The present invention is concerned with an improved non-woven web product and a method for producing this type of product.

The substitution of a non-woven product for cotton gauze in the field of surgical and dental bandages and dressings, sanitary napkins, and similar products, has long been considered desirable from the standpoint of reduced cost and improved softness characteristics. When cotton gauze is treated to provide a suitable backing for bandages and dressings of the types indicated, it goes through several processing steps which normally leave the gauze with a distinctly harsh feel, which for many uses is quite objectionable. This is particularly true of gauze bleaching operations involving the use of caustic, where the relatively drastic caustic treatment removes many of the natural oils and waxes present in cotton fiber, leaving the final product quite harsh.

Several previous attempts have been made to produce a non-woven web having sufficient strength, softness, and other characteristics, both in the dry and wet condition, to permit its use in place of cotton gauze. Since non-woven webs that are even reasonably soft are extremely flimsy and have very little strength, the web fibers must be bonded in some way to increase the strength characteristics. The normal procedure in strengthening a web of this type consists in applying various types of adhesives to the web in a pattern or otherwise, thereby to bond the fibers together. The selection of suitable adhesives, as well as the application of the adhesives to the web, have always presented problems whose solutions thus far has been more or less a compromise.

The selection of adhesives for non-woven webs to be used in place of cotton gauze for surgical and sanitary purposes is complicated by the fact that such adhesives must be non-toxic, and preferably should be odorless and colorless. For those uses of a finished product requiring that the product be sterilized at relatively high temperatures (250° F. and higher), the adhesive used should desirably have a low point which is higher than the sterilizing temperature.

With a given adhesive, there is still the problem of applying a correct amount of adhesive onto the web to achieve the optimum porosity and strength characteristics. If very minute amounts of adhesive are applied, the strength of the web both in the dry and wet condition is not materially improved and the web is too fragile for the intended purpose. On the other hand, if substantially greater amount of the adhesive are used, for example, as much as 50 percent or more of the total weight of the adhesive-containing web, the strength is increased at the expense of the porosity, the capillarity, the softness, and other of the desired physical characteristics. Thus the addition of large amounts of adhesive to the web does not provide a satisfactory solution to the problem presented.

In contrast with these prior procedures, the present invention provides an improved treated web product having remarkable strength characteristics and a porosity which is not substantially less than the porosity of the untreated web. At the same time, these advantages are achieved without the loss of the characteristic softness of the non-woven web.

The objects of the present invention include the provision of improved non-woven web products having such porosity and strength that the product is suitable for use in the manufacture of bandages, dressings and other sanitary products of the type now made by the use of cotton gauze; the provision of a non-woven web product which is of extremely light weight, which is very soft and which has excellent "feel" characteristics; and the provision of methods for producing and for treating thin, non-woven webs to produce products of the type described.

In the process of the present invention, fibers, which may be cotton fibers, rayon fibers, or synthetic fibers, or any desired mixture of these fibers, are formed by carding, garnetting, air laying, or other means, into a thin, tenacious web having high water absorption properties. The web is sized with a water soluble sizing material to provide a product having sufficient strength to hold together without distortion in the subsequent steps of the process. In the succeeding steps, the sized web is printed under controlled conditions with a hot-melt, thermoplastic, resinous adhesive. The characteristics of the adhesive are such that it solidifies quite rapidly after the removal of heat and securely bonds the constituent fibers of the web together into a strong but flexible bond. After printing, the web is treated with hot water, thereby removing a considerable amount, if not all, of the water soluble sizing material, and materially softening the web. In the next stages of the process, the web is dried, slit, and finally wound up into rolls.

A further description of certain exemplary embodiments of the present invention will be made in connection with the attached sheets of drawings wherein

Figure 1 is a schematic view of the sizing and preliminary web-treating mechanisms;

Figure 2 is a schematic view of the printing and other mechanisms used in the other steps of the process;

Figure 3 is an enlarged, fragmentary view of the printing cylinder and doctor blade of the assembly shown in Figure 2;

Figure 4 is a view in elevation of the printing cylinder employed in the assembly of Figure 2; and

Figure 5 is a greatly enlarged fragmentary view of a portion of the surface of the etched cylinder shown in Figure 4.

