3,486,208

PROCESS FOR MAKING WOVEN STRETCH FABRICS


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6 Claims

ABSTRACT OF THE DISCLOSURE

A stretch fabric is made from staple fibre yarn of isotactic polypropylene, nylon, or cellulose triacetate by weaving the yarns, excepting the fabric in the direction of one set of yarns while allowing relaxation in the direction of the other set of yarns to effect crimp in the other set of yarns by crimp interchange and heat-setting the crimp while maintaining the tension in the first set of yarns.

This invention relates to woven fabrics having stretch characteristics.

Woven fabrics having stretch characteristics in the warp or weft are known. They may be produced by known methods comprising incorporating a stretchable filament yarn which has adequate elastic elongation properties in the warp or weft of the fabric. Suitable elastic filament yarns comprise crimped yarns such as Ban-lon which is a stuffer box crimped yarn, Halanca, which is a twist crimped yarn, or elastomeric yarns such as Lyca. Ban-lon, Halanca and Lyca are registered trademarks. Another method comprises treating the fabric with chemical setting agents.

In the specification of our United Kingdom patent specification 983,968 a process is described for making stretch fabrics from synthetic fibres having a glass-rubber transition temperature above 30°C. In which the woven fabric is stretched in one direction and allowed to relax in the other direction to cause crimp interchange, followed by heat setting and then cooling the fabric in that condition. Polyester yarns such as Terylene (registered trade mark) are particularly suitable in this process.

Previously we have found that fabrics made from yarn other than those having a second order transition temperature when wet above 80°C do not have adequate stretch properties and that any imparted stretch properties are not durable after washing.

We have now found, unexpectedly, that improved stretch fabrics made from fibres other than those claimed in British Patent 983,968 can be made from cellulose triacetate, and from synthetic thermoplastic fibres particularly from nylon and isotactic polypropylene, provided that the fabric or the yarn used for making the fabrics from such synthetic thermoplastic fibres have not been previously heated after their formation up to and including a temperature required for the crimp interchange treatment. This treatment provides fabrics with stretch characteristics that are durable to machine washing up to at least 60°C. and fabrics with acceptable dimensional stability, and provided that a yarn and fabric construction, described hereafter, is used.

According to our invention therefore, we provide a woven fabric as defined which has stretch characteristics and which may be elongated by at least 10 and up to 40% under a load of 2 kgs. on a 2 inch strip of the fabric in one direction i.e. either in the warp or the weft, due to yarn crimp which has been imparted by crimp interchange and fixed by a heat treatment between the two sets of yarns in fabric form, the said yarns lying substantially parallel but out of phase with the crimps in neighbouring yarns, at least the yarns with the yarn crimp comprising at least a major proportion of thermoplastic fibres and the others in the transverse direction also comprising thermoplastic fibres and also lying substantially parallel, in straight lines but substantially in one plane when the fabric is supported on a flat planar surface, in which the fabric has a cover factor D, as defined, from 10.5 to 15 and in which the yarns are staple spun yarns of substantially circular section having a count in singles form of 1/8 to 1/80s cotton count, the yarns comprising thermoplastic fibres other than those claimed in the specification of our U.K. patent specification No. 983,968, said fabrics retaining the defined stretch characteristics even when machine washing at temperatures up to at least 60°C.

Suitable thermoplastic fibres for making fabrics for use in our fabrics comprise fibres made from isotactic polypropylene, polyamides such as nylon 6 and nylon 6:6 and cellulose triacetate. The yarns may be made in conventional manner by spinning said fibres, preferably from crimped fibres, having a staple length between 14 and 8 inches using sufficient twist during spinning to result in yarns having a substantially circular cross-section and which will result in only a small amount of distortion or flattening during crimp interchange. The yarns should have twist factors within the range of conventional weaving twist factors for that particular spinning system. We define twist factor as follows:

\[
\text{Twist factor} = \frac{\text{Number of Turns/inch}}{\text{yarn count}}
\]

On the metric system

\[
\text{Twist Factor} = \frac{\text{Number of Turns/metre}}{\text{metre count}}
\]

Thus crepe yarns which would impart stretch characteristics are excluded from the scope of our invention. Similarly crimped filament yarns and elastomeric filament yarns are similarly excluded.

