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(54) METHOD AND APPARATUS FOR MAKING A FIBROUS BOARD-LIKE PRODUCT✓

(71) We, JOHNS-MANVILLE CORPORATION, a corporation organized under the laws of the State of New York, United States of America, having a place of business at Ken-Caryl Ranch, Jefferson County, Colorado, mailing address P.O. Box 5723, Denver, Colorado 80217, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method and apparatus for making two or more strips of fibrous duct board. Air duct made from inorganic fibrous board-like material is old. One known process and apparatus suitable for making board-like fibrous precursor for air duct produces a product of about 4 feet in length and having a female edge on one side and male edge formed on the other side. The board-like material is cut into lengths equivalent to the circumference of the duct to be formed and grooves are cut perpendicular to the male and female edges corresponding to the locations where it is necessary to bend the board-like material to form a duct, typically having a rectangular or square cross-section. Once the duct is formed, one end has a female end and the opposite end has a male end so that the 4 foot duct sections can be joined together for support and to provide a seal. As used herein, the terms female edge and male edge are to be understood to refer to those edges of the duct board which, when the latter is bent in the manner described, form first and second peripheral edges bounding the openings at opposite ends of the duct such that the first peripheral edge (formed by the male edge) can be inserted into the second peripheral edge (formed by the female edge) of a like duct. The male and female edges may be substantially alike and hence interchangeable according to which way the duct board is bent and the specification is therefore to be construed accordingly.

In this prior art method and apparatus a single strip 4 feet wide is formed in such a manner that the male and female edges are formed along the outer edges. While this process and apparatus produce a satisfactory product, and a product having satisfactory male and female edges, its production capacity and efficiency is undesirably low for this type of product due to the 4 foot width limitation. Production speed is limited because of the required curing time for the binder in the blanket.

With a known modification of the above-described prior art method, see Figures 1 and 2, the production capacity is increased by at least doubling the width of the blanket being produced. Upon going to a greater width and producing at least two 4 foot wide strips simultaneously, it is necessary to form two male or two female edges simultaneously down the center portion of the fiber glass blanket and then to separate the wide strip in the center to form two strips of material suitable for 4 foot long duct sections. Preferably, the female edge for both strips is formed in the center of the wide blanket using heated platens and by placing a die having a rectangular cross-section on its bottom surface down the center of the upper platen in a first set of heated platens as shown in FIG. 2. In this known modification, the leading edge of the die is tapered like a wedge to reduce the tendency of the blanket to hang up on the leading edge of the die. This known process and apparatus produces a finished female edge such as that shown in FIG. 3. This is an undesirable configuration because of the relatively gradually sloped portion between the top of the duct board and the higher density outer lip. When a male edge is inserted into a female end of this sloped configuration, the male portion of the duct can ride up the relatively flat slope (long radius) thereby producing a projection into the interior of the duct that causes undesirable air resistance.

Although the die shown on the upper platen in FIG. 2 is the same type of die used

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to form the male edges on the outer edges of the platen, when used in the center of the platen to form two female edges back-to-back, the undesirable long-radius relatively flat slope shown in FIG. 3 is produced. The reason for the longer radius and flatter slope produced in the center of the blanket is not fully understood, but may be caused by the fact that the blanket in the center is not as free to move and stretch as it is along the outer unrestricted edges where the male edges are formed. The male edges produced by the same die shown on the upper platen in FIG. 2, but located along the outer edges of the lower platen produce a shorter radius and steeper sloped edge of the type shown in FIG. 9, but of course inverted.

It is an object of the present invention to overcome the disadvantages of the prior art by providing a method and apparatus for forming a fibrous board-like product having male and female edges in an economical and reliable manner.

The present invention provides a method of making two or more strips of fibrous duct board, each strip having a female edge and a male edge wherein a blanket of collected fibers having a heat setting binder thereon is passed between a pair of spaced apart heated surfaces to cure the binder in the top and bottom surface portions of the blanket, said partially cured blanket is then passed between opposed heated first and second platens spaced apart less than the thickness of said blanket to shape the blanket and cure the binder in said blanket, the first said platen having a shoe located between its side edges and running along the length of the platen to form a flat valley depression along the length of said blanket, the portion of the blanket lying below the flat valley depression having a higher density than the blanket adjacent said valley, the said second platen having a male edge forming die running along its length at or near each side edge of the platen to form a male edge along each outer edge portion of said blanket, and separating said blanket longitudinally in said flat valley depression to form said strips; the improvement comprising forming the portion of said blanket between the shoe and the opposite second platen to essentially its final thickness in the upstream portion of said platens and gradually reducing the thickness of those portions of the blanket on each side of said shoe as said blanket is moved along between said first and second platens, said final thickness of the blanket in said adjacent portions being formed only in the downstream end portion of said platens.