In the practice of the invention by the apparatus illustrated in the drawings, it is first necessary to produce a suitable water absorptive basic mat or web of fibers. As previously indicated, the fibers used in the production of this web may be of cotton, rayon, synthetic material, such as nylon, vinyon, acrylic esters and the like. Desirably the fibers are of substantial length, i. e. over 3/4 inch, and the web is conveniently produced on a card, garnetting machine, or other suitable apparatus. It may be a single layer or a multi-layer.

Such a web or mat is illustrated at 10 in Figure 1, and as there shown, the mat 10 is first caused to pass between a pair of calender rolls 11 and 12. These rolls condense the mat and thereby increase its strength sufficiently to assure that the web will hold together without distortion during the time the sizing composition is applied. In instances where the completed product is to be used as a wrapper for sanitary napkins, particularly desirable results are obtained by the use of 100 percent dill viscose rayon fibers or a blend of dill viscose rayon fibers with about 25 percent by weight, based on the total weight of the finished product, of cotton fibers.

The fiber web 10 after being compressed by the action of the calender rolls 11 and 12 is passed through a sheeting mill consisting of a pair of cooperating rolls 14 and
16. The upper roll 14 is a rubber covered roll and has a small polished roll such as a chromium plated steel roll 17 bearing against it to cause the dry web to adhere to the down rubber coated roll 14 to such an extent that the lay of the fibers will not be distorted while the web passes through the roll nip while wet with the sizing solution.

The pressure at the nip of the sheeting mill rolls 14 and 16 may be controlled hydraulically at a value depending upon the nature of the fibers and the weight of the web. In the manufacture of webs for use in bandages, sanitary napkins, and the like, nip pressures of the order of from 20 to 50 pounds per linear inch may be used. The lower roll 16 may also be a chromated plated steel roll, and it is partially immersed in a pan 18 containing a water soluble sizing solution 19, such as an aqueous solution of polyvinyl alcohol. While in other applications of web-treating, very dilute solutions of polyvinyl alcohol have been used to achieve certain characteristics in the web, we have discovered that the use of a sizing solution which contains substantially more polyvinyl alcohol than was heretofore considered practical has certain important advantages. Specifically the most satisfactory sizing solution for our purposes contains from 1 to 3 percent by weight of the polyvinyl alcohol sizing agent and preferably contains approximately 2 percent.

The sizing solution may also contain a wetting agent such as an alkyl aryl polyether alcohol (“ Triton X-100”) in amounts of about ½ percent by weight of the polyvinyl alcohol present. The wetting agent is added primarily to aid in dispersing the sizing material throughout the fibrous web.

While polyvinyl alcohol sizing solutions have important advantages, for our purposes, other water soluble sizing materials such as alginites, casein, starch, latex emulsions, and dextrine can be used, although not with completely equivalent results.

In the production of products for use in bandages, sanitary napkins, and the like, the web 10, as it enters the sheeting mill, is barely self-sustaining and has a weight within the range of from about 4 to 14 grams per square yard. In the sheeting mill, sufficient amounts of sizing material are applied to produce a web which weights from 5 to 15 grams per square yard. The strength of the web is considerably increased by the impregnation with polyvinyl alcohol. For example, a web weighing 10 grams per square yard composed of 100 percent of viscose rayon staple fibers and having practically no strength in the as-formed condition, will, when treated with the polyvinyl alcohol solution, evidence a strength in the machine direction of 1600 to 1800 grams per inch of width, and about 200 grams per inch in the cross-machine direction. The strengthened web can be passed directly into the printing machine or it can be stored for indefinite periods in rolls, as illustrated at 24.

The next step of the process consists in printing the treated web with hot-melt compositions of thermoplastic resins. A suitable apparatus for practicing this step of the process is illustrated in Figure 2.

