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[54] **PROCESS OF MANUFACTURING TIGHTLY WOVEN ACRYLIC FABRIC**

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[52] **U.S. Cl.** ....**28/76 R**

[51] **Int. Cl.**..........................**D06c 27/00,** D06c 29/00

[58] **Field of Search**........................28/72, 72 FT, 76, 28/76 E, 72 R, 76 R; 139/383, 420, 421

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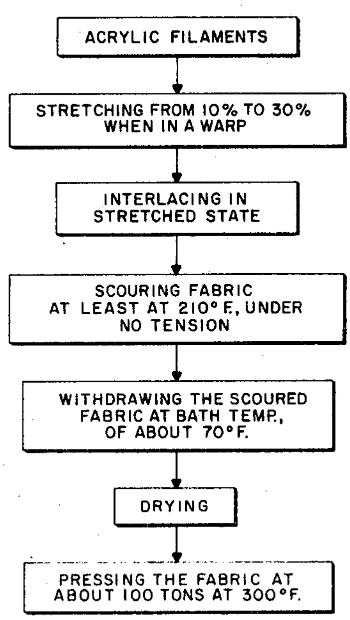
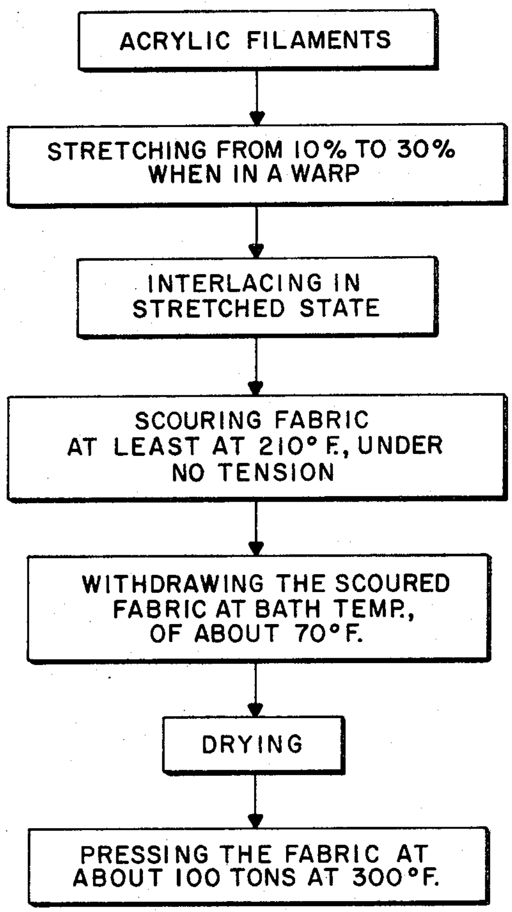
[57] **ABSTRACT**

The invention relates to a method using polyacrylonitrile filaments having a tensile strength less than 50,000 psi and an elongation between 20 and 50 percent for weaving a fabric structure having a very restricted network of interstitial openings of such a nature that there is a marked resistance to the passage of solar radiation and particles in a fine state of subdivision.

5 Claims, 1 Drawing Figure




ACRYLIC FILAMENTS
STRETCHING FROM 10% TO 30% WHEN IN A WARP
INTERLACING IN STRETCHED STATE
SCOURING FABRIC AT LEAST AT 210° F., UNDER NO TENSION
WITHDRAWING THE SCOURED FABRIC AT BATH TEMP., OF ABOUT 70° F.
DRYING
PRESSING THE FABRIC AT ABOUT 100 TONS AT 300° F.

PROCESS OF MANUFACTURING TIGHTLY WOVEN ACRYLIC FABRIC

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a tightly woven fabric comprised of acrylic and modacrylic fibers having retaining ability for particulate solids. More particularly, it relates to a method of making a woven fabric from filaments of relatively low tenacity and high elongation wherein the fabric has its interstitial construction substantially reduced.

