April 12, 1966 G. O. ETCHISON ET AL 3,245,854

PROCESS OF MANUFACTURING NONWOVEN FABRICS

Filed March 23, 1961

Fig. 1.

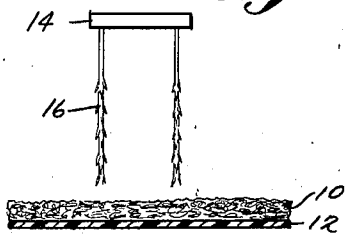


Fig. 2.

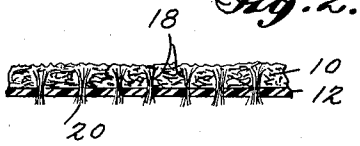


Fig. 3.

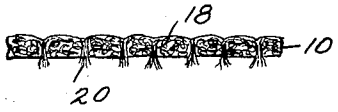


Fig. 4.

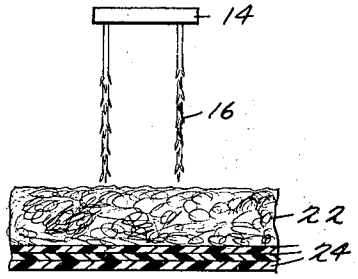


Fig. 5

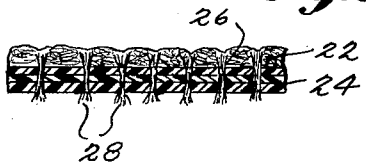


Fig. 6.

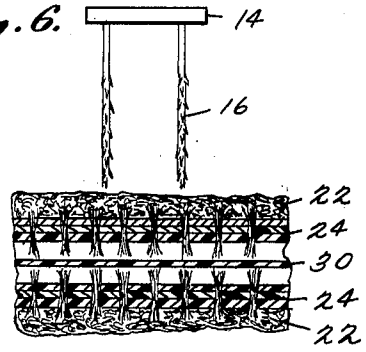


Fig. 7.

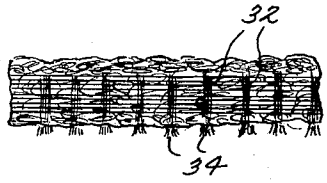


Fig. 8.

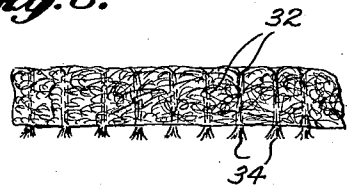


Fig. 9.



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PROCESS OF MANUFACTURING NONWOVEN FABRICS

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This invention relates to the manufacture of nonwoven fabrics, and particularly to the manufacture of needle punched nonwoven fabrics exhibiting high internal bond strength and resistance to delamination. The invention involves a novel and superior method of needle punching unbonded or lightly bonded fiber webs, and subsequently bonding the punched webs.

It is known that carded webs exhibit high strength primarily in a single direction. By cross-laying carded webs, nonwoven structures exhibiting high strength in two or more directions may readily be obtained. It is also known, for example as in Wilson et al. Patent 2,477,675, to airlay nonwoven fabrics by utilizing an air stream to deposit fibers in random fashion, whereby fabrics exhibiting high strength in all directions in the plane of the fabric surface may be obtained.

It is known, further, that nonwoven fabrics may be needle punched, thereby disposing some of the fibers in direction normal to the fabric surfaces. This offers the possibility of increasing the internal bond strength of the fabric, particularly if the vertically oriented fibers are fixed in such disposition. As a practical matter, however, the improvement of internal bond strength by needle punching presents serious difficulties.

For example, it will be readily understood that in the manufacture of nonwoven fabrics, the initial deposition of the fiber web is critical, it being essential for most applications to insure uniformity of thickness, fiber arrangement and the like. It has been found that if a newly deposited and unbonded fiber web is subjected to conventional needle punching, the fibers of the web are seriously disarranged, producing such lack of uniformity, discontinuity and irregularity as to render the web commercially unacceptable. Also, such fibers as are vertically oriented do not contribute materially to internal bond strength, since they are not bonded or otherwise engaged to adjoining fibers. On the other hand, if a fiber web is bonded before needle punching, other difficulties are encountered. It has been found that fibers of bonded webs are frequently locked together adequately to resist relative displacement, whereby fibers engaged by the needles of a needle loom are broken. The broken fibers, while they may be vertically oriented by needle punching, do not contribute materially to internal bond strength. Also, conventional bonding agents in nonwoven fabrics may foul the needles or unduly load the needle loom, causing damage to the machine and/or necessitating excessively slow operation.

A principal object of the present invention is to provide an improved and superior method of needle punching and bonding nonwoven fiber webs, whereby completely unbonded or only lightly bonded webs may be needle punched with only local disruption of the fiber arrangement, without disturbing the desired configuration and arrangement of the remaining fibers. A related object is to produce nonwoven fabric in which some fibers are disposed normal to the fabric surfaces, and firmly locked in such arrangement.