The float length of a yarn is defined as the length of yarn in the surface of the fabric between adjacent intersections. The float length for our fabrics should not exceed 4 and corresponds to the number of threads over or under which the intersecting yarn passes in a warm structure.

We also provide a process for making the defined fabrics and imparting stretch characteristics thereto, comprising stretching the fabrics which have not been preheated to within 50°C to 120°C of the melting temperature of the thermoplastic fibres in the yarns from which the fabric has been made, stretching the fabric in the direction of one set of parallel yarns by at least 5 and up to 40% and as much as possible without breaking the yarns, whilst allowing the yarns in the other direction of the fabric to relax by at least 10 and up to 40%, to bring about the crimp interchange in the two directions of the yarn, heating the fabric in this condition to a temperature up to between 20 and 80°C below the melting temperature of the thermoplastic fibres for at least 30 secs and allowing the fabric to cool or cleaning the fabric to a temperature below heat setting of the yarn up to at least 50-200°C below the melting temperature of the thermoplastic fibres before removing a substantial proportion of the stretching force, so as to maintain the imparted crimp interchange. Heating and stretching of the fabric during crimp interchange is carried out by applying heat, and a preferred method of heating is a current of air heated to the required temperature. Suitable apparatus for heating and stretching may be provided on a conventional
stenter which has been modified to impart the required stretch, heating and cooling, which are essential for the yarn crimp interchange treatment. Suitable modifications for imparting wet stretch comprise: (a) means for controlled stretching and heating in the same zone (b) fitting tension bars which will not bend when the fabric is stretched 10–40% (c) non-use of any means preventing free wet contraction e.g. pins (d) means for positive cooling after heating zone, e.g. with a cold air fan, whilst fabric remaining at imparted stretch tension.

It should be appreciated that only fabrics of substantially plain woven construction and having no long floats with the required cover factor, are suitable for our treatment. If more open fabrics are used, or denser fabrics, the desired stretch properties will not be achieved.

Similarly if the fabrics have been preheated to higher temperatures than those stipulated, the imparted stretch characteristics we have found will not be durable to machine washing at elevated temperatures. Moreover the imparted stretch characteristics will be decreased below our specified level, and they will not have the desired recovery properties.

Suitable temperatures during the crimp interchange treatment will differ depending on the polymer from which the thermoplastic fibre component has been made. In the case of synthetic thermoplastic fibres, the fabric should not be preheated to within 50°C to 120°C of the melting temperature of the fibres or yarns from which the fabric has been made. Suitable temperatures for heating during the crimp interchange treatment are 20°C–80°C below the melting temperature of fibres as already stated.

The table below gives maximum temperatures for any previous heat treatment, such as heat setting, of the fabric together with suitable temperatures for the heat treatment during crimp interchange and the melting temperatures of the preferred fibres, which are further illustrated in the following examples.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Isotactic polypropylene</th>
<th>Cellulose triacetate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melting temperature, °C</td>
<td>180–220</td>
<td>180–220</td>
</tr>
<tr>
<td>Maximum fabric heat temperature, °C</td>
<td>120–140</td>
<td>120–140</td>
</tr>
<tr>
<td>Crimp interchange temperatures, °C</td>
<td>120–140</td>
<td>120–140</td>
</tr>
</tbody>
</table>

It should be appreciated, referring to the above table, that the temperature during the crimp interchange treatment should be at least 10 preferably 15°C higher than any previous fabric treatments. Thus for nylon 6.6 suitable crimp-interchange temperatures are from 180–220°C, for cellulose triacetate suitable temperatures are from 180°C to 220°C and for isotactic polypropylene are from 125°C to 140°C.

(b) Under the above conditions the optimum stretch characteristics and dimensional stability are retained even after washing in domestic automatic washing machines at temperatures of up to 60°C. Higher temperatures up to the boil may also be used, if desired, for short periods.

It should also be appreciated that only certain fabrics are suitable for crimp interchange treatment. In order to impart the desired stretch properties such fabrics have a cover factor from 10.5 to 15 preferably 12–13.2 and a denier count of yarns from single 1/8s to single 1/80s cotton count. The “cover factor” D defined hereunder depends on the number and count of yarns in the warp and weft of the fabric thus:

\[ D = \frac{\text{ends or picks per inch}}{\text{cotton count}} \]

where \( D \) is 10.5 to 15 and the cotton count 1/8s to 1/80s.