In the process of the present invention, a female edge, having a shorter radius and much steeper slope than that produced by

the prior art described above, is produced by tilting at least one of the first set of platens such that the space between the platens where the blanket enters is greater than the space between the platens at the down-stream end of the first set of platens and placing a tapered shim between the shoe on the first platen and the first platen whereby the first blanket between the shoe and the opposite platen is formed to essentially its final thickness in the upstream portion of the first set of platens while the final thickness of those portions of the blanket on each side of the shoe is not formed until the blanket reaches the downstream end portion of the first set of platens.

Preferably, the shoe is tapered and turned up at its front end in a manner similar to a snow ski to avoid hanging up on the blanket of fibrous material and also preferably, a cross-section of the forming portion of the shoe is trapezoidal in shape with the long edge being next to the fibrous blanket and the short edge being closest to the platen. Also, the surface of the blanket that will be next to the forming shoe is preferably slit to a desired depth prior to entering the first set of platens.

The present invention also provides an apparatus for practicing the above-described method of consolidating, shaping and curing a blanket formed of low density masses of fiber having a heat settable binder throughout, comprising a first means for compressing a moving body of a low density mass of fiber containing a heat setting binder throughout and for heating the compressed surfaces of said mass of fiber to cure the binder contained in the compressed surface portions, a second means following said first means and comprising a pair of spaced apart heating platens providing stationary skid plates for further compressing and shaping said moving mass of fibers containing binder throughout in sliding contact therewith to consolidate and conform the mass of fibers to the desired product density and configuration, for smoothing the compressed surfaces in contact therewith and heating the compressed surfaces to complete the cure of the binder throughout the compressed and shaped mass of fibers fixing the desired thickness and configuration, one of said platens having a centrally-located forming shoe running lengthwise for compressing said fibrous mass between the outer surface of said shoe and the surface of the opposite platen to a higher density than the fibrous mass adjacent either side of the shoe, and a pulling assembly for applying a pulling force on the shaped and bonded product after it has passed through said second means to pull said fibrous mass through said first and second means; the improvement wherein said platens are ar-

ranged such that the space between the platens at their entry end is greater than the space between the platens at their exit end, and a tapered shim is located between said shoe and the platen to which said shoe is attached, said shim being tapered such that the distance between the outer surface of said shoe and the surface of the opposite platen remains substantially constant along the length of said shoe. Preferably the portion of the shoe adjacent to the upstream end of the platen is tapered and turned up in a similar manner to a snow ski and also preferably, a cross-section of the forming shoe has a trapezoidal shape with the longest edge being the edge farthest from the surface of the platen to which the shoe is attached.

Figure 1 is a portion of a prior art device;

Figure 2 is a partial front view of a modification of the first set of platens in the apparatus shown in Figure 1;

Figure 3 shows an end view of a female edge produced by the apparatus shown in Figure 2;

Figure 4 is a side view of a first set of platens having a forming shoe according to the present invention;

Figure 5 is an end view of the platens shown in Figure 4 and looking from the upstream end to the downstream end of the platens;

Figure 6 is a side view of a forming shoe and a shim used on the upper platen in Figure 4;

Figure 7 is a plan view of the shoe and shim shown in Figure 6;

Figure 8 is a front view of the shoe and shim shown in Figures 6 and 7;

Figure 9 is a partial view of a duct board having a female edge and made according to the present invention.

Referring to Figure 1, a blanket of inorganic fibers, such as glass fibers, having a heat settable binder coated on the surface is passed between a pair of heated moving surfaces, such as searing rolls 4, to produce a thinner blanket 5 having surface portions 6 in which the binder is cured to provide sufficient strength to allow the blanket to be pulled through heated platens 10 by a pulling assembly (not shown) which applies a pulling force to the shaped and cured blanket after it has passed through the heated platens to pull the blanket through the rolls 4 and the platens 10. A pair of guide and compression rolls 8 can be used to reduce the thickness of the blanket sufficiently to facilitate the blanket passing into the first set of heated platens 10. As indicated by Figure 1 as many sets of heated opposed platens can be used as is necessary to shape the fibrous blanket to the desired thickness and configuration and to cure the binder on the surfaces of the fibers suffi-

ciently to essentially maintain that thickness and configuration. Each of the platens 10 comprises an upper heated platen 12 and a lower platen 14.

