulating the said applied pressure at lower and lowering values substantially to maintain said minimum thickness of an integrated panel to be formed from said mixture, closing of the platens on the layer being effected while the integrating thermosetting action is substantially incomplete in every part of the layer, whereby the binder is thereafter thermoset to integrate the layer while the particles are substantially fixedly positioned in said compressed layer, and immediately after so closing the platens regulating the said applied pressure at lower and lowering values substantially to maintain said minimum spacing as back pressure from said layer decreases to a substantially constant value and said compressed layer is set substantially at said predetermined thickness, then opening the platens, and removing the resulting integrated panel.

5. The method which comprises forming a substantially uniformly thick and dense layer of a dry homogeneous mixture of comminuted wood and a normally solid heat-softerning thermosetting binder therefor, said mixture having a moisture content of at least 6 parts by weight per 100 parts of the mixture and having from 4 to 25 parts by weight of said binder to 100 parts bone-dry weight of wood, placing said layer between spaced-apart heated platens having a temperature in the range from 250° F. to 400° F., promptly thereafter initiating movement to close said platens on said layer by pressure acting only against the resistance of said layer and thereby compressing said layer at a minimum spacing of the platen corresponding to a predetermined minimum thickness of an integrated panel to be formed from said mixture, closing the platens on the layer being effected while the integrating thermosetting action is substantially incomplete in every part of the layer, whereby the binder is thereafter thermoset to integrate the layer while the particles are substantially fixedly positioned in said compressed layer, and immediately after so closing the platens regulating the said applied pressure at lower and lowering values substantially to maintain said minimum spacing as back pressure from said layer decreases to a substantially constant value and said compressed layer is set substantially at said predetermined thickness, then opening the platens, and removing the resulting integrated panel.

6. The method which comprises forming a substantially uniformly thick and dense layer of a dry homogeneous mixture of comminuted wood and a normally solid heat-softerning thermosetting phenol-formaldehyde resin as binder therefor, said mixture having a moisture content of at least 6 parts by weight per 100 parts of the mixture and having from 4 to 25 parts by weight of said binder to 100 parts bone-dry weight of wood, placing said layer between spaced-apart heated platens having a temperature in the range from 250° F. to 400° F., promptly thereafter initiating movement to close said platens on said layer by pressure acting only against the resistance of said layer and thereby compressing said layer at a minimum spacing of the platen corresponding to a predetermined minimum thickness of an integrated panel to be formed from said mixture, closing the platens on the layer being effected while the integrating thermosetting action is substantially incomplete in every part of the layer, whereby the binder is thereafter thermoset to integrate the layer while the particles are substantially fixedly positioned in said compressed layer, and immediately after so closing the platens regulating the said applied pressure at lower and lowering values substantially to maintain said minimum spacing as back pressure from said layer decreases to a substantially constant value and said compressed layer is set substantially at said predetermined thickness, then opening the platens, and removing the resulting integrated panel.

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Number Name Date
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