To convert the cotton count to the metric system the count number has to be multiplied by 0.59.

Lubrication of the yarns in the fabric is of importance. The tension required to produce a crimp interchange is lower if inter-fibre and inter-yarn friction is low. Textile lubricants containing silicones are preferred.

Fabrics having a cover factor below 10.5 are too floppy and they, as well as fabrics having a cover factor above 13 do not give the required characteristics.

It is preferable to use yarns of the same count in warp and weft and desirable to select counts which do not differ by more than double the count in both directions of the fabric.

By the term “stretch characteristics” we mean that the fabric can be elongated by at least 10% and up to 40% in at least one direction i.e. in the warp or weft direction and that this elongation under a load which must be below the elastic limit of the yarn crimp and not cause fibre rupture, is recoverable by at least 85%, i.e. when releasing the stretching force, the fabric will rapidly assume substantially its previous size and shape. A convenient minimum load is 2 kg. on a 2 inch strip of the fabric, as already stated.

It should be noted that although the fabrics suitable for our treatment can be stretched and recovered from stretch before the treatment, the amount of stretch is only about 1 to 5%; whereas after the treatment the fabrics assume the defined stretch characteristics and can be elongated by at least 10%, preferably 15–40%.

We have found that quite simple operations in finishing can increase yarn crimp and so give stretch characteristics. If warp stretch is required then warp crimp should be increased. This can be done by stretching the defined fabric in width so that wet crimp is removed. This causes the warp crimp to increase, by virtue of the crimp interchange properties of woven fabrics, and the correct amount of overfeed, the fabric will be reduced in length, as the warp crimp develops.

Spun yarns are preferred to filament yarns for imparting the stretch properties to the fabric. For maximum stretch properties the greatest possible amount of crimp interchange is required and this occurs with yarns which maintain their circular cross-section under transverse pressure against adjacent yarns. When filament yarns are used which have low twist, flattening occurs with resulting filament separation at the bends and as a result such fabrics suffer considerable crimp by crimp interchange because of filament interference. Filament yarns should therefore not be used in the stretch direction of the fabric.

For practical purposes the tensions required can be determined sufficiently accurately by measuring the extension under loads which of course must be less than those which would ruin the fabric by breaking individual yarns. Tensions which result in extensions of 7–35% in one direction are preferred for our fabrics. During this tensioning the fabric is allowed to relax preferably by about 15–25% in the transverse direction in which the thermoplastic best settable yarns are situated.

When the desired crimp interchange takes place, the slightly undulating parallel yarns in one direction of the fabric are pulled substantially straight, and at the same time the parallel yarns in the other direction are thereby pulled farther apart and the undulating path over and under the substantially straight yarns in the other direction is very much enhanced. It will be appreciated that for the desired crimp interchange to be possible, the following requirements in fabric construction and which are defined by our cover factor \( D \) and the yarn count, will have to be met:

(a) The spacing between the yarns in both directions should be such that the yarns lie in an undulating path due to inter-twining at substantially right angles to each other.

(b) The spacing between the yarns should be such as to allow movement of the yarns in the transverse direction when the other set of yarns is pulled into straight lines under high tension.

(c) The spacing should not be too large between the yarns but appreciable undulation should be present to cause...
a substantial movement of the yarns in the other direction when one set of yarns is pulled straight.

Table 1

<table>
<thead>
<tr>
<th>Yarn</th>
<th>Threads per inch</th>
<th>Heat setting conditions</th>
<th>Percent extension at 2 kgf/m² strip</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/12s 100% Polypropylene</td>
<td>34 x 34</td>
<td>28 x 28</td>
<td>135°C for 1 min</td>
</tr>
<tr>
<td>1/12s 100% CTA</td>
<td>42 x 38</td>
<td>34 x 28</td>
<td>180°C for 45 sec</td>
</tr>
</tbody>
</table>

2 After 1 min. relaxation. After 5 min. relaxation CTA has a non-recoverable extension at 2 kgf/m² strip of 5%. CTA referred to hereinafter denotes cellulose triacetate.

