FINISHING POLYESTER FABRICS

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No Drawing. Application December 12, 1956
Serial No. 627,743

5 Claims. (Cl. 28—76)

This invention relates to a process for finishing fabrics composed of polyester yarns and more particularly to a process for improving the aesthetics of said fabrics. It is known to treat polyester fabrics with caustic soda and similar alkaline materials to improve handle. It is also known to heat-treat polyester fabrics prior to caustic treatment for the purpose of further improving fabric properties. Both of these known treatments improve drape and liveliness of polyester fabrics.

It is an object of this invention to provide polyester fabrics having improved aesthetics. A further object is to provide a new method of finishing said fabrics to improve their handle. Another object is to provide a method for producing a patternless fabric composed of polyethylene terephthalate yarns and having a handle resembling that of silk fabrics. Other objects will appear in the description which follows.

In accordance with this invention a fabric comprising polyester yarns is calendered at elevated temperature and pressure and then treated with an aqueous solution of an inorganic alkaline material until there is a fabric weight loss of at least 5%. In a preferred embodiment a fabric woven from polyethylene terephthalate yarns is calendered at a temperature of 100° F.—450° F. under a pressure of from about 0.12 tons per linear inch to about 2 tons per linear inch, or preferably about the fabric to dry heat while it is partially relaxed at a temperature of from about 250° F. to about 450° F. until the fabric has shrunken at least 3% warpwise and at least 35% fillingwise and then subjecting the fabric to hydrolysis in the presence of an aqueous solution of an alkaline material such as an alkali metal hydroxide or alkali metal salt derived from the said or an alkaline earth metal hydroxide or hydroxide to produce a fabric weight loss of 5%—25%.

The purpose of the calendering step is to flatten the fabric surface and as a result of this treatment the cross-section of the fibers of the fabric is deformed. The calendered fabric also has a noticeable chintz-like glaze on the surface. In order to accomplish the desired changes in the fabric by means of the calendering operation several variables must be controlled. First, the temperature should be in the range of 100° F.—450° F. and preferably 100° F.—350° F. Pressure on the fabric surface should be maintained in the range of 0.12 ton per linear inch to 2 tons per linear inch, and preferably between about 0.2 and about 0.8 ton per linear inch. Rate of the calendering depends on the temperature and pressure employed and the results desired in the particular fabric being treated. Typically the fabric is calendered at between about 20 and about 100 yards per minute. Fabric construction will also affect the properties of the finished fabric. It will be obvious to those skilled in the art that the proper fabric construction must be chosen in order to obtain the particular body and handle desired in the finished fabric.

One of the most important factors in the calendering operation is the nature of the surface of the fabric roll. In order to achieve the most desirable results of this invention the fabric surface must be deformed uniformly throughout its area by contacting at least 50% of the surface area of the fabric with calender rolls. This may be accomplished using either a standard smooth surfaced, highly polished stainless-steel calender roll which compresses and deforms 100% of the fabric surface area, or a Schreiner roll which is a steel roll having many fine lines per inch engraved in it, and which, depending upon the number of lines, will compress about 50% or more of the fabric surface during calendering. Failure to deform at least 50% of the fabric area during calendering produces fabrics which are deficient in surface cover and dryness. A Schreiner or smooth calender roll is normally complemented by a standard hard smooth paper covered hush roll contacting the other side of the fabric in order to obtain the necessary amount of pressure against the fabric surface.

In addition to compressing at least 50% of the fabric area, the calendering step in this invention should not leave any pattern, visible to the unaided eye, on either fabric surface. The deformation of the fabric is obtained on only one surface at a time in contrast to embossing rolls which contact and compress both sides of the fabric and leave a defined visible pattern on both surfaces. Moreover, because the finest patterned embossing rolls will not deform anywhere near 50% of the fabric area, embossed fabrics lack the surface dryness and cover obtainable by this invention.

When in the calendering treatment temperatures approaching 450° F. are employed, the finished fabric retains too much plastic-like handle unless excessive caustic treatment follows the heat treating step. In order to keep the caustic treatment at a minimum, and thereby reduce fabric weight loss and cost, the fabric may be scoured relaxed at the boil after calendering. After this additional scouring, the fabric is dried, heat-set, and treated with caustic. This alternative procedure removes any excessive plastic-like handle with only about 10% fabric weight loss instead of as much as 20%—35% weight loss in the case of certain types of fabrics which have not been scoured following calendering.

