PROCESS OF SOLVENT BONDING NAPPED TEXTILE FABRIC

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Claims.

1. This invention relates to a method of bonding the fibers in textile materials and, more particularly, to a method of applying a mist to yarns and fabrics.

In United States application Serial No. 845,339, filed October 9, 1959 in the name of Joseph A. Generieux, now abandoned, of which application Serial No. 125,316, filed Aug. 31, 1961, now abandoned, is a continuation-in-part, and which, of the latter application, application Serial No. 758,759, filed July 8, 1963, is a continuation, a process is described for improving the properties of textile materials by bonding the surface fibers having one free end. This process is particularly valuable, since it reduces the shedding and surface distortion of napped fabrics without increasing their thickness. It is of particular value in the preparation of blanket materials and has been observed to provide improved resistance to shrinkage.

In scale-up operations it has been found that application of the process of Generieux, identified above, when the mist is applied to both sides of a fabric simultaneously while it is traveling in a horizontal position, difficulties in commercial production are sometimes encountered.

It is an object of the present invention to provide a novel and useful improved means of applying vaporized finish liquids to the surface of fabrics.

Another object is to provide apparatus suitable for the application of finishes such as described in the Generieux application without the formation of spots and other surface defects.

These and other objects will become apparent in the course of the following specification and claims.

The above objects are accomplished by providing a process for bonding fibers of a textile material which comprises applying to both sides of a textile material, while the said textile is in a full width condition and vertically disposed, a mist composed of discrete liquid particles, substantially all of which are less than 0.012 inch in size, dispersed in a gaseous medium, each liquid particle resulting from the atomization of a liquid comprising from about 1% to about 25% of a latent solvent for the fiber in a volatile diluent which is inert to the fibers to be bonded, the quantity of solvent being by weight of the total liquid, under conditions such that no fibers are substantially displaced within the textile material and the textile material maintains its original thickness, then activating the latent fiber solvent to cause bonding at a number of points in the material where two or more fibers contact each other, and removing the excess diluent, and optionally the solvent.

The invention will be more readily understood by reference to the drawings. FIGURE 1 is a schematic diagram showing the flow of the fabric through the various steps of the process. In the figure, fabric 1 preferably held at full width by securing means (not shown) along its edges (preferably by pins), passes into shield area 2, wherein a mist 3 is applied to each side of the moving fabric from nozzles 4. Thereafter the fabric is led around guide rollers 5 into a drying tenter frame 6 wherein heat is applied to remove the diluent, after which the still tentered fabric 7 is then caused to proceed to the fabric collector 8, which collects the fabric by conventional means, such as by wind-up, folding, lapping, or the like.

FIGURE 2 shows the system in greater detail. In this figure fabric 1, preferably on a pin frame, is directed over swivel 8 and thereafter around guide 9 to place it in a vertical position. Thereafter it enters the shield area 2, containing the web-wetter 10 which contains nozzles 4 (not shown). Shield area 2 is equipped with flame exhauster 11. When leaving the shield area the fabric is trained around guides 12, 13 and 14 into drying tenter frame 6, then, while still tentered, is cooled and thereafter proceeds to fabric collector 7.

As a typical way of carrying out the invention, a woven blanket consisting of 100% polyacrylonitrile fibers distributed in the blanket such that approximately 25% of the total thickness of the blanket is in the center and 75% of the total thickness of the blanket is in the nap on both surfaces of the fabric is treated. A suitable mist for bonding this polyacrylonitrile blanket was prepared from an aqueous solution containing 5% sodium thiocyanate by weight by misting said solution in the web-wetter described in the example given hereinafter. The blanket was fed continuously in a vertical position between two nozzles of the web-wetter without coming in contact with the apparatus while tiny droplets of the liquid from the mist deposit on both sides of the blanket. The fabric then was led directly through a 15-foot drying oven maintained at 300° F. at a speed of two yards per minute in order to activate the fiber solvent by evaporation of the diluent to bond the fibers at a number of crossover points. The oven also served to remove all of the diluent, leaving a completely dry (i.e., non-tacky) fabric. The dried bonded fabric picked up 0.07 gram of sodium thiocyanate per square yard of each fabric face. This bonded fabric exhibited less shedding and less surface distortion than the equivalent unbounded control fabric.