Table 2

<table>
<thead>
<tr>
<th>Yarn</th>
<th>Threads per inch</th>
<th>Heat setting conditions</th>
<th>Percent extension at 2 kgf/m² strip</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/12s 100% Nylon not heat set</td>
<td>40 x 42</td>
<td>44 x 38</td>
<td>180°C for 1 min</td>
</tr>
<tr>
<td>1/12s 100% Nylon heat set</td>
<td>44 x 40</td>
<td>44 x 38</td>
<td>180°C for 1 min</td>
</tr>
</tbody>
</table>

(d) To assist movement between the yarns a lubricant should be provided on the surface of the yarns.

(c) The undulated yarns should consist of or contain at least a major proportion of fibres which during the heat treatment in the tensioned condition can be heat set in that position under conditions such that this setting becomes practically irreversible during any subsequent processing or during wear.

The yarns or threads in one direction will be absolutely straight and show a crimp elongation or undulation of less than 5% under a load of 0.5 g.p.d. whereas the yarns which are causing the stretch characteristics in the fabric will show a crimp elongation of at least 15% and up to 50% under the same load.

From the following examples it will be seen that fabrics made from polypropylene fibres result in adequate stretch and recovery properties. Heat set and not heat set nylon fibre-containing fabrics give adequate stretch of about 15-29%. On the other hand triacetate fibres such as “Tricot” (registered trademark) has given fabrics with very promising stretch properties of 42% with 5% non-recoverable extension.

The previous history of the fabric, which includes any heat treatment, must be taken into account in order to obtain fabrics having not only the required stretch characteristics, but also the desired other properties such as high stretch recovery and retention of stretch during laundering and in wear.

Singles yarns are preferred but folded yarns may be used, if desired e.g., 2/60s in one direction and 1/30s cotton count in the other direction.

If it is desired to heat-treat the fabric to give them the required width and dimensional stability before the crimp interchange treatment, this can be done by heating the fabrics and if necessary by stretching them under small loads during heating, hollowed by cooling. As already mentioned however, the temperatures during this heating must be controlled within the specified limit, since otherwise the recovery properties are impaired and the maximum stretch characteristics are not obtained.

The following tables and examples illustrate but do not limit our invention.

Refering to the tables, fabrics were woven to give the number of threads indicated, heat set after stretching in the warp direction, as indicated in the third column and resulting in the weft stretch and recovery properties as given in the 5th and 6th column. Further examples are given after the table which particularly illustrate the fabric extensions and contractions produced as a result of the crimp interchange treatment.

Example 1

A 100% polypropylene fabric woven plain from 1/12s cotton count (c.c.) yarn of substantially circular cross-section and spun from 1½ inch staple which fabric had not been heated in fabric form above 90°C. since its formation was stretched 16% in the warp direction and allowed to contract 12% in the weft direction, the fabric being heat fixed at 135°C for 1 min. during crimp interchange in the fabric.

Sett/ins. (yards per inch) 40 x 38
Square cover factor before treatment 11.3
After treatment 44 x 32

The treatment gave 16% weft stretch which was durable to machine washing at 60°C. and which had good recovery properties.

Example 2

A 100% cellulose triacetate, 1/12s cotton count plain weave fabric having a square cover factor of 12.2 and which had not been heated in fabric form above 100°C. was treated at 180°C for 30 seconds giving it a warp extension of 35% and allowing weft contraction of 20%, as indicated in the following table which also included the properties of the fabric before and after the treatment.

Example 3

A 100% nylon 6:6 fabric woven plain from 1/12s cotton count yarn of substantially round cross section using 2 inch fibre in which the crimp had not been fixed by a heat treatment and having a square cover factor of 12.4 was stretched 11% in the warp direction allowing 24% weft relaxation, the fabric was heat treated under...
such tensions at 210° C. for 30 seconds. The properties of the fabric before and after treatment are given in the table below.

<table>
<thead>
<tr>
<th></th>
<th>Before treatment</th>
<th>After treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sellt.</td>
<td>45 x 60</td>
<td>54 x 38</td>
</tr>
<tr>
<td>Square cover factor</td>
<td>12.4</td>
<td></td>
</tr>
<tr>
<td>Percent stretch</td>
<td>&lt;5</td>
<td>20</td>
</tr>
<tr>
<td>Percent recovery</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>Wart extension</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Wart contraction</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>

After washing in a domestic washing machine at temperatures up to 60° C. the imparted stretch and percent recovery properties remained unimpaired.