2. Description of the Prior Art

In weaving in which there is an interlacing of two or more systems of filaments in a predetermined order, it is observed that a network of voids can be seen without the aid of magnification when the fabric is unstretched and an even more pronounced network thereof when the fabric is stretched. For a number of woven fabrics, the average size of the interstices may be greatly reduced by simply narrowing the distance between adjacent filaments during the weaving operation. This may generally be accomplished by the to and fro beating means whereby the filling yarn after passing through the shed is beaten into place and into its tightest relationship with the woven fabric by a reed.

In attempting to make a tight fabric of materials having high tenacity and limited elongation there is generally little difficulty in producing a finished fabric having virtually closed interstitial openings as such a fabric possess mechanical properties lending themselves to be machined in a more or less conventional manner. This is true with nylon and polyester wherein the tensile strength is relatively high per weight factor, generally well above 50,000 psi. There are, on the other hand, a number of materials of relatively lesser fiber strength and upon being fabricated produce a loosely structured article. Notably, among such materials posing such a difficulty are the acrylonitrile polymerization products wherein the mechanical properties as breaking tenacity and tensile strength are much lower than nylon and polyester. A light-weight woven acrylic fabric would generally be unsuited for containing or transporting matter in a finely divided state since such matter would simply pass or leach out through the interstitial construction.

It may be added that owing to the weaker strength, acrylic filaments have become unattractive for certain applications which require the making of tightly woven fabrics. With respect to high tenacity materials weaving becomes a straightforward procedure but when dealing with medium or low tenacity (below 50,000 psi) and a relatively high elongation (20 to 50 percent) a number of problems are encountered. Again, the end result is a woven material of substantially large interstitial construction which is unsuited for retaining fine granular solids. In effect, due to the weaker strength of the acrylic and modacrylic fibers, it is difficult to weave them into a light-weight and tightly constructed fabric. This is a rather unfortunate situation since such fibers as acrylic are well known for their durability and resistance to decay. In particular, durability is an important consideration, with respect to a fabric for use in levee construction, especially in sea coast or river channel stabilization fabric. At any rate, various procedures have been advocated to attain a fabric

structure having tightly woven construction with good dimensional stability. Often the characteristics of a filamentary structure are altered in such attempts whereby strength and resistance are sacrificed. Heretofore, various weaving and post treatments have been proposed with various degrees of success.

One approach has been to partially or totally fill the interstices of a given fabric with a thermoplastic substance by treating the fabric after the weaving or knitting process. A number of disadvantages are inherently associated with such coated articles as there is often a reduced flexability and adhesion problems therewith a considerable increase in product weight, coatings, chemical and physical durability, not to mention the added cost. Suffice it to say that although various procedures have been advocated to produce a fabric composed of acrylic having a very restricted network or interstices therein, such procedures have been wanting in several aspects and, prior to this invention, have not been successfully fabricated.

SUMMARY OF THE INVENTION

The present invention is to provide the art with a process for making a fabric in which the interstices, or openings between adjacent filaments are almost virtually closed, the material of the fabric being one in which the tensile strength is relatively low, viz., below about 50,000 psi. The process of this invention is most advantageously applied to polymeric substances comprising polyacrylonitrile, copolymers and terpolymers, containing acrylonitrile with polymers and copolymers of other polymerizable mono-olefinic monomers. Admittedly, such polymeric substances are useful in a wide variety of textile applications but such substances are at a disadvantage as aforedescribed with respect to conventional weaving due, in part, to their weaker strength. Thus, the tensile strength of acrylic polymers falls generally between about 30 to 50,000 psi and, hence, filaments formed from acrylic polymers become very difficult to fabricate into a very tight structure, i.e., one in which there is a restricted network of interstices therein.

A principal object of this invention is the provision of a new method for making woven materials of polymeric substances of the acrylic type in such a way as to improve their resistance to passage of finely divided materials therethrough and to substantially shield out light transmission. A particular feature of the present invention is that essentially permanent modification of the polymeric substance is attained without any chemical modification thereof. As a result, the invention yields the advantages of rapid and simple operation with attendant decrease in cost of production.