Surprisingly, it has been found that the stiffness of the bonded fabric is primarily dependent upon the quantity of fiber solvent picked up on the face of the fabric, whereas the resistance to distortion and shedding resistance of the fabric are dependent upon both the quantity of fiber solvent picked up on the fabric face as well as the concentration of latent fiber solvent in the liquid solution from which the mist is formed. Therefore, in order to achieve bonded fabrics with a desirable combination of stiffness and shedding resistance, at least two factors involving the fiber solvent are highly critical. The concentration of latent fiber solvent in the mist-forming solution must be between about 1% and 25% of latent fiber solvent based on the weight of the total solution, and preferably between 4% and 6% when using sodium thiocyanate as the latent fiber solvent for bonding polyacrylonitrile fibers. Also, in the case of using sodium thiocyanate, for example, as a latent fiber solvent for polyacrylonitrile fibers, the quantity of thiocyanate salt deposited on the fabric (dry weight) should be between 0.02 and 1.0 gram per square yard of each fabric face, and a more optimum range of fabric stiffness values for blankets is obtained when this quantity is between 0.06 and 0.15 gram.

By latent fiber solvent as used herein is meant any liquid or solid material or solution of same, soluble or miscible in the liquid medium, which is, in the initial simple phase liquid solution, a non-solvent for the fiber but capable of bonding (i.e., at least rendering the fiber surface tacky) the fiber after activation of the latent solvent. The fiber solvent may be used herein by dissolving it in a separate liquid solvent for the same or by using it alone in the liquid medium specified.

Typical fiber solvents for acrylonitrile polymer fibers include aqueous solutions of sodium thiocyanate, lithium iodide, sodium iodide, calcium thiocyanate, potassium thiocyanate, calcium bromide, zinc chloride, lithium bromide, magnesium thiocyanate, cupric
chloride, magnesium chloride, ferric chloride, ferrous bromide, cadmium iodide, barium chloride, and cobaltous iodide. Suitable fiber solvents also include propylene carbonate, ethylene carbonate, dimethyl sulfoxide, tetramethylenesulfone, dimethyl formamide, dimethyl acetamide, butyrolactone, trimethylene carbonate, and the like. These may be dissolved in water, or many of them may be dissolved in alcohol, ethylene glycol, benzene or the like. Typical fiber solvents for polyamide fibers include aqueous solutions of the inorganic salts listed above for acrylonitrile polymer fibers, as well as materials such as nitric acid, formic acid, phenol, cresol, and the like. These may be dissolved in water, ethanol, methanol, benzene, and the like, depending upon the fiber solvent used. Typical fiber solvents for polyester fibers include benzyl alcohol, benzene, dichloro acetic acid, trichloro acetic acid, trifluoroacetic acid, dichloro phenol, and aqueous solutions of calcium and magnesium thiocyanate. Similarly, known solvents for other polymers listed below may be used when such polymers are present. In the case of natural fibers, etc., any water-soluble solvent may be used. Typical solvents for wool include alkali metal salts of thioglycolic acid, and sodium sulfide. Dilute aqueous solutions of ferric chloride, etc., are suitable for rayon.

The liquid medium employed in the preparation of the one-phase liquid solution of this invention may be the sum of the individual solvents desired, as illustrated above in the lists of fiber solvents, or the liquid medium may be a different liquid which is miscible with the liquid employed to dissolve the fiber solvent. The liquid medium may be aqueous or organic or a mixture of two or more liquids which are miscible with one another. In each case the liquid medium should be capable initially of dissolving the fiber solvent to form the single phase liquid solution. The liquid medium should be relatively inert to the fibers of the fabric and should not be a good solvent for the polymer from which the fibers are made.

Although the composition of the liquid solution will normally be limited to consist essentially of two ingredients (i.e., latent fiber solvent and liquid medium), it may be advantageous in treating certain textile materials to employ in the small amounts of inert extenders (such as polyethylene oxide), softeners, antistats, sickeners, agents, sizes and finishes, pigments, and dyestuffs, and other adjuvants which can be dissolved or dispersed in the solution to achieve particular results. However, these additional ingredients must be carefully chosen in amount and composition so as not to disrupt the cooperating function of the two main ingredients of the solution in forming the mist and direct application and processing of the mist on the textile material.

The textile materials which may be treated in accordance with this invention may include sliver, tow, yarns, warps, batts, and woven, knitted, and non-woven fabrics. The woven fabrics may be woolen spun or worsted spun flannels, tweeds, shetlands, blankets, carpets, pile fabrics and the like. The knitted fabrics may be warp knitted or circular knitted, jerseys, sweaters, hosiery, suitings, gloves, scarfs, and the like. The non-woven fabrics may be carpets, upholstery, fleece, furs, flannels, sweaters, felts, hats, and the like.