The resin employed in the manufacture of web products suitable for surgical and sanitary use should be nontoxic and are preferably odorless and colorless. The resin should also have a relatively high specific heat and in order to facilitate printing of the web at a relatively high speed, the resin should exhibit a small temperature differential between its flow point and its hardening point. For most commercial speeds of operation, this differential should not exceed about 30°F. Where the non-woven web product is to be sterilized in use, the resin should have a flow point about 50°F. lower than the sterilization point.

One particularly suitable material for the purposes of this invention is a hot-melt composition whose major constituent is solid polyethylene. One very satisfactory resin is a polyethylene having a molecular weight within the range of about 12,000 to 15,000, a viscosity at 190°C of 30,000 to 50,000 centipoises, and a melting point of range of 200 to 250°F. In order to improve the flow characteristics of this resin in its molten stage, it is desirable to include small amounts of wax, such as microcrystalline wax in amounts of 5 to 25 percent by weight of the hot-melt composition.

Another suitable material consists of a hot-melt composition of n-butyl methacrylate polymer (“Hypalon P-4”) having a viscosity in a 43 percent solution in toluene of 40 to 70 seconds at 25°C, a specific gravity of 1.06, and a refractive index of 1.480.

Referring to Figure 2, the sizing composition consisting of the thermoplastic resin or a mixed mixture of resin and wax is supplied to the apparatus there shown in particle form from a hopper 26 which feeds the particles onto a vibrating feeder mechanism 27. The feeder 27, in turn, applies the agitated particles onto the surface of a hard steel printing cylinder 28 maintained at a temperature above the flow point of the hot-melt composition. For the polyethylene compositions mentioned, the cylinder 28 should be at temperatures in the range from 330 to 450°F. The actual temperature depends upon the speed of the cylinder. As the particles strike the surface of the cylinder 28, they fuse and form a small molten bead 29 against the surface of a heated doctor blade 30. As the cylinder 28 rotates, the bead 29 also rotates. The constant rotation of the bead, its small size and the rapidity with which it is used up, and its immediate application to the surface of the web affords a small time for oxidation of the material and minimizes any tendency of the hot-melt composition to oxidize.

The printing cylinder 28 cooperates with a resiliently covered impression cylinder 31, having a coating which can withstand the temperatures employed. For some hot-melt compositions, a rubber covered cylinder will function satisfactorily, but where the temperatures are on the order of 350°F or above, the cylinder 31 may be covered with a siloxane polymer, such as a “Silicone,” which can withstand temperatures up to 500°F and more without breaking down.

The hot melt plastic is printed onto the web in the process of the present invention by a combination of intaglio and offset printing methods. The printing cylinder 28 constitutes the intaglio cylinder and, as seen in Figures 4 and 5, includes a steel shell 28k in which spaced cells 28k are etched. The cells 28k can be arranged along the surface of the cylinder 28 in various patterns, although there are certain advantages in using the brickwork pattern illustrated in the drawings, in which the succeeding rows of cells 28o are in staggered relation. See particularly the illustration in Figure 5.

The size of the cells, the depth of the cells, and their arrangement will depend to a large extent upon the nature of the hot-melt composition being printed and the speed of the web through the printing rolls. There should be a sufficient number of cells present to deposit sufficient resin during the printing operation to provide a resin content in the finished web which is in the range of 25 to 35 percent by weight of the web on an air dry basis. In one installation, using web speeds of 20 to 60 feet per minute, the cylinder 28 measures twenty-three inches in length and the etched portion of the cylinder, constituting the printing area, extends about 18 inches. The distance from the leading edge of the one cell to the next adjacent cell in the same row measures about ⅛ inch, the spacing between the cells being about ⅜ inch. The cells were arranged to have a cell breadth of ⅜ inch, and a space
The cells themselves may have a depth of 1 to 5 mils and are usually about 2 mils deep. The total area covered by the cells should be within the range of from about 20 to 40 percent of the total printing area, i.e., the portion of the cylinder 28 in which the hot-melt material is extruded.