It is another main object of this invention to provide a process for the substantial reduction of interstitial construction of a woven acrylic fiber.

Another object is to provide a process for increasing the retaining ability for particulate solids, especially of the noncohesive type.

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

In accordance with the present invention, a process is provided where filaments of low tenacity and high elongation are made into a tightly woven fabric comprising the steps of stretching the filaments when in a warp, interlacing the warp while in the stretched state with filling filaments to form a woven fabric, scouring the woven fabric under substantially no tension or very slight tension for a time and at a temperature sufficient to provide for warp shrinkage, withdrawing the scoured fabric when the fabric is sufficiently cooled, drying the fabric, and pressing the woven fabric at a pressure and at a temperature sufficient to further reduce the size of the opening between adjacent filaments in the fabric.

The accompanying drawing depicts a flow sheet illustration of the process of this invention.

By the terms "low tenacity" is meant any fiber which has a tensile stress at rupture of between 30,000 and 50,000 psi (pounds per square inch).

By the term "high elongation" is meant that extension from 25 to 50 percent of a fiber caused by tensile force, expressed as a percentage of the original length. Elongation as used herein is taken at the point of break unless otherwise stated.

DESCRIPTION OF THE PREFERRED EMBODIMENT

One preferred embodiment for accomplishing the object of the present invention contemplates stretching acrylic filaments up to 30 percent while in a warp, weaving the warp while in the stretched state with filling filaments of acrylic to form a woven fabric, scouring the woven fabric for at least **10** minutes at 210° F., drying the fabric, and calendering the woven fabric at least 260° F., or above, and at a pressure of 100 tons.

The term "scouring" is used herein to denote the shrinking process as well as the removing of such materials as sizing used in the warp in the interlacing operation.

The term "interlacing" includes interlacing of fibers and encompasses felting and bonding or fusing, braiding of fiber, netting and lacemaking, knitting and weaving. The expression "fabric" is used to refer to any planar structure produced by interlacing of filaments, yarns, or fibers.

"Pressing" as used herein denotes any mechanical means done to flatten a fabric and encompasses calendaring done by rolls, as well as other methods used to to flatten a fabric. The temperature of the rolls must be constant with time and uniform over the width of the roll. The rolls can be heated by superheated steam, pressurized water, oil, gas, or electrically operated.

The interstitial construction of the subject invention takes the form of a fabric having substantially restricted square-like apertures therethrough. Thus, articles in the shape of spheres ore irregular bodies are retained and confined against the construction. The size of the interstitial openings must have a width slightly less than the axial measure of any particulate solid to be retained.

In weaving a fabric of filaments having a relatively high tenacity and low elongation characterized by such materials as polyester and nylon, it is conventional to stretch the warp between 3 and 5 percent. It has been found that such conventional stretching while in the warp is simply not suitable for reaching the objectives of this invention with respect to materials as acrylic and modacrylic fibers, but that higher warp stretching is possible and essential, the stretching being in the range of 5 to 35 percent, and preferably between 10 and 15 percent.

Again, it is essential to this invention to introduce a high degree of tension into the woven fabric during its construction. This can be readily accomplished by stretching the warp yarn from anywhere between 5 percent to about 35 percent and applying stress to the fill yarn corresponding to a tension from about 20 percent to about 70 percent of the yarn breaking strength. A preferred embodiment contemplates a warp yarn stretch of about 15 percent and a fill yarn having an applied stress of about 30 percent of the yarn breaking strength. Stretching the wrap yarn may be done by a number of means well-known in the art. The stretching of the warp may be conveniently practiced on conventional textile treating apparatus. Thus, stretching may be done during the slashing operation. The fabric to be stretched may also be placed on a tenter frame and stretched to the prescribed amount.

