[54] METHOD FOR THE HIGH SPEED PRODUCTION OF NON-WOVEN FABRICS


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[57] ABSTRACT

A method of making a non-woven fibrous web comprises providing a fluid stream, incorporating fibers in that stream, continuously directing the stream into a centrifugal flow, and collecting the fibers from the flow as a substantially endless web.

9 Claims, 18 Drawing Figures
METHOD FOR THE HIGH SPEED PRODUCTION OF NON-WOVEN FABRICS

This application is a division of copending application Ser. No. 51,967 filed July 2, 1970.

This invention relates generally to the manufacture of non-woven fabrics and more particularly to the manufacture of such products by substantially dry procedures.

Non-woven fabrics pose the potential of supplying the need for disposable bed sheets; but heretofore, machinery has not been available for producing such fabrics in sufficient width for use as sheeting and with sufficient speed to achieve necessary economy. For example, carding machines operate too slowly, require relatively long staple fiber and are restricted in practical width. Rando-Webber machines are capable of handling inexpensive, short-staple fibers but are limited in width.

Therefore, an important object of the present invention is to provide methods of producing a non-woven fibrous web at high speeds and in substantial width.

A more general object of the invention is to provide new and improved methods of producing a non-woven fibrous web.

These and other objects and features of the invention will become more apparent from a consideration of the following descriptions.

The invention will be better understood by reference to the following disclosure and drawings forming a part thereof, wherein:

FIG. 1 is a diagrammatic perspective view of apparatus for use in the practice of the method of the present invention;

FIG. 2 is a view similar to the showing of FIG. 1 but with the suction plenum and other equipment removed to show the tubularization of the fiber collecting belt;

FIG. 3 is a view similar to the showing of FIG. 1 but with the suction plenum removed and a portion of the belt broken away to show the fiber spray nozzle arrangement, the binder spray nozzle and the complementary air flow system;

FIG. 4 is an elevational view of the head pulley used in the apparatus of FIG. 1;

FIG. 5 is a cross-sectional view taken along the line 5-5 of FIG. 4 with the fiber-collecting belt removed;

FIG. 6 is an elevational view of the tail pulley used in the apparatus of FIG. 1;

FIG. 7 is an enlarged cross-sectional view taken through the exhaust plenum;

FIG. 8 is a further enlarged cross-sectional view showing the channels used in tubularizing the travelling belt;

FIG. 9 is an enlarged fragmentary view showing the interior of the exhaust plenum and details of its construction;

FIG. 10 is a fragmentary perspective view showing details of the construction of the travelling belt;

FIG. 11 is an enlarged elevational view of the binder spray nozzle used in the apparatus of FIG. 1;

FIG. 12 is a central cross-sectional view of the binder spray nozzle of FIG. 11;

FIG. 13 is an enlarged perspective view of a part of the fiber distributing unit used in the apparatus of FIG. 1;

FIG. 14 is an enlarged longitudinal sectional view taken through the exhaust plenum;

FIG. 15 is a diagrammatic view relating to the process of the present invention;

FIG. 16 is a view similar to the showing of FIG. 14 but illustrating a modified embodiment of the invention;

FIG. 17 is a cross-sectional view taken substantially along the line 17-17 of FIG. 16, and

FIG. 18 is a fragmentary elevational view of a further modified embodiment.

The present invention contemplates injecting a fiber-air suspension onto the inside of a porous tube formed by curling a section of a foraminous belt and subsequently flattening out the blet so that the formed and finished web may be lifted off and transferred to subsequent processing stations. This arrangement facilitates uniform distribution of the fibers and promotes application of bonding agents in liquid form.

Referring now in detail to the drawings, specifically to FIG. 1, apparatus for producing a non-woven fibrous web in practicing the method of the invention is indicated by the reference numeral 20; and the apparatus 20 broadly comprises a flexible, endless foraminous belt 22, a guide unit 24, a fiber suspension supply arrangement 26 and an air exhaust plenum system 28. A drive arrangement which will be described more fully hereinafter, caused continuous, longitudinal movement of the belt 22 in the direction of arrow 30 and between a head pulley 32 and a tail pulley 34.