The composition of the staple fibers and/or continuous filaments making up the textile materials should be at least 25% by weight of organic, polymeric fibers material capable of being bonded in order to achieve benefit from the misting treating in accordance with this invention. Blends of synthetic and/or natural fibers may be advantageously treated where all the fibers are to be bonded, or the solutions may be carefully chosen so that they are inert with respect to the fibers present that are not to be bonded.

Typical of the synthetic organic fibers and filaments which may be treated according to this invention include those prepared from polyamides such as poly(hexamethylene adipamide), poly(hexamethylenesecabamide), polycaproamide, and copolyamides, polymers, and copolymers such as condensation products of ethylene glycol with terephthalic acid, ethylene glycol with a 90/10 mixture of terephthalic/iso-phthalic acids, ethylene glycol with a 98/2 mixture of terephthalic/5-(sodium sulfonphenoxy)isophthalic acids, and trans-p-hexahydroxyphenoxy]ethylene glycol with terephthalic acid, polyacrylonitrile, copolymers of acrylonitrile with other monomers such as vinyl acetate, vinyl chloride, methyl acrylate, vinyl pyridine, sodium styrene sulfonate terpolymers of acrylonitrile/methyl acrylate/sodium styrene sulfonate made in accordance with United States Patent 2,837,501, vinyl and vinylidene polymer and copolymers, polyamides, polyethylenes, polypropylenes, fluorinated ethylen polymer and copolymers, cellulose derivatives, such as cellulose acetate, cellulose triacetate, rayon, viscose, etc. composite filaments such as, for example, a sheath of polyamides around a core of polyester as described in the copending application of Breen, United States Serial No. 621,443, filed November 9, 1956, now abandoned, and of which application Serial No. 771,676, filed November 3, 1958, is a continuation-in-part and which is now U.S. Patent No. 3,038,236 and two acrylonitrile polymers differing in ionizable group content spun as a sheath and core as described in the copending application of Taylor, United States Serial No. 526,908, filed November 18, 1957, now abandoned, and of which application Serial No. 771,677, filed November 3, 1958, is a continuation-in-part and which is now U.S. Patent No. 3,038,237, and the like. The fibers and filaments may be crimped or uncrimped, drawn or undrawn, and/or bulked or unbulked.

Another highly critical factor in the present invention is the particle size of the discrete liquid particles which form the mist being applied to the textile materials. The maximum size of these liquid particles comprising liquid fiber solvent and diffusent is about .012 inch. When the size of these liquid particles in the mist are much above the critical maximum given, the bonded resulting fabrics lose their good hand and aesthetics, the fabrics become undesirably stiff and blankets bonded with too large a particle have an undesirable loss in thickness of nap. Any suitable apparatus or method for forming a fine mist of discrete liquid particles less than .012 inch in size is suitable herein. There are commercially available humidifiers, fog nozzles, mist-forming apparatus, sprayers, and the like suitable for application. Any person practicing this invention is one that atomizes the liquid solution into a mist, such as the humidifiers described in the Feldermann Patents 2,022,415 and 2,591,057. This type of humidifier produces a mist having a wide distribution of liquid particle sizes. The large heavy particles which are unsuitable for bonding the fibers in accordance with this invention, strike the walls of the humidifier, coalesce and fall back into the supply tank so that none of these large liquid particles ever contact the fibers or the fabric being bonded, only a portion of the smaller particles ever reach the fabric. The discrete liquid particles in the mist used in this invention are essentially round.

Another important limitation of the present invention lies in the conditions under which the mist is applied to the textile material. The mist of discrete liquid particles must contact the surface of the yarn, fabric, or other textile material without any accompanying mechanical compressive force such as the application of a roller or paddler. In addition, the particles of the mist must not contact the textile material at such high speeds that they compress the fibers in any sense. In this connection, many of the commercial patented sprayers are unsuitable for applying a mist in accordance with this invention because the air and/or liquid pressure developed in the nozzle of the sprayer is so strong that it compacts the
surface fibers of the textile material, which act reduces the thickness of the pile of napped fabrics and blankets and decreases the other desirable properties of these textile materials. Also, the use of these high pressures for forcing the liquid particles against the textile material results in non-uniform application of the liquid fiber solvent across the width of the fabric, which leads to fabrics having non-uniform properties and makes it difficult or impossible to reproduce fabrics having the same properties.

Normally the mist is applied to the surface of the textile material at room temperature, although the temperature of the mist or the fabric may be elevated so long as it is well below the temperature necessary to convert the latent fiber solvent to an active fiber solvent for the fibers. A suitable temperature range for drying and bonding polyacrylonitrile fibers is from 215° F. to 350° F., and preferably from 250° F. to 300° F. for one to five minutes contact time. Obviously the temperature of application of the fog, drying and bonding should not be so high that it melts the surface fibers of the textile material or deforms the surface fibers to such an extent to destroy their fibrous character.