It is critical to this invention with respect to the scouring step that the scoured fabric be not withdrawn from an aqueous scouring bath when hot. That is to say, the scoured fabric should be cooled to a temperature of about 100° F. or below before removal from the souring bath. In effect, the fabric after weaving is scoured at about 212° F. to provide for warp shrinkage. Thus, by allowing the fabric to cool sufficiently a desirable warp shrinkage is achieved and corresponding restriction of interstitial openings obtained.

Scouring the woven fabric may be carred out by conventional equipment and the type of equipment is not critical to the invention. A beck scouring machine may be conveniently used. It has been found that a beck scouring machine wherein the woven fabric is scoured for twenty minutes at a bath temperature of about 210° F. with a non-ionic detergent may be advantageously employed. A preferred scouring temperature is between 130° F. and 210° F.

It is also essential that the fabric during the scouring step be substantially free of tension or that tension be at a minimum, viz., at a tension less than one-tenth gram per denier. That is to say, the fabric structure is in a relaxed state while under little or not tension. This can be done while the fabric structure, for example, is on the run as while advancing by rollers or while lying on an advancing belt. The time required for the scouring treatment will depend to some extent on the weave, bath temperature, and chemical agents employed in the souring bath. In a preferred embodiment the fabric structure is scoured and cooled to about 70° F., before the structure is removed from the bath. It was found that in this way, restretching was avoided and substantial shrinkage was accomplished.

Similarly, the practice of this invention can be applied effectively to a fabric structure to accomplish shrinkage of a higher magnitude than obtainable at the boil under atmospheric pressure by employing pressurized equipment.

Any conventional weaving equipment may be used for the process of this invention, such as a Crompton and Knowles or a Draper. The yarn employed in the weaving equipment may be spun or drawn to relatively fine count, viz., between 5/1 c.c and 50/1 c.c (cotton counts). Yarn spun by woolen and worsted systems of corresponding counts may equally well be employed after this invention.

In the greige goods an original fabric construction of between about 50 to about 90 ends per inch to about 30 to about 70 picks per inch answers well after this invention. In particular, a construction having about 75 ends to about 35 picks per inch is found advantageous. Moreover, after scouring and calendaring it is preferred that there be about 85 (±5) picks per inch in the finished fabric.

It is found that air permeability of a fabric constructed after the method of this invention has generally a decrease to between one-quarter to one-tenth of the air permeability of the original greige goods. Air permeability of a fabric is measured in accordance with ASTM D737–69. Generally, air permeability of about 10 $ft^3/ft^2 \cdot$ min. or less is preferred. Light transmission, on the other hand, may be measured by placing the fabric in the path of a high intensity light source and determining the percent of light which passes through the fabric. This may conveniently be done by measuring the transmitted light via standard microphotometer. The preferred range is below 0.0001 percent.

After scouring, the fabric is cooled slowly and thoroughly rinsed with fresh water. In effect, the fabric is scoured at the boil to provide for warp shrinkage and for closing the weave of the fabric. It is preferred that the scoured fabric not be withdrawn from the scouring bath when hot (i.e. below 140° F.) but that it be first cooled sufficiently to avoid restretching. This restretching is generally pronounced in acrylic woven fabric.

The polymeric materials contemplated by the subject invention gives excellent resistance to outdoor exposure. It is well known, for example, that acrylic materials are highly resistant to weathering and biological activity and, hence, exhibit splendid outdoor durability. In particular, acrylic materials are highly desirable for river banks and levee construction as in the form of sandbags and also nursery applications in the form of shade cloth and soil bags for plants. In such applications, it is essential that the fabric be of the tightest construction with maximum number of ends and picks so as to be effective, but barely air and water permeable.

Drying of the fabric may be carried out by any suitable drying equipment. We have found for acrylic fiber that a drying temperature of 240° F. is very suitable. In order to expedite the drying, we prefer to vacuum extract the woven fabric with conventional equipment.