The guide unit 24 includes a fore section 36 which tubularizes the foraminous belt and an aft section 38 which de-tubularizes the belt. The guide unit 24 additionally includes an intermediate guide section 40 which corresponds with the tubularized length of the belt. Turning now to FIG. 10 for a description of the foraminous belt 22, it will be appreciated that the edges of the belt traverse a greater distance in forming the tubularized section than does the center line of the belt. While these different amounts of movement may be accommodated by means of crowned pulleys or "bent" pulleys, in accordance with the present invention they are accommodated by means of bias woven strands 42 and 44, strands 42 running at a 45° angle to the center line of the belt in one direction and strands 44 running at a 45° angle in the opposite direction so that the respective sets of strands cross each other at right angles. Thus, local changes in the bias angles permit the belt to flex internally and accommodate the differential movements. Flexible edge strips 46 are secured to the cut ends of the woven strands to complete the assembly. Various materials can be used for the strands 42 and 44 including metallic wire and such synthetic materials as nylon and polyester resins. With reference to FIG. 8, the edge strips 46 are provided with mutually interengageable aligning means comprising a pair of spaced, resiliently convertible blades 48 fashioned on one edge strip and a mating groove 50 fashioned in the opposite edge strip. Upon the two edge strips being brought forcibly together, the blades 48 wedge into the groove 50 and provide alignment and a seal. Carrier elements are mounted on the edge strips 46 for use in directing the foraminous belt in its tubularizing and de-tubularizing movements. Specifically, button rollers 52 are affixed to the edge strips 46 at spaced intervals by means of a bushing 54 and a rivet 56. Reinforcing bands 58 and 60 are situated within the edge strips on opposite sides of the belt 22 in the vicinity of the rivets 56. The button rollers 52 travel in inverted channel...
members or rails 62 forming the respective sections of the guide unit.

In order to drive the foraminous belt longitudinally, gear teeth 64 are fashioned on appropriate surfaces of the flexible edge strips 46; and turning to FIG. 6, the tail pulley 34 includes a pair of spur gears 66 which meshably engage the gear teeth of the respective edge strips 46. Similarly, and with reference to FIG. 4, the head pulley 32 includes a pair of spur gears 68 which mesh with the gear teeth 64. Power is supplied to the drive arrangement by means of a sprocket 70 and a drive chain 72, sprocket 70 being attached to the head pulley 32 by means of a shaft 74 and the chain 72 being drivenly connected with a suitable motor, now shown.

It is advantageous to lift the fibrous web from the foraminous belt 22 at the end of belt travel in the machine direction; and for this purpose, head pulley 32 comprises a perforated metal drum 76 that is arranged coaxially with an air duct 78. As will be seen in FIG. 5, the duct 78 includes a central cylindrical portion and a radially extending vent portion 80 which communicates the central portion with the perforated surface of drum 76. If desired, the duct 78 may be arranged to be rotated to position the vent portion 80 for maximum effectiveness.

In order to promote efficiency in the deposit of fibers on the tubularized section of the foraminous belt, suction is applied by means of the exhaust plenum 28, and with reference to FIG. 1, the plenum 28 comprises an outer shell 82 and a suitable number of suction lines 84. Turning to a consideration of FIG. 7 in conjunction with FIG. 9, the exhaust plenum 28 additionally comprises a cylindrical perforated inner shell 86 which is spaced apart from the outer shell 82 by ribs 88. In order to minimize the frictional attack on the foraminous belt, rectangular spacer bars 90 with rounded, smoothly polished edges are secured to the inner shell 86 to extend radially inwardly toward the belt 22. In addition, the bars 90 are hardened or hard-coated. As is best seen in FIG. 9, the spacer bars 90 are situated at a shallow angle with respect to the direction of belt travel 30 in order to avoid blind spots in the fiber deposit; and the bars 90 on opposite sides of the shell 86 are oppositely angled to avoid inducing rotation of the belt.