EXAMPLE 4

Nylon fibre in which the fibre crimp had been heat fixed during manufacture at 25 p.s.i. for 7 mins. was used to spin yarn of 1/12s cotton count. A 100% nylon plain weave fabric was produced from this yarn and the fabric dried at 100° C. was extended 14% in the warp direction allowing 12% weft contraction, the fabric being heat treated at 210° C. for 30 seconds. After this treatment the fabric had 24% stretch with 96% recovery. Fabric details are given in the table below:

<table>
<thead>
<tr>
<th></th>
<th>Before treatment</th>
<th>After treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sellt.</td>
<td>45 x 41</td>
<td>52 x 37</td>
</tr>
<tr>
<td>Square cover factor</td>
<td>32.7</td>
<td></td>
</tr>
<tr>
<td>Percent stretch</td>
<td>&lt;5</td>
<td>24</td>
</tr>
<tr>
<td>Percent recovery</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Wart extension</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Wart contraction</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

After washing in a domestic washing machine at temperatures up to 60° C. the imparted stretch and percent recovery properties remained unimpaired.

EXAMPLE 5

A plain weave fabric woven in 100% CTA from 1/12’s cc. yarns was subjected to a heat treatment of 180° C. for 60 secs. during the fabric finishing sequence. This fabric was then extended 25% in the warp direction allowing 16% weft contraction, the fabric was heat treated during this crimp interchange stage process at 190° C. for 60 secs. The fabric details before and after treatment are given in the table below.

<table>
<thead>
<tr>
<th></th>
<th>Before treatment</th>
<th>After treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sellt/both (thread/both)</td>
<td>44 x 30</td>
<td>54 x 34</td>
</tr>
<tr>
<td>Square cover factor</td>
<td>11.9</td>
<td></td>
</tr>
<tr>
<td>Turn count = 1/12s cc.</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>Percent stretch at 3 kg./24 sq. yard of fabric.</td>
<td>&lt;5</td>
<td>20</td>
</tr>
<tr>
<td>Percent recovery</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>Percent weft extension</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>Percent weft contraction</td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>

After washing in a domestic washing machine at temperatures up to 60° C. the imparted stretch and percent recovery properties remained unimpaired.

What I claim is:

1. A process for making woven fabrics containing thermoplastic fibres selected from the group consisting of isotactic polypropylene fibres, nylon 6 fibres, nylon 6/6 fibres and cellulose triacetate fibres and imparting stretch characteristics to the fabrics, said process comprising: preheating the fabric within the range 100° C–110° C. for a fabric containing isotactic polypropylene fibres, 140° C–180° C. for a fabric containing nylon fibres and 120° C–130° C. for a fabric containing cellulose triacetate fibres; stretching the fabric in the direction of one set of parallel yarns by at least 5% and up to 40% and as much as possible without breaking the yarns whilst allowing the yarns in the other direction of the fabric to relax by at least 10 and up to 40%, to bring about crimp interchange in the two directions of the yarn; heating the fabric without bonding, in this condition to a temperature up to between 20 and 80° C. below the melting temperature of the thermoplastic fibres for at least 30 seconds; and allowing the fabric to cool or cooling the fabric to bring about heat setting of the yarns to a temperature at least 30–200° C. below the melting temperature of the thermoplastic fibres before removing a substantial proportion of the stretching force, so as to maintain the imparted crimp interchange.

2. A process as in claim 1 wherein the fabric contains isotactic polypropylene fibres and wherein the fabric is heated during crimp interchange at a temperature of 125° C–140° C.

3. A process as in claim 1 wherein the fabric contains nylon 6/6 fibres and wherein the fabric is heated during crimp interchange at a temperature of 180° C–220° C.

4. A process as in claim 1 wherein the fabric contains cellulose triacetate fibres and wherein the fabric is heated during crimp interchange at a temperature of 180° C–220° C.

5. A process according to claim 1 in which the temperature during the crimp interchange treatment is at least 15° higher than any previous fabric treatment.

6. A process according to claim 1 comprising lubricating the yarns in the fabric before crimp interchange treatment.

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R. L. MAY, Assistant Examiner

U.S. Cl. X.R.

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