The printing cylinder 28 and the impression cylinder 31 are preferably geared together and have the same radius from the center to the nip. The pressure at the nip is controlled by varying the relative positions of the cylinders 28 and 31, and is adjusted to a value of at least 50 pounds per linear inch.

By providing cylinders which are the same size and are geared together, the hot-melt material prints through the porous web onto the impression cylinder with the result that on successive revolutions of the cylinders an impression of each cell is in turn deposited onto the underside of the web directly under the individual etched cell that originally printed that impression through the web. Thus, a direct and an offset impression of each cell is applied to the web simultaneously and in continuous register. If the cylinders are not of the same size, the plastic material that prints through the web onto the impression cylinder will be transferred at random to the underside of the web on the passage through the nip, and this is very detrimental to the final softness and absorbency of the web.

The printed web 33 may then be washed and dried directly, but we prefer to reheat the composition on the web and then stretch the resin and the web to improve the strength properties. Very shortly after the printed web 33 leaves the nip of the cylinders 28 and 31, the resin composition which has been applied thereto during the printing operation will have solidified on the fibers of the web, the hardening point of the composition being very close to the flow point. When this has occurred, the printed web is passed to a pair of heated calendaring rolls 34 and 36 which rotate at the same speed as the printing cylinders. Each of the calendaring rolls 34 and 36 is maintained at a temperature sufficient to soften the resinous composition. For a polyethylene composition, as described above, each of the rolls will be maintained at a temperature above 175°F., the exact value depending on the speed. The upper roll 34 can be identical with printing cylinder 28 except that it does not contain the etched pattern but has a smooth surface. The lower roll 36 can also be provided with a heat resistant, flexible covering of the same type used on the impression cylinder 31.

Beyond the heated calendaring rolls 34 and 36 are a pair of pull rolls, consisting of an upper roll 37 of steel or other hard, smooth-surfaced metal, and a lower rubber covered roll 38. These rolls 37 and 38 are operated at an adjustable speed and are set to rotate at a speed slightly greater than the speed of the calendaring rolls 34 and 36 to thereby tension and stretch the web while the web is being reheated by the calendaring rolls. This tensioning and stretching of the web aligns the fibers of the web in the machine direction, and is of material value in improving the physical properties of the web. The pull rolls 37 and 38 are not heated and are operated at a velocity sufficient to stretch the web on the order of 6 percent in the machine direction.

The stretched web then passes over a pair of rolls 39 and 40 and is conducted into a tank 41, partially filled with water 42 which has been heated to a temperature of about 160°F. The tank 41 is supplied with hot water at the boiler 43, and has an overflow at the outlet 44. About 1 gallon of water per minute is allowed to overflow from the tank 41 in order to keep the surface of the hot water free from scum. In the illustrated apparatus the web passes successively over the roll 40, under a roll 43 immersed in the tank 41, then over a roll 44 and finally is reintroduced into the tank 41 about a roll 46.

The immersion of the web in the hot water contained in the tank 41, and the movement of the web through that water, effects the removal of a substantial amount of the polyvinyl alcohol or other water soluble sizing material. The remainder of the sizing material available for extraction with hot water can be removed by passing the web through a spray of hot water while it is supported on a fluid permeable support means, for example, the web can be conducted over a wire mesh covered cylinder 47 disposed in a second tank 48, while it is subjected to a spray of hot water directed through the web and into the hollow cylinder 47 by one or more spray nozzles 49. The overflow from the tank 48 is removed from the tank 48 through an outlet 50.

After the washing operation, the wet web passes under a guide roll 51 and thence through a pair of squeeze rolls 52 and 53. These squeeze rolls reduce the moisture content of the web to a point where the weight of the water still remaining in the web is equal to from about 45 to 50 percent of the weight of the web on an air dry basis.