Turning to FIG. 3 for a description of the fiber delivery system and related equipment, a conduit 92 delivers a suspension of suitably opened fibers to the tubularized section of the foraminous belt. Numerous types of fibers may be employed in the invention, such as wood, synthetic cellulose, cotton, synthetic polymers, asbestos and glass; and these fibers are opened to the point where each fiber is detached from the others and becomes a separate entity. Long staple can be fluffed up and separated by well known devices such as opening pickers, cards and garnets while wood cellulose is generally provided in sheet form that can be fluffed up by equipment such as hammer mills, special cards arranged for that purpose, and disc grinders. After opening, the fibers are mixed with flowing air delivered by a fan 94 shown in FIG. 15.

Continuing with reference to FIG. 15 together with FIG. 3, the fiber supply conduit 92 terminates at the tubularized section of the foraminous belt in a nozzle arrangement 96 which releases the suspension into a tapering angular chamber defined between an upstream conical member 98 and a downstream conical member 100. A series of deflector vanes 102 are mounted between the conical members 98 and 100 to produce a swirl flow in a substantially tangential direction along the inside of the foraminous belt. The shaping of the vanes 102 is shown in greater detail in FIG. 13.

It is oftentimes advantageous to provide at least preliminary bonding of the non-woven web before it exits from the tubularized section of the foraminous belt. For this purpose, a binder supply conduit 104 for liquid binder material is arranged coaxially with the fiber supply conduit 92. As is shown in FIGS. 11, 12 and 14, a rotating nozzle ring 106 carries a suitable number of radially disposed spray nozzles 108 and surrounds a stationary ring 110. Liquid binder material flows from the conduit 104 to a rotating toroidal manifold 112 through a suitable number of flaring pipes 114 which also serve as the mechanical connection between ring 106 and a swivel joint 116. A suitably energized drive motor 118 is provided with a spur gear 120 on its output shaft, and the spur gear 120 meshes with a second spur gear 122 mounted on the swivel joint 116. In addition, the swivel joint 116 includes a rotary liquid coupling to make a leaktight seal between the conduit 104 and the pipes 114.

With reference to FIGS. 11 and 12, each of the binder spray nozzles 108 communicates with the manifold 112 through a stub conduit 124, and a shut-off needle 126 is slidably disposed in a nozzle bore intercepting the conduit 124 at right angles thereto. A spring 128 biases the needle generally away from the stub conduit. The needle 126 terminates in the radially inward direction in a heel plate 130 which is positioned to engage a stationary cam 132 on the ring 110 once each revolution. Thus, the nozzles are shut off periodically; and this has been found to create surge loads having a tendency to clear the nozzles of incipient coagulants. The narrow region where no spray occurs is advantageously arranged to coincide with the united edge strips 46 in the tubularized section of the foraminous belt, shown for example in FIG. 7. It will be appreciated that no substantial fiber deposition occurs on these edge strips because there is no suction behind them. Thus, the fibrous web is formed initially with a longitudinal discontinuity which permits flattening without cutting.