After calendering, the fabric is subjected to dry heat at a temperature of 250° F.—450° F. for a period of time sufficient to heat-set the fabric in order to obtain optimum drape and liveliness. In this heat-treating step the fabric may be either relaxed or unrelaxed. The fabric is heat-set if the fabric is treated in at least a partially relaxed condition at the above temperature for a time sufficient to permit shrinkage of at least 3% warpwise and 3% fillingwise or treated the same number of minutes at the same temperature in an unrelaxed condition. Thus the time required for heat-setting the fabric under unrelaxed (not free to shrink) conditions is the time in minutes required to heat-set the same fabric at the same temperature under relaxed (free to shrink) condition. Preferably the fabric is partially relaxed during heat treatment so as to allow the fabric to shrink somewhat in the warp and filling. Heat treatment under at least partially relaxed conditions results in higher liveliness, surface dryness and drape and less threadiness in the finished fabrics than is obtained in fabrics that are heat-set unrelaxed according to the process of this invention. In some cases it may be desirable to accomplish the heat-setting of the fabric simultaneously in the calendering treatment. However, this procedure does not allow the fabric to undergo relaxation; hence, the drape and liveliness are generally not as good as with a separate heat treatment step.

After heat-setting, the fabric is hydrolyzed to remove part or all of the glaze or plastic-like handle produced
on the surface of the fabric by calendering, as well as to generally improve the fabric handle. This step in the process further modifies the cross-section of the component fibers by preferentially dissolving part of the fiber surface, thereby accentuating the deformed cross-section produced by the calendering step, which introduces random high and low points in the surface of the fiber cross-section.

Hydrolysis may be carried out by treating the fabric with an aqueous medium containing inorganic alkaline material capable of producing a weight loss in this step of at least 5%. Preferably this weight loss is held to a minimum of 5%–25%, depending upon the type and construction of fabric employed, in order to keep the process economical. However, in certain instances where it is desired to produce extremely high drape and liveliness in the final fabric, the weight loss may be extended to as much as 30%. Suitable alkaline materials include sodium hydroxide, which is preferred because of its availability and low cost, potassium hydroxide, and salts thereof derived from weak acids, said salts being characterized by a pH of at least 12 in 0.1 N aqueous solution. Examples of useful salts include alkali metal sulfides, alkali metal sulfates, alkali metal phosphates and alkali metal silicates. Other suitable inorganic alkaline materials include calcium hydroxide, barium hydroxide, strontium hydroxide and the like.

Concentration of the alkaline material in the aqueous hydrolysis bath is preferably at least 2% based upon the bath weight. Concentration of alkaline material, the fabric exposure time in the bath, and the temperature of the hydrolysis bath may be varied at will to produce the desired weight loss in the fabric. Normally it is convenient to immerse the fabric in an aqueous solution of the desired alkaline material and to have the bath at or near normal boiling temperature at atmospheric pressure. In some cases it may be desirable to employ lower temperatures and longer times. Hydrolysis reduces the size of the yarn to a finer denier than that in the original fabric.

After hydrolysis the fabric is generally rinsed with water, scoured with a dilute aqueous acid wash, and rinsed again, to remove any residual alkaline material remaining. The fabric then is dried at ordinary temperatures, usually at 200°–240° F.

Although the process of this invention has been described with respect to treating fabrics composed of polyethylene terephthalate yarns, it should be understood that the invention is likewise applicable to improving the handle of fabrics made from other polyester and copolyester yarns. Preferably the yarns will be composed of polyesters in which at least 90% of the recurring structural units are ethylene terephthalate units, with any residues present comprising other dicarboxylic acids or other glycols. For example, the ethylene terephthalate copolyester may contain residues of sebacic acid, isophthalic acid, sodium sulfosuccinphthalic acid, or butylene glycol. Furthermore, the fabrics finished by this invention may be composed of yarns prepared from fibers and filaments having odd cross-sections, for example, in the shape of ribbon, dogbone, cruciform, Y-shaped, and the like, as well as the conventional circular cross-section.