The advantage of this invention is the provision of a novel process for bonding the fibers of textile materials, and particularly, loose surface fibers. Another advantage is the fact that the process provides a method for making blankets which have high resistance to surface distortion and high resistance to shedding without affecting the good hand of the blanket and without reducing the thickness of the nap of the blanket. Another advantage is a process for reducing the shedding and fuzzing of yarns and fabrics without substantially affecting the stiffness of the yarn or fabric. Still another advantage lies in the fact that the method of the present invention reduces the fuzzing and pickiness of non-woven fabrics. Another advantage is that this process produces blankets having improved resistance to surface distortion upon repeated washings and launderings. The process of this invention also produces bonded fabrics which have greater cover and smoothness than the unbonded fabrics.

The following example is cited to illustrate the invention and is not intended to limit it in any manner.

EXAMPLE

Using the arrangement shown in FIGURE 2, a woven napped blanket made from staple fibers of a copolymer of 94% acrylonitrile and 6% of methyl acrylate is passed vertically upwards between two nozzles which propel the mist against both surfaces of the fabric simultaneously, said mist being propelled at an oblique angle in the direction of fabric travel, while the fabric is tentered. The mist is generated in a "Web-Wetter," which is available from Walton Laboratories, Inc., Irvington, New Jersey. The "Web-Wetter" is continuously charged through a feed line from a reservoir with an aqueous solution containing 5% sodium thiocyanate by weight. The speed of the fabric as it is passed through the mist is approximately 10.5 yds./min. After passing through the mist, the still-tentered fabric is fed through drying oven containing circulating air at 300° F. The length of the drying oven is 55 feet. The tentered fabric then passes immediately through a 35 foot length cooling chamber containing still air at room temperature. Special precautions are taken during the fabric treatment with mist so as to avoid compacting either surface of the fabric. The resulting fabric is found to have an excellent hand, and to be very uniform and smooth in appearance. The fabric undergoes no substantial change in hand or appearance even after three washings in a home washing machine. Before washing, the dry fabric was analyzed and found to contain 0.13 gram of sodium thiocyanate per square yard of each fabric face. No spotting is noted, which is characteristic of fabric when treated with the same mist from both sides simultaneously, while the fabric passes horizontally between two misting nozzles. As the concentration of sodium thiocyanate is increased above 5%, there is no appreciable effect upon the appearance of the fabric, but its stiffness increases.

While the invention has been illustrated by treatment of a napped polyacrylonitrile blanket, it is to be understood that the identical steps may be used to apply a mist containing known solvent to textile materials made from any other polymer which is amenable to bonding by the application of a liquid which has substantially no solvent effect on the polymer at room temperature but which may be activated by heating to render the polymeric fibers cementitious at contact points where a droplet of the mist has been deposited, and the solvent may subsequently be removed, leaving the fibers point bonded. As shown in the drawings the fabric may be treated with mist while moving vertically downwards or upwards or it may move along its edge while vertically disposed.

The foregoing detailed description has been given for clearness of understanding only and no unnecessary limitations are to be understood therefrom. The invention is not limited to the exact details shown and described for obvious modifications will occur to those skilled in the art.

What is claimed is:

1. In a process for bonding contiguous fibers of a napped fibrous textile fabric having substantial thickness in which the surface fibers have one end held within the fabric structure and one free end raised therefrom forming a nap thereon wherein a controlled amount of a liquid containing 1 to 25 weight percent of a latent solvating material for said fibers is deposited simultaneously on both surface of said textile fabric in the absence of substantial propelling force and in the form of a mist of discrete liquid particles having an average particle size of less than about 0.012 inch in diameter with said fibers being maintained in their relative positions without significant displacement while depositing said particles thereon and contiguous fibers are bonded without compression of the nap at points where said particles have been deposited solely by employing said discrete liquid particles and by heating the treated fabric to a temperature in the range of 215° F. to 350° F. to activate the solvating material, the improvement which comprises directing said textile fabric in a vertical path while depositing said liquid particles on said fabric.

2. The process of claim 1 wherein the fibers to be bonded are made of acrylonitrile polymer.

3. The process of claim 2 in which the liquid from which said mist is formed contains from about 4% to 6% of sodium thiocyanate in aqueous solution.

4. The process of claim 2 in which the liquid from which said mist is formed is aqueous ethylene carbonate.

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