The apparatus disclosed in Figure 1 can be used to make fiber glass duct board in a manner shown in Figure 2. Figure 2 is a partial end view of the first set of platens 10 showing the upper platen 12 and the lower platen 14 with the fiber glass blanket 5 therebetween. A male edge forming die 16 runs the entire length of the lower platen 14 along each of its outer edges. The male edge forming die 16 is wedged at the front end to reduce the tendency of the fiber glass blanket 5 from hanging up on the leading edge of the male forming die. A female edge forming die 18 is attached to the upper platen 12 and runs down the center portion of the upper platen 12. The female edge forming die 18 is wedged at the front end in the same manner as the male edge forming die 16.

As can be seen in Figure 2 a shoulder 20 on the male edges is very steep having a short radius while shoulders 22 on the two female edges formed in the center of the blanket by the die 18 have a very gradual slope and a large radius. It is not completely understood why the shoulders 20 are so much deeper than the shoulders 22, but it is thought that this might be caused by the different locations of the forming die 16 and the forming die 18 with respect to the outer edges 4 of the blanket. The forming dies 16 are much closer to edges 24 than the forming die 18, and the fiber glass blanket adjacent to the forming dies 16 is not as restricted to movement by the platens 12 and 14 as that area of the blanket 5 in contact with and immediately adjacent to the female edge forming member 18.

After the blanket 5 has passed through a sufficient number of platens to complete the cure, a separation is made in the center of the female edge portions represented by a dotted line 26 to form two strips of duct board material having female edges such as shown in Figure 3 on each strip. The outer rough edges 25 of each strip are also trimmed off to provide a sharp male edge.

The present invention provides a method and apparatus for producing a female edge in the process and apparatus described above having a steep shoulder with a small radius, not unlike the male edges produced in the process described above. One form of apparatus used to accomplish this result is shown in Figures 4-8. It is to be understood that a complete and detailed set of drawings would include the male edge forming members as disclosed in Figure 2, but these have not been shown in order to better illustrate the present invention.



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In the illustrated embodiment of the present invention, the prior art female edge forming die 18 is replaced by a die 28 and a shim 30, as shown in Figures 4 and 5 and as illustrated in more detail in Figures 6-8. A front portion 32 of the die 28 is preferably tapered and turned upward like a ski tip to facilitate entry of the fibrous blanket into the set of platens.

As best shown in Figures 4 and 5, the first set of platens are tilted such that the distances between the surface of the upper platen 12 and the lower platen 14 is greater at the entry end 34 than at the exit end 36. This difference in the distances may be about $\frac{1}{4}$ inch. The shim 30 is tapered such that the upstream end 38 is thicker than the downstream end 40. It will be seen that the degree of taper in the shim 30 matches the degree of tilting of one or both platens 12 or 14. Thus, when the fibrous blankets enters the entry end 34 of the first set of platens, that portion of the blanket beneath the upstream end of the die 28 is quickly formed substantially or essentially to its final thickness, while the blanket adjacent either side of the die 28 is formed to a thickness greater than its final thickness and is gradually formed to its final thickness as the blanket moves along the length of platens 12 and 14. To achieve this effect, it is preferred to tilt the upper platen 12, as shown in Figures 4 and 5.

Figure 9 illustrates the improved female edge produced by the apparatus and technique of the invention. Note the steepness of the shoulder 42 and its much smaller radius as compared to the shoulder 22 in the prior art female edge, Fig. 3.

As shown in Figure 8, the die 28 is preferably trapezoidal in cross-section. The long side of the trapezoidal lies in the working face of the die 28.

Sometimes wrinkling of the surface on the shoulder 42 occurs. This wrinkling can be avoided by slitting the upper surface of the fibrous blanket to a depth of $\frac{1}{4}$ to $\frac{1}{2}$ inch deep, preferably $\frac{1}{2}$ to $\frac{1}{4}$ inch deep and more preferably $\frac{1}{4}$ of an inch deep, in the center of the blanket in the vicinity of the line where the blanket will later be separated to form two strips (see line 26 in Figure 2). This slitting can be accomplished with any suitable device, such as the roller blade. Apparently this slitter allows the surface portion of the fibrous blanket to stretch sufficiently to avoid wrinkling.

The male edges are formed in the same manner as in the prior art and as shown in Figure 2. Preferably, the underneath section of the blanket 5 is slit in the vicinity of the male die 16 prior to entering the first set of platens, but this is not essential.

While the shoe 28 and the shim 30 are shown in the drawings as separate pieces,

it is to be understood that the two pieces could be made as a single element.