Woven fabrics of this invention are composed of at least 50% by weight of polyester fibers or filaments. That is, the fabrics may be made from blends of polyester fibers with other synthetic and natural fibers, providing the fabric is free from wool and other components which would be deleteriously affected by the caustic treating step in the process. Other fibers that may be blended, plied, and otherwise mixed during weaving with polyester fibers include those made from polyamides and polyurethanes and their copolymers, acrylic polymers and copolymers, cellulose derivatives such as cellulose acetate, regenerated cellulose, cotton and the like. Fabrics finished by the process of this invention exhibit a very desirable handle along with other improved properties. These fabrics exhibit improved drape and suppleness (which may be measured, for example, by flexural rigidity), improved surface dryness, increased surface friction, liveliness, and luster, improved resilience, increased surface cover and opaqueness, and reduced threadiness. In addition, the treatment reduces yarn shiftiness in the fabric. In many respects the finished fabrics appear like silk and have similar scrop and rustle. The process of this invention yields fabrics that have good handle and silk-like appearance in addition to good surface covering power and dryness which is unattainable in fabrics that have been heat-set and caustic treated without the combination of the preliminary calendering treatment.

Examples of typical fabrics which may be processed by this invention include taffetas, georgettes, sand-crepes, tissue-sailes, foulards, broadcloths, batistes, light weight suiting, dress and blouse fabrics, shirtings, lingerie, and rainwear.

The following examples illustrate specific embodiments of this invention. All parts and percentages are by weight unless otherwise indicated.

In the examples flexural rigidity (which is a measure of the suppleness and drape of a fabric, the lower the value the better the drape) is measured by the "hanging test" method originated by Pierce (Journal of the Textile Institute, 21, T377, 1930) and performed as described by Hoffman and Besse in Textile Research Journal, XXI, No. 2, 66 (February, 1951).

Contact covering power in percent (I0), which is a measure of the surface cover, is determined by measuring the effect of background color on the reflectance of the fabric when exposed to a light source. The reflectance values in the equation below are determined using a Goniophotometer (model 610 (Photovolt Reflectometer Corporation)):

\[ I_0 = \frac{(R_w - R_b) - (R_{FW} - R_{FB})}{R_w - R_b} \]

where:

- \( R_b \) = Reflectance of black background in percent.
- \( R_{FW} \) = Reflectance of fabric on white background in percent.
- \( R_{FB} \) = Reflectance of fabric on black background in percent.

The coefficient of surface friction (\( \mu \)) (which is a measure of the surface dryness of the fabric, the higher the value the drier the fabric) is determined from the formula:

\[ \mu = \frac{1}{\phi} \frac{T}{T_0} \]

where \( \phi \) is the total contact angle in radians (the sum of the three angles formed by the suspended fabric as a result of its contact with the three probes), and \( T_0 \) is the weight in grams attached to the bottom of the suspended fabric. The surface friction is measured by using a modified Instron tensile tester. The tester is modified so that a movable probe is positioned in the same plane and in horizontal parallel opposed relationship with two separated fixed probes, so that the movable probe can be advanced between the two fixed probes. All three probes are covered with samples of the test fabric. Preparatory to testing, a stationary weighted sample of the same test fabric is suspended vertically with the movable probe on one side and the fixed probes on the other. The movable probe is first advanced, pushing the suspended fabric between the two fixed probes and forming an angle in the suspended fabric at each line of contact with the probe. As the cross head of the Instron tester is lowered, the three fabric covered probe surfaces, which are fixed spatially with respect to each other and which are in frictional contact with the suspended fabric, are drawn along the length of the suspended stationary fab-
The dynamic and static forces required to overcome the friction between the suspended fabric and the covered probes are recorded on the Instron tester. These forces in grams are averaged and the average force reported as T in the formula above.

**EXAMPLE I**

A continuous filament polyethylene terephthalate yarn, having 34 filaments and a total denier of 70, is woven into a plain weave fabric of 136 x 95 construction, weighing 2.5 ounces per square yard. This fabric is taken from the loom and scoured at 180°F with 2% soap solution for two passes at a fabric speed of 0 yards per minute. After scouring, the fabric is dried at wet dimensions on a pin-tenter frame at 225°F. The fabric is calendered between a smooth stainless steel roll and a smooth husk roll at 350°F, 0.5 ton/linear inch pressure and 25 yards per minute fabric speed. The fabric is heat-set on a pin-tenter at 440°F for one minute exposure with 5% overfeed in warp direction and two inches under width. After heat setting, the fabric is immersed for five minutes in a boiling caustic solution containing 3% by weight of sodium hydroxide, the weight of the solution being about 50 times the weight of the fabric. The caustic treated fabric is removed and rinsed with warm water for five minutes, treated with 1% acetic acid for ten minutes, rinsed again with warm water for 5 minutes, and finally dried at about 225°F. The resultant fabric lost approximately 25% of its weight during the caustic treatment. The fabric now has a drier, livelier and a much more desirable silk-like handle than the original control fabric. Table I shows some physical characteristics of the fabric.