Returning to FIG. 14, the exhaust plenum 28 is advantageously divided into three separate sections by means of annular bulkheads 134 and 136. When these bulkheads are positioned as shown, the leading section becomes a fiber air return; the intermediate section, a binder air return; and the trailing section, a dryer air return. Furthermore, an imperforate tubular chamber 138 desirably penetrates the first section of the exhaust plenum so that an air stream may be injected generally in the direction of belt travel. In addition, the upstream section of the exhaust plenum is advantageously penetrated by a tubular duct 140 so that an air stream may be injected in the downstream direction generally opposite the stream delivered through the tube 138. A diffuser unit 142 is secured to the bulkhead 136 in alignment with the duct 140 to direct the air stream in a generally outward direction. The two air streams that are injected into the intermediate exhaust plenum section cooperate both in directing binder material away from the bulkheads and other structures and in carrying the bonding liquid deep into the fibrous structures carried on the foraminous belt.
Since it is frequently desirable to distribute heated air over the fibrous web, as for example to evaporate water, extract solvents, fuse binder material or foam a binder material, means are provided in the present invention for supplying heated air to the final section of the exhaust plenum. Specifically, an annular chamber 144, shown in FIG. 14, is arranged to receive a supply of heated air from a fan 146 and hangers 148, shown in FIG. 115, the annular chamber 144 being defined by a perforated metal tube 150 and the duct 140. Electromagnetic drying may be used in place of heated air, and the cylindrical shape of the tubularized section of belt 22 presents an ideal configuration for radio frequency drying.

With respect to the operational characteristics of the described apparatus and considering FIG. 15, fibers are introduced into the inlet fiber supply conduit 92 by suspending them uniformly in a moving air stream. The resultant suspension is a function of the nature of the fiber or fibers involved, a high density, thick fiber generally requiring more air than a light, thin and irregularly shaped fiber. However, in general, best results are obtained if the suspension has a density of not less than 30 cubic feet of air per pound of fiber, preferably between 50 and 200 cubic feet of air per pound of fiber. The velocity to which the suspension is adjusted is also a function of fiber characteristics. The minimum suspension velocity to maintain the fibers in suspension and prevent any undesirable degree of fiber agglomeration is approximately 1,500 feet per minute and preferably in the range of about 3,000 to about 5,000 feet per minute. The suspension is directed toward the moving foraminous felt 22 in a centrifugal flow by the nozzle arrangement 96, the suspension being volumetrically expanded in a substantially uniform manner until its average velocity at right angles through the belt is less than about 1,000 feet per minute and preferably less than about 300 feet per minute. The vanes 102 act to direct the suspension in successive streams whereby to provide commingling layers of deposited fibers. Section from the exhaust plenum 28 cooperates in the volumetric expansion of the suspension flow and promotes uniformity in the fiber deposit by tending to draw more fiber toward thin areas than those where the deposit is thicker. Belt speed, suspension density and suspension velocity determine the weight of the deposited web.

After the fibers have been deposited, binder is sprayed onto the resultant web by means of the spinning nozzles 108 while the web and the foraminous belt are still in tubularized form, air assist from both the upstream and the downstream direction promoting rapid efficient binder deposition. Thereafter, and in continued tubularization of the foraminous belt, heated air from the fan 146 is delivered to the dryer section through the perforated drum 150 for curing the binder material.

After exiting from the final section of the exhaust plenum 28, the foraminous belt 22 is de-tubularized by the channels 62 of aft guide section 38, and the bonded fibrous web is lifted from the head pulley 32 by air from the duct 78, as is shown in FIG. 3, for such finishing operations as additional bonding, coating, printing and embossing. After it has passed from the head pulley 32, the belt 22 may be backwashed with air, scrubbed with solvent, brushed and dried, during its return trip to tail pulley 34.

While a particular embodiment of the invention has been thus far shown and described, it should be understood, of course, that the invention is not limited thereto since many modifications may be made. In order to enhance the understanding of the invention, one such modified form of the invention has been illustrated in FIGS. 16 and 17. Since many of the elements of this modified embodiment are similar to those shown and described with reference to FIGS. 1–15, like parts have been identified with like numerals, the suffix letter "a" being employed to distinguish those elements associated with the embodiment of FIGS. 16 and 17.

The embodiment of FIGS. 16 and 17 is distinguished by the manner in which the fiber suspension is directed toward the foraminous belt. More specifically, a plurality of fiber dispensing nozzles are focused toward the foraminous belt and are continuously directed in a path of movement generally away from the point of instantaneous impingement at the belt. Structurally, a nozzle unit 152 is disposed within the tubularized section of the foraminous belt coaxially therewith, the nozzle unit 152 being provided with an upstream collar 154 which fits rotatably over a suspension delivery conduit 156. The collar 154 supports the nozzle unit 152 from the conduit 158 and establishes an end seal therewith.