Next the web is subjected to the action of a pair of web expander rolls 56 and 57, following which it is ready for drying. The web expander rolls 56 and 57 may conveniently be corrugated steel rolls which grip and stretch the web laterally (crosswise) prior to the drying of the web.

The web is dried by passing it through a drier 58 which includes a blow 59 and heating coil 60 through which a heated medium such as steam is continuously passed. The blower 59 blows heated air at the web passing through the drier 58 over a series of rollers 61. The moisture carried off by the heated air is vented through a vent 63. It is very desirable to avoid tensioning the web during the drying operation, and important benefits are achieved if the web has enough slack so that it is fairly limp and will flutter during the drying operation due to the movement of the hot air against the traveling web surface.

As the web is being dried, it has a tendency to shrink so that the rollers spaced nearer the outlet end of the drier should revolve at a lower speed than those at the inlet end of the drier to compensate for shrinkage. If this is not done, the increased tension on the web detracts from the softness of the final product. Rayon or rayon and cotton fiber webs of the type previously described should be dried to a moisture content within the range of from about 5 to 11 percent by weight, based on the weight of the bone dry web.

While the web is held relatively limp in the drier, it is necessary to keep the web fairly taut during winding after drying. In order to tension the dried web after it leaves the drier 58, the assembly is provided with a soft rubber roller 64, having an adjustable brake (not shown) which can be adjusted to provide the desired tension on the web as it is being wound. A solid metal cylinder 66 rides by its own weight on the surface of the roll 64 to press the web against the surface of that roll.

The last steps of the process consist in passing the web 33 over a series of slitting knives 67 and then over a plurality of winder drums 68 and onto a core 69.

The application of the resin onto the web in the form of a hot melt rather than as an emulsion has several distinct advantages. For one, the resin in its molten condition has an affinity for the web fibers thereby facilitating its application to the web by a printing operation. In addition, the molten resin forms a tough, thin film about the fibers, locking the individual fibers in position. To the naked eye, the finished web appears to have continuous strips or blocks of the resin printed across the web in the pattern of the printing cylinder. Under microscopic examination, however, it will be seen that the film of resin does not bridge many of the voids existing between the randomly disposed fibers but that the resin actually coats the fibers without occupying many of the spaces between the fibers. As a result the
of 5 to 15 grams per square yard, fusing particles of an adhesive material, printing the fused adhesive material along spaced areas to said sized web in amounts sufficient to yield an adhesive content of 25 to 35 percent by weight of the final product, cooling said adhesive after application to said web, and washing the printed web with water to remove at least a portion of the sizing material.

4. The method of making a web product which comprises sizing a non-woven web with a water soluble sizing composition to produce a sized web having a weight of 5 to 15 grams per square yard, fusing particles of an adhesive material containing polyethylene, printing the fused adhesive along spaced areas to sized web in amounts sufficient to yield an adhesive content of 25 to 35 percent by weight of the final product, cooling said adhesive after application to said web and washing the printed web with water to remove at least a portion of the sizing material.

5. The method of making a web product which comprises the steps of fusing particles of an adhesive material, applying the fused adhesive onto the surface of a rotating printing cylinder having spaced, recessed printing cells formed thereon occupying between 20 and 40 percent of the printing area of said cylinder, passing a non-woven web between the nip of said printing cylinder and a cooperating impression cylinder, rotating said printing cylinder and said impression cylinder at the same peripheral velocity, applying pressure at said nip to press the fused material through said web, and cooling the fused material after application to said web to solidify said material onto said web.

6. The method of making a web product which comprises sizing said web with a water soluble sizing composition to produce a web having a weight of 5 to 15 grams per square yard, fusing particles of an adhesive material, applying the fused material onto the surface of a rotating printing cylinder having spaced recessed printing cells formed thereon occupying between 20 and 40 percent of the printing area of said cylinder, passing a non-woven web between the nip of said printing cylinder and a cooperating impression cylinder, rotating said printing cylinder and said impression cylinder at the same peripheral velocity, applying pressure at said nip to press the said material through said web, cooling said material after application to said web and thereafter washing said web with water to remove at least a portion of sized sizing composition.