### Table I

<table>
<thead>
<tr>
<th>Fabric</th>
<th>Weight (Oz./Sq. Yd.)</th>
<th>Flexural Rigidity (mg. cm.)</th>
<th>Surface Friction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated Control (scoured)</td>
<td>2.5</td>
<td>28.8</td>
<td>0.249</td>
</tr>
<tr>
<td>Example I</td>
<td>1.86</td>
<td>16.0</td>
<td>0.280</td>
</tr>
</tbody>
</table>

**EXAMPLE II**

A 2 x 2 twill foulard fabric of 264 x 102 construction, weighing approximately 1.8 ounces per square yard, is woven from polyethylene terephthalate filament yarn. The warp is made of 30 denier yarn, having 30 filament, 7 Z turns per inch, and the filling of 60 denier yarn, having 60 filament, 3.5 Z turns per inch. The fabric is taken from the loom, and scoured, dried and calendared, as in Example I. In this example, the fabric is not heat-set after calendaring, as in the first example, but is treated in a caustic bath and rinsed as described in Example I.

The treated fabric exhibits a much more desirable handle than the original control fabric as shown in Table II, and is silk-like.

### Table II

<table>
<thead>
<tr>
<th>Fabric</th>
<th>Weight (Oz./Sq. Yd.)</th>
<th>Flexural Rigidity (mg. cm.)</th>
<th>Surface Friction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated Control (scoured)</td>
<td>1.8</td>
<td>24.7</td>
<td>0.033</td>
</tr>
<tr>
<td>Example II</td>
<td>2.9</td>
<td>10.5</td>
<td>0.087</td>
</tr>
</tbody>
</table>

**EXAMPLE III**

In this example, fabric and finishing treatment are the same as in Example I, except that during heat-setting, the fabric is completely relaxed (i.e., it is allowed to shrink to the maximum extent possible in the pin-tenter). Warpwise shrinkage is 6% and fillingwise shrinkage is 7%

The treated fabric exhibits a much more desirable and silk-like handle than the original control fabric, as shown in Table III.

### Table III

<table>
<thead>
<tr>
<th>Fabric</th>
<th>Weight (Oz./Sq. Yd.)</th>
<th>Flexural Rigidity (mg. cm.)</th>
<th>Surface Friction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated Control (scoured)</td>
<td>2.5</td>
<td>28.8</td>
<td>0.249</td>
</tr>
<tr>
<td>Example III</td>
<td>2.1</td>
<td>17.8</td>
<td>0.456</td>
</tr>
</tbody>
</table>

**EXAMPLE IV**

In this example, fabric and finishing treatment are the same as in Example I, except that a stainless-steel Schreiner roll is used instead of a smooth surfaced calender roll. The Schreiner roll contacts about 60% of the fabric surface during calendaring. The treated fabric is silk-like and exhibits a much drier surface handle than even the finished fabric obtained in Example I.

### Table IV

<table>
<thead>
<tr>
<th>Fabric</th>
<th>Weight (Oz./Sq. Yd.)</th>
<th>Flexural Rigidity (mg. cm.)</th>
<th>Surface Friction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated Control (scoured)</td>
<td>2.5</td>
<td>33.8</td>
<td>0.249</td>
</tr>
<tr>
<td>Example IV</td>
<td>1.9</td>
<td>16.1</td>
<td>0.508</td>
</tr>
</tbody>
</table>