Another object of the invention is to provide a novel and efficient process for the production of nonwoven fabrics having high internal bond strength and resistance to delamination.

A further object is to provide a method for the production of nonwoven fabrics wherein precise control of the quantity of binder applied is readily attained. The method also permits use of cheap polymeric materials as binders, materials that cannot readily be used or produced in emulsion or solution form, due to the circumstance that they are not readily emulsified or solubilized in aqueous systems, or for other reason. The new process is versatile, and useful for producing needle punched products ranging from lift, soft waddings or battings up to heavy, semi-rigid moldable panel structures. Further objects will be in part evident and in part pointed out hereinafter.

The invention and the novel features thereof may best be made clear from the following description and the accompanying drawings, in which:

FIGURES 1–3 are diagrammatic views sequentially illustrating a simplified embodiment of the process of the present invention, and

FIGURES 4–9 are diagrammatic views sequentially illustrating a variation of the process, suitable for production of a relatively heavy and stiff molding panel.

In accordance with the present invention, a fiber web of desired structure and weight is placed in surface contact with a thermoplastic film. The assembled web and film are then needle punched by means of a conventional needle loom, the film serving to lend effective support to the fiber web in the needle punching operation, even though the web may be lightweight and completely free of binder. The needle punched assembly may be readily handled, the fibers displaced by the needles being effectively maintained in displaced position normal to the web surfaces by the film, and the support by the film permits needle punching with only local disruption of the fibers; that is, except for the local areas affected, the original fiber disposition is not disturbed.

The needle punched assembly is then heated in an oven to a temperature adequate to fuse the film material, whereupon the film fuses and permeates the web, and then cooled, whereupon the thermoplastic material functions as a binder, locking the fibers in needle punched disposition. As will be evident, the method provides not only effective support for an unbonded or lightly bonded web through a needle punching operation, but also provides novel procedure for the uniform application of binder in predetermined quantity.

Referring to the drawings, in FIGURE 1 is shown a fiber web **10** resting on a thermoplastic film **12**, in position to be needle punched by needle loom **14** provided with conventional barb needles **16**. The needle punched assembly is illustrated in FIGURE 2, wherein fibers **18** have been rearranged by the needle punching in position normal to the fiber web surfaces, and fiber tufts **20** have been punched through the film **12**. As previously indicated, the tufts **20** are firmly held in place, at this stage, by the film **12**. FIGURE 3 illustrates the needle punched assembly of FIGURE 2, after heating to fuse the thermoplastic film. As shown, the thermoplastic film has completely disappeared as such. The fiber web **10** retains its needle punched configuration, with vertically disposed fibers **18** and fiber tufts **20** extending from one surface thereof. The thermoplastic material has permeated the web, wherein it remains as a coating on the fibers, serving as a binder to maintain them in the needle punched arrangement.

FIGURE 4 shows a heavier fiber web **22** supported by a plurality of thermoplastic films **24**, in position to be needle punched by the needle loom **14**. After needle punching, this assembly has the appearance of FIGURE 5, wherein fibers **26** have been rearranged by the needles in position normal to the fiber web surfaces, and fiber tufts **28** have been punched through the films **24**.

In FIGURE 6, two punched assemblies as shown in FIGURE 5 are laid together with an intervening thermoplastic film **30**, the assemblies being arranged, as is preferred, with the tufted sides (the underside in FIGURE 5) facing the central film layer **30**. The plied assembly is again needle punched by the needle loom **14**, resulting in a condensed product illustrated in FIGURE 7, wherein additional fibers **32** are arranged transversely of the product, and forced through the bottom as tufts **34**. Upon heating the intermediate product of FIGURE 7, the films **24**, **30** fuse and lose their film character, permeating throughout the fiber mass and resulting in the product illustrated in FIGURE 8. The FIGURE 8 product, if desired, may be calendered while hot, to yield a condensed, relatively heavy and stiff product, shown in FIGURE 9 as body **36**.

The following examples are illustrative of the invention.

EXAMPLE 1

A cotton web is airlaid by means of apparatus of the type disclosed in Wilson et al. Patent 2,478,148, to produce a fiber web of random distribution weighing two ounces per square yard. The fiber web is laid on a polyethylene film ½ mil thick, weighing approximately 0.6 ounce per square yard, and the assembly is then needle punched by means of a conventional Hunter 105 inch Fiberlocker needle loom, equipped with regular barb needles. The assembly is run through the needle loom with the film underneath the web, whereby the needles penetrate first the web and then the film. The needle penetration is adjusted to penetrate one inch through the film, whereby the first barb of each needle penetrates ¾ inch through the film and the first several barbs pass therethrough. The web speed is adjusted to effect 200 punches per square inch. The film effectively supports the web through the needle punching operation, and fibers are reoriented by the needles into direction normal to the web surfaces, with only local disruption of the web.