In describing the invention certain embodiments have been described to illustrate the invention and the practice thereof. However, the invention is not limited to these specific embodiments as other embodiments and modifications will readily occur to those skilled in the art on reading this specification. The invention is thus not intended to be limited to the specific embodiments disclosed, but instead is to be limited only by the claims appended hereto.

WHAT WE CLAIM IS:--

1. A method of making two or more strips of fibrous duct board, each strip having a female edge and a male edge wherein a blanket of collected fibers having a heat setting binder thereon is passed between a pair of spaced apart heated surfaces to cure the binder in the top and bottom surface portions of the blanket, said partially cured blanket is then passed between opposed heated first and second platens spaced apart less than the thickness of said blanket to shape the blanket and further cure the binder in said blanket, the first said platen having a shoe located between its side edges and running along the length of the platen to form a flat valley depression along the length of said blanket, the portion of the blanket lying below the flat valley depression having a higher density than the blanket adjacent said valley, the said second platen having a male edge forming die running along its length at or near each side edge of the platen to form a male edge along each outer edge portion of said blanket, and separating said blanket longitudinally in said flat valley depression to form said strips; the improvement comprising forming the portion of said blanket between the shoe and the opposite second platen to essentially its final thickness in the upstream portion of said platens and gradually reducing the thickness of those portions of the blanket on each side of said shoe as said blanket is moved along between said first and second platens, said final thickness of the blanket in said adjacent portions being formed only in the downstream end portion of said platens.

2. A method as defined in Claim 1 wherein the thickness of the blanket in said blanket portions on each side of said shoe is about $\frac{1}{4}$ inch greater at the upstream end portion of said platens than the thickness of the blanket in said blanket portions at the downstream end of said platens.

3. A method as defined in Claim 1 or 2 wherein the upper surface of said blanket is slit to a depth of between $\frac{1}{4}$ inch to $\frac{1}{2}$ inch along the length of the blanket just prior to entering said platens, the slit being

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2. A method as defined in Claim 1 wherein the thickness of the blanket in said blanket portions on each side of said shoe is about $\frac{1}{2}$ inch greater at the upstream end portion of said platens than the thickness of the blanket in said blanket portions at the downstream end of said platens.

3. A method as defined in Claim 1 or 2 wherein the upper surface of said blanket is slit to a depth of between $\frac{1}{4}$ inch to $\frac{1}{2}$ inch along the length of the blanket just prior to entering said platens, the slit being



made in the surface to be adjacent to said shoe and at a location that will be in contact with the forming surface of the shoe.

4. An apparatus for consolidating, shaping and curing a blanket formed of low density masses of fiber having a heat settable binder throughout, comprising a first means for compressing a moving body of a low density mass of fiber containing a heat setting binder throughout and for heating the compressed surfaces of said mass of fiber to cure the binder contained in the compressed surface portions, a second means following said first means and comprising a pair of spaced apart heating platens providing stationary skid plates for further compressing and shaping said moving mass of fibers containing binder throughout in sliding contact therewith to consolidate and conform the mass of fibers to the desired product density and configuration, for smoothing the compressed surfaces in contact therewith and heating the compressed surfaces to complete the cure of the binder throughout the compressed and shaped mass of fibers fixing the desired thickness and configuration, one of said platens having a centrally located forming shoe running lengthwise for compressing said fibrous mass between the outer surface of said shoe and the surface of the opposite platen to a higher density than the fibrous mass adjacent either side of the shoe, and a pulling assembly for applying a pulling force on the shaped and bonded product after it has passed through said second means to pull said fibrous mass through said first and second means; the im-

provement wherein said platens are arranged such that the space between the platens at their entry end is greater than the space between the platens at their exit end, and a tapered shim is located between said shoe and the platen to which said shoe is attached, said shim being tapered such that the distance between the outer surface of said shoe and the surface of the opposite platen remains substantially constant along the length of said shoe.

5. An apparatus as defined in Claim 4 further including means for slitting the surface of the blanket to a depth of from $\frac{1}{8}$ inch to $\frac{1}{4}$ inch, said means being located upstream of said platens.

6. An apparatus as defined in Claim 4 wherein the upstream end of said shoe is tapered and turned up to facilitate the entry of said blanket between said platens.

7. An apparatus as defined in Claim 4 wherein said shoe is trapezoidal in cross-section normal to the length of said shoe, the longest edge of the trapezoid lying in the working face of said shoe.

8. A method substantially as herein described with reference to (Figures 4 to 9 of the accompanying drawings.

9. An apparatus substantially as herein described with reference to, and as shown in, Figures 4 to 9 of the accompanying drawings.

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