**EXAMPLE V**

Polyethylene terephthalate yarn having 34 filaments and a total denier of 70 is woven into a plain weave of 112 x 86 construction, weighing 1.83 ounces per square yard. This fabric after weaving is "crab" scoured at 212°F with 2% soap solution and dried at 225°F. The dry fabric is calendered on a stainless steel Schreiner roll at 300°F and 0.6 ton/linear inch pressure once on each side of the fabric. The fabric is backed up by a smooth hard paper covered husk roll. The Schreiner roll has 260 diagonal lines per inch at a 60° angle and contacts about 60% of the surface area of the fabric. Each line's cross-section represents an equilateral triangle having a dimension of 0.0037 inch on each side, while the cross-section of the Schreiner roll surface resembles that of a saw tooth. After calendaring, the fabric is "crab" scoured again at 212°F and dried at 225°F. It is heat-set at dry dimensions (i.e., unrelaxed) at 440°F for one minute, and then immersed in an aqueous solution containing 3% by weight sodium hydroxide at 212°F for 90 minutes. The fabric is removed from the caustic solution, rinsed in water to remove excess alkali and dried at 215°F. The resulting fabric showed a weight loss of 19.7% in the caustic treating step. The finished fabric has good drape, suppleness, liveliness and cover, in addition to the properties shown in Table V.

### Table V

<table>
<thead>
<tr>
<th>Property</th>
<th>Control Fabric</th>
<th>Example V Fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (oz./yrd.)</td>
<td>2.5</td>
<td>1.9</td>
</tr>
<tr>
<td>Thickness (mil)</td>
<td>0.0037</td>
<td>0.0037</td>
</tr>
<tr>
<td>Density (g./cm.3)</td>
<td>1.24</td>
<td>1.24</td>
</tr>
<tr>
<td>Specific volume (cm.3/g.)</td>
<td>2.02</td>
<td>2.02</td>
</tr>
<tr>
<td>Flexural rigidity (mg. cm.)</td>
<td>33.8</td>
<td>33.8</td>
</tr>
<tr>
<td>Coefficient of friction (g/cm.3)</td>
<td>36.5</td>
<td>36.5</td>
</tr>
<tr>
<td>Handle</td>
<td>plastic-like</td>
<td>silk-like</td>
</tr>
</tbody>
</table>

The control fabric in Table V was given a standard commercial finishing treatment involving scouring at 212°F with 2% soap solution, drying at 225°F, and then heat-setting by subjecting the fabric to dry heat at 360°F for 45 seconds. It was not calendered or treated with caustic.

**EXAMPLE VI**

A spun yarn of 60 cotton count made from 65% polyethylene terephthalate fibers (1.2 denier per filament and
1.5 inches in length) and 35% cotton fibers is woven into a plain weave of 120 x 68 construction. This fabric, after weaving, is "crab" scoured at 212° F. with 2% soap solution and dried at 215° F. The dry fabric is calendered on a stainless steel Schreiner roll at 275° F. once on each side of the fabric using 0.6 ton/linear inch pressure, using the same Schreiner roll as in Example V. The fabric is backed up by a smooth hard paper-covered husk roll. After calendering, the fabric is "crab" scoured again at 212° F., then dried at 215° F. The fabric is heat-set at dry dimensions (i.e. unrelaxed condition) at 440° F. for one minute, then treated with an aqueous solution containing 3% by weight sodium hydroxide at 212° F. for 60 minutes. The fabric is removed from the caustic solution and rinsed in water to remove excess alkali and then dried at 215° F. The resulting fabric showed a weight loss of 6.8% in the caustic treating step. The finished fabric has good drape, suppleness, liveliness, and cover. In addition, the fabric has improved uniformity (reduction in visible reed marks, reduction in unevenness of yarn bundle, and an over-all better appearance) in comparison with a fabric of equivalent construction which has been finished by a scour and heat-set treatment, but has had no calendering or caustic treatment.

I claim:

1. A process for treating a polyethylene terephthalate fabric which comprises deforming the fabric by means of compressive force applied to at least 50% of the surface area of the fabric and distributed uniformly over the entire surface area of the fabric at a temperature between about 100° F. and 450° F., heat setting the fabric by subjecting it to dry heat at a temperature from about 250° F. to about 450° F., and then immersing the fabric in an aqueous alkaline solution until the fabric has lost at least 5% in weight, followed by washing and drying the fabric.

2. The process of claim 1 in which the fabric is compressed by calendering at a temperature between about 100° F. and 350° F. at a pressure of between about 0.12 ton and about 2 tons per linear inch.

3. The process of claim 2 in which the aqueous solution contains an alkali metal hydroxide.

4. The process of claim 3 in which the fabric is 100% polyethylene terephthalate.

5. The process of claim 4 in which the alkali metal hydroxide is sodium hydroxide.

References Cited in the file of this patent

UNITED STATES PATENTS

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