The needled assembly is then passed through an oven and heated briefly to a temperature of 300° F. At this temperature, the ½ mil film fuses readily and permeates the web, losing its character as a film and coating the fibers of the web, particularly at the fiber intersections. On cooling, the fabric is effectively bonded in the needle punched arrangement by the polyethylene, and the product is particularly useful as a backing for vinyl upholstery fabrics, as felt-like material and as filter medium. By using a higher binder-to-fiber ratio, as by using a thicker polyethylene film, a product is obtained which may be pressed or calendered to form waterproof protective fabrics like tarpaulins.

EXAMPLE 2

A carded crosslaid batt weighing 10 ounces per square yard is made from a mixture of 12% wool fibers, 12% nylon fibers and 70% napper waste, a commercial mixture of short, synthetic fibers. The batt is laid on three layers of 1½ mil polyethylene film, and the assembly then needle punched as in Example 1, the speed of the assembly through the needle loom being adjusted to effect 300 punches per square inch. The combined weight of the polyethylene film is approximately 5.4 ounches per square yard.

Two needle punched assemblies made as above are then assembled with another 1½ mil polyethylene film, and the assembly again needle punched, applying 300 punches per square inch. In plying the initially needle punched assemblies with the film, the assemblies are disposed with the original upper sides outermost, the original film sides being disposed adjacent the central film layer. The plied product is then passed through an oven and heated to 250° F., and calendered while hot. In the oven, the polyethylene films fuse readily and permeate the product. The use of multiple relatively thin films is found to facilitate fusion and permeation, the 1½ mil films fusing and flowing much more easily and at a lower temperature than is the case when thicker films, for example 4.5 mil, are used. The heated product emerging from the oven is approximately ¼ inch thick, and is consolidated by the hot calendering to a final thickness of approximately 1/16 inch. The product is relatively heavy and stiff, and is particularly suited as molding panels for luggage, moldable hat materials, and heat formable automobile head lining.

The fiber web may be composed of any conventional textile fibers, natural or synthetic, including cotton, viscose rayon, acetate rayon, nylon and the like. The initial fiber web may be formed by crosslaying card webs, by airlaying, by picking or in other conventional manner, and may vary in weight from ½ to 16 ounces per square yard or more.

The thermoplastic film employed to support the web through the needle punching operation and to serve thereafter as binder may be any thermoplastic or initially thermoplastic film material capable of fusing at temperatures not detrimental to the fibers. The film material, for example, besides polyethylene may be nylon, polyesters, vinyl chloride polymers and copolymers, vinylidene chloride polymers and copolymers, polypropylene, cellulose acetate, polyvinyl alcohol, starch, copolymers of acrylonitrile butadiene styrene, and thermoplastic elastomeric materials, such as uncured natural and synthetic rubber, and acrylonitrile polymers and copolymers. While the plastic film is preferably disposed in the needle punching operation below the fiber web, that is away from the punching needles so that the needles in punching encounter first the fiber web and then the film, it may also be disposed above the fiber web or between fiber web layers.

The needling operation may involve needling from one or both sides of the web-film assembly, and may be applied to assemblies including a single web or a plurality of fiber webs. The extent of needle punching may vary from about fifty punches per square inch up to several hundred or several thousand punches per square inch, depending upon the desired extent of fiber disposition normal to the fabric surfaces.

In heating the needle punches assembly to fuse the film and cause the film material to permeate the web to serve as binder, the temperature to which the needle punched assembly is heated may be varied in accordance with the character and thickness of the film material, varying usually from about 200° to about 350° F. The fusion temperature of the film chosen should be substantially below the fusion or heat distortion temperature of the fiber in the web. Nylon fiber, for example, fuses at 480° F., Dacron and Orlon at about the same temperature. Vinyl chloride film fuses at about 350–360° F. The thickness of film applied may correspond to as little as two or three percent by weight of the fiber web, and may be as much as several hundred percent by weight of the fiber web, depending upon the degree of bonding and the character of product desired. As will be evident, the final product may have additional binder applied thereto, by saturation or other conventional method.

It will thus be seen that there has been provided by this invention a method in which the various objects hereinbefore set forth, together with many practical advantages, are successfully achieved. As various possible embodiments may be made of the novel features of the above invention, all without departing from the scope thereof, it is to be understood that all matter hereinbefore set forth is to be interpreted as illustrative, and not in a limiting sense.

We claim:

1. Process of manufacturing nonwoven fabrics comprising the steps of placing a substantially unbonded fiber web in surface contact with a discrete thermoplastic film, needle punching the assembled web and film, and then heating the needle punched assembly to fuse the film material and permeate the web therewith, whereby the film completely disappears as such and is transformed to a

binder coating the fibers throughout the web, particularly at the fiber intersections.

2. Process as defined in claim 1, including the subsequent step of applying additional binder to the product.

3. Process as defined in claim 1, wherein the web and film are assembled and needle punched in such disposition that the needling is from the web side toward and through the film side.

4. Process as defined in claim 1, wherein a plurality of webs and films are needle punched together.

5. Process as defined in claim 1, wherein said thermoplastic film is polyethylene.

6. Process as defined in claim 1, wherein said assembly is needle punched from both sides.

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