7. The method of making a porous web product which comprises the steps of fusing particles of an adhesive material, applying the fused material onto a surface of a rotating printing cylinder having spaced recessed printing cells formed therein occupying between 20 and 40 percent of said printing cylinder, passing a non-woven web sized with a water soluble sizing composition between the nip of said printing cylinder and a cooperating impression cylinder, rotating said printing cylinder and said impression cylinder at the same peripheral velocity, applying pressure at said nip to press the said material through said web, applying a sufficient amount of molten adhesive to said web to achieve an adhesive content in the final product in the range of 25 to 35 percent by weight, cooling said material after application to said web and thereafter washing said web with water to remove at least a portion of sized sizing composition.

8. The method of making a porous web product which comprises sizing a non-woven web with a water soluble sizing material, printing a fused, thermoplastic resinous material onto said web, washing said web with water to remove at least a portion of the water soluble sizing material, and drying said web.

9. The method of making a web product which comprises distributing discrete solid particles of polyethylene resin onto a heated rotating printing cylinder maintained
at a temperature above the fusion temperature of said resin to thereby fuse said resin, and immediately thereafter pressing said cylinder against a moving non-woven web so as to print the fused resin from said cylinder onto said web.

10. The method of making a reinforced, non-woven web product, which method comprises the steps of distributing discrete solid particles of thermo-plastic resin on a heated rotating intaglio printing cylinder which has a series of mutually spaced printing recesses distributed approximately uniformly over its surface and which recesses are of a size and depth to carry sufficient adhesive to imprint between 20 and 40 percent of the area of the web with adhesive sufficient to constitute between 25 and 35% of the weight of the finished web, maintaining said cylinder at a temperature above the fusion temperature of said resin to thereby fuse said resin on said printing cylinder, causing said fused resin to be confined to said printing recesses, guiding a non-woven web which is sized with water soluble sizing into printing contact with a portion of the surface of said cylinder, thereby to print the fused resin on said sized web, passing the printed web through a size removing wash, partially drying the web by squeezing a substantial portion of the washing fluid from the web, and then drying the web while subjecting it to facewise flexing motion.

11. The method of making a thin, strong and flexible, non-woven web of fibers which comprises the steps of providing a non-woven web of fibers having a basis weight of from 4 to 14 grams per square yard, sizing and thereby stabilizing the web, printing adhesive material on spaced areas of the web which areas comprise from about 20 to about 40 percent of the web area, the adhesive being applied to said areas in amounts sufficient to penetrate the entire thickness of the web in said areas, and, after said material is set in the web, washing the printed web to remove at least a substantial portion of said sizing.

12. The method of making a strong but flexible non-woven web of fibers which method comprises the steps of distributing on a heated rotating printing cylinder, discrete solid particles of a thermoplastic resin, thereby to fuse the resin on the cylinder, doctoring the fused resin on the cylinder so as to form a predetermined printed coating of said fused resin on the cylinder, guiding a non-woven web of fibers across a portion of said cylinder containing said printing coating so as to transfer the resin from said cylinder to said web, and controlling the rate of application of said particles to said cylinder so that only a small and rapidly used up supply bead of the fused resin is collected in a trough formed between the surface of the doctoring means and the surface of said cylinder, thereby to minimize oxidation of the fused material before the same is transferred to said web.

13. A non-woven web product made in accordance with the method of claim 11.


References Cited in the file of this patent

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Patent Number</th>
<th>Inventor</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,039,312</td>
<td>Goldman</td>
<td>May 5, 1936</td>
</tr>
<tr>
<td>2,402,621</td>
<td>Gifford</td>
<td>June 25, 1946</td>
</tr>
<tr>
<td>2,513,434</td>
<td>Tinsley</td>
<td>July 4, 1950</td>
</tr>
<tr>
<td>2,545,952</td>
<td>Goldman</td>
<td>Mar. 20, 1951</td>
</tr>
</tbody>
</table>