In order that the motor 118a may drive both the nozzle unit 152 and the rotary binder spray arrangement, motor 118a is displaced upstream from the nozzle unit 152, and the swivel joint 116a is replaced by a simple support ring which is connected to a drive sleeve 158. A spur gear 160 is mounted on the sleeve 158 to be driveingly coupled to the motor 118a through a meshing pinion gear 162. Rotary motion is imparted to the nozzle unit 152 by means of a pinion gear 164 which meshes with the pinion gear 162 and which powers the nozzle unit by means of a ring gear 166 fashioned on the nozzle unit and a pinion gear 168 carried on a common, journaled shaft 170.

The nozzle unit 152 is provided with a suitable number of discharge orifices 172 which open to the delivery conduit 156 through respective, arcuate channels 174. An aerodynamic shroud 176 is located upstream from the drive motor 118a to minimize distractions in the fiber suspension movement which might otherwise be caused by the drive arrangement; and in order to promote uniform volumetric expansion of the fiber suspension, the nozzle unit 152 is rotated in the direction of arrow 178 generally in a direction opposite to the tangential velocity vector of the individual exiting streams. Spin rates on the order of 1,500 r.p.m. have proved useful in a specific embodiment of the invention where the tubularized section of the belt took a diameter of one foot. Slower spin rates have proved useful with larger diameter sections.

Air supply for the binder is provided exclusively from the exhaust conduit 140a. In addition, the discharge from nozzle unit 152 is substantially radial whereas the discharge from nozzle arrangement 96 is more nearly a downstream divergent, hollow, conical flow. In other respects, the apparatus of FIGS. 16 and 17 is constructed and operates similarly to the apparatus of FIGS. 1–15.

A modified form of rotating discharge member is shown in FIG. 18 where slots 172b of nozzle unit 152b are flared in the upstream direction in order to level fiber discharge, the general direction of air travel being shown by arrow 180.
An electrostatic field may be included in the apparatus of the invention for enhancing fiber deposit and is of special advantage in that it will permit electrostatic flocking at high machine speed and accomplish flocking with long staple fibers.

The specific embodiments herein shown and described are to be considered as being primarily illustrative. Various changes beyond those described will, no doubt, occur to those skilled in the art; and such changes are to be understood as forming a part of this invention insofar as they fall within the spirit and scope of the appended claims. The invention is claimed as follows:

1. The method of making a non-woven fibrous web comprising the steps of: providing a gaseous stream; incorporating discrete fibers in said stream; continuously directing said stream into a centrifugal flow; collecting said fibers from said flow as a substantially longitudinally endless tubular web; and de-tubularizing and flattening said web.

2. The method according to claim 1 wherein said method comprises the additional step of adding binder to said fibers.

3. The method according to claim 2 wherein said binder is added to said fibers after they have been formed into said tubular web.

4. The method according to claim 1 wherein said fibers are collected from said flow using suction.

5. The method according to claim 1 wherein said flow is a downstream diverging, hollow, generally conical flow.

6. The method according to claim 1 wherein said flow is a substantially radial flow.

7. The method according to claim 1 wherein said tubular web is formed initially with a longitudinal discontinuity whereby to facilitate flattening.

8. The method of making an agglomerated web comprising the steps of: providing a gaseous stream having particulate fibrous matter incorporated therein; continuously directing said stream into a centrifugal flow; collecting said particulate matter from said flow as a substantially longitudinally endless web.

9. The method according to claim 8 wherein said stream is collected on a foraminous member and wherein said stream is continuously directed into a centrifugal flow which is caused to move relatively generally away from the point of instantaneous impingement at said member.