Flattening or pressing of the fabric may be carried out by hot calendering with a Schreiner calender at least 260° F. with a pressure of 100 tons at a speed of 12 yards per minute. Thus, the calendering modifies the filament cross-section from a circular to that of lenticular whereby the interstices are almost completely closed and whereby the porosity of the fabric is greatly restricted. The pressing of fabric is preferably made between 2400 lbs/in^2 to 5000 lbs/in^2.

Having now described the polymeric substances which may be used in this invention and the type of equipment used in the process, a preferred embodiment of the invention will now be given.

A fabric of acrylic filaments of about 100 denier was prepared in a conventional power loom, the warp having 78 ends per inch and 35 wefts per inch. A plain weave was made using 10 harnesses. The loom was adjusted and allowed to take the warp at about 12 percent stretch and the loom allowed to weave while the warp was in the stretched condition to form a roll of woven fabric of 25 yards. The woven fabric was thereafter beck scoured for about 20 minutes at the boil to provide for warp shrinkage. The fabric was vacuum extracted and loop dried at 240° F. The greige width was 37.5 inches and the wet width off the beck was 35 inches. The scoured fabric was not withdrawn from the scouring bath when hot but was first cooled to avoid any stretching. The width after drying was 35.25 inches. The warp shrinkage after loop drying was 12.5 percent, the finished width being 36.5 inches.

The fabric was thereafter calendered at 300° F., with 100 tons pressure at 12 yards per minute via Butterworth, Schreiner calender. The hot calendering altered the cross-section of the filaments from that of a circular to that of a lenticular cross-section. The finished fabric has an air permeability of 1.6 $ft^3/ft^2 \cdot$ min min and a light transmission of 0.0001 percent.

Any departure from the above description which conform to the present invention is intended to be included within the claims.

That which is claimed is:

1. A process for making a tightly woven inelastic fabric from acrylic filaments comprising the steps of:
   a. stretching the filaments between about 10 percent to about 30 percent when in a warp;
   b. interlacing the filaments while in the stretched condition to form a woven fabric;
   c. scouring the woven fabric for a sufficient time in a souring bath having a temperature of at least about 210° F., at substantially no tension to provide for warp shrinkage;
   d. withdrawing the scoured fabric when the temperature of the bath and fabric is about 70° F., whereby the interstitial construction of the woven fabric is reduced;
   e. drying the fabric; and
   f. pressing the woven fabric at about 100 tons and at a temperature of about 300° F., whereby the interstitial openings of the fabric are substantially further reduced to increase resistance of the fabric to the passage of solar radiation and particles in a fine state of subdivision.

2. A process as recited in claim 1 wherein the fabric is scoured to provide for at least a 10 percent warp shrinkage.

3. A process for making a tightly woven fabric as recited in claim 1, wherein the scouring steps comprises scouring the woven fabric at a pressure over atmospheric for a time and at a temperature sufficient to increase by 20 to 40 percent the number of ends per inch.

4. A process for making a tightly woven inelastic fabric from filaments selected from the group consisting of acrylic and modacrylic filaments of low tenacity and high elongation, comprising the steps of:
   a. stretching the filaments at least 5 percent when in a warp;
   b. interlacing the warp while in the stretched state with filling filaments to form a woven inleastic fabric;
   c. scouring the woven fabric in a scouring bath for at least 10 minutes under substantially no tension and at a temperature of at least about 210° F. to pro-

vide for warp shrinkage to thereby decrease the size of the openings between the filaments in the woven fabric;

d. cooling the contents of the scouring bath with the fabric therein to below about 100° F.;

e. withdrawing the scoured fabric from the cooled scouring bath;

f. drying the fabric; and

g. pressing the woven fabric at a pressure and at a temperature sufficient to partially flatten the filaments in the fabric to thereby further reduce the openings in the fabric to increase resistance of the fabric to the passage of solar radiation and particles in a fine state of subdivision.

5. The process of claim **4** wherein the filaments are acrylic.

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