NON-SLASH WEAVING

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This invention relates to the manufacture of woven textile fabrics and more particularly to weaving without slashing.

The object of this invention is to provide a method of manufacturing a woven fabric from a continuous filament yarn without slashing or imparting a high twist to the yarn.

In the art of weaving continuous filament yarn in a warp, the purpose of slashing, i. e., applying a size to the warp prior to weaving by immersing it under controlled conditions in a sizing solution, is not primarily to increase strength but to hold together the individual filaments of the yarn and thereby prevent a united and single front against the stress and abrasive action of the loom. This purpose may also be effected by imparting a high twist to the yarn. Twisting overcomes some of the disadvantages of slashing such as the necessity to remove the sizing after weaving; however, to give the yarn a high twist is, in general, less economical than slashing and also requires an additional step in preparing the warp. Hereinafter, it has been considered impossible, but it has now been found that a low-twist continuous filament yarn can be woven as a warp on an automatic power loom without slashing if the yarn is made up of individual filaments of relatively large cross-sectional area.

The adjective "no-slash" as used herein describes a yarn which can be successfully woven as a warp in an automatic power loom without being slashed. It has also been discovered that for a yarn of a given size, a quantitative measure of the ability to withstand the action of a loom is the product of

\[(\text{The number of turns per unit length})^2 \times (\text{the cross sectional area of an individual filament})\]

Therefore, to construct a low-twisted "no-slash" yarn that can be woven with the same efficiency as a highly twisted yarn, the denier of the filaments is increased so that the product of the above factors for the low-twist yarn is the same as that for the high-twist yarn.

Another factor which affects the weaving efficiency of a "no-slash" yarn is the size of the yarn, i. e., the sum of the cross-sectional areas of the several filaments. Where the size of the individual filaments is constant, the relationship between twist and yarn size with respect to "no-slash" effectiveness is

\[(\text{Turns per unit length})^2 \times (\text{total cross-sectional area of the filaments})\]

Combining the above relationship with the product of the twist and filament size factors, the following equation for "no-slash" continuous filament warp yarn is established:

\[\text{Weaving efficiency} = (\text{yarn size}) \times (\text{cross-sectional area of an individual filament})^2 \times (\text{turns per unit length})^4\]

Since the cross-sectional area of a filament is directly proportional to

denier of the filament

density

denier may be substituted in the efficiency equation for comparing yarns made from the same materials and the equation read

\[E = (\text{yarn denier}) (\text{filament denier})^2 (T. P. I.)^4\]

wherein E is weaving efficiency and T. P. I. is the abbreviation for turns per inch. To compare yarns of different materials E is multiplied by

\[\left(\frac{1}{\text{denier}}\right)^3\]

where a significant difference in density occurs. Specific gravity may be substituted for density as a practical expedient.

To simplify the above formula the obvious substitution of

\[(\text{The number of filaments}) \times (\text{filament denier})\]

for (yarn denier) may be made. The formula is then

\[E = n(\text{filament denier})^2 (T. P. I.)^4\]

wherein n is the number of filaments which make up the yarn.

The above set-forth formulas are useful in calculating the warp weaving efficiency of "no-slash" continuous filament yarn of at least 50 denier. There is no upper limit on yarn denier for constructing a "no-slash" yarn in accordance with this invention and the only practical limit is governed by the particular power loom and its accessories. Yarns from 50 to about 1200 denier can be woven on the looms contemplated by this invention.

It should be noted that formulas described herein apply in general to all continuous filament yarn constructions of at least 50 denier including the highly twisted yarns which are well known in the art. The novelty of this invention, however, lies in a method of weaving low-twist yarns. Yarns having ten or less turns per inch and preferably seven or less are contemplated. A twist of ten turns per inch or less is especially advantageous because it can be readily imparted to the yarn in conjunction with the filament forming process as the several filaments are twisted together to form a yarn. A higher twist may be imparted at that time but the rate of filament-forming must be substantially decreased to allow the yarn to be highly twisted as it is collected by conventional means, e. g., a centrifugal bucket employed in the viscose rayon spinning process. The minimum amount of twist is that required to form a yarn which can be handled on conventional textile equipment and is of the order of one-half turn per inch. A yarn having at least two turns per inch is preferred.

It is obvious from the prior art that a single filament of heavy denier, i. e., about 150 denier, can probably be woven without slashing. It also follows that a yarn comprising more than one such heavy denier filament will withstand the stress of a loom, but it is an obvious and wholly unexpected result that a warp yarn composed of three or more continuous filaments of from about eight to fifty denier can be effectively woven without being slashed or highly twisted.

When

\[E = (\text{yarn denier}) (\text{filament denier})^2 (T. P. I.)^4\]

the acceptable values of E for regenerated cellulose continuous filament "no-slash" warp yarn are from
the acceptable range is from 0.6×10^6 to 2.0×10^6 and the preferred above 2.0×10^6. (The specific gravity of regenerated cellulose is about 1.5.) The above values taking into account the density factor are defined as $E_a$ and thus

$$E_a = E\left(\text{specific gravity}\right)^3$$

Values for $E_a$ therefore, can be applied to continuous filament yarns comprising materials such as polyamides including nylon, polyesters including polymers of the ester of ethylene glycol and terephthalic acid, acrylic polymers including those containing at least 75% by weight of acrylonitrile, vinyl and vinylidene polymers including polyvinyl chloride, polyvinyl acetate and polyvinylidene chloride, polyethylene, protein including corn zein, soya bean protein and casein and cellulose esters including acetate and butyrate.

It is, of course, also necessary when filaments comprising materials other than regenerated cellulose are used to construct yarns in accordance with this invention that certain physical properties of the filaments must approximate or be made to approximate the properties of regenerated cellulose. These properties include stiffness which should be from about 5 to 50 grams per denier or modified by a suitable plasticizer to fall within this range. The surface characteristics of the yarn must approach the smoothness and hardness of regenerated cellulose or a suitable finish applied to the yarn to so modify its surface. Strength, which is usually defined in terms of tenacity, elongation, and elastic recovery is not a particularly critical factor in "no-slash" weaving since a continuous filament yarn which has sufficient strength to be wound, spun and subjected to the usual textile operations prior to weaving has the strength to be woven as a "no-slash" warp yarn. This is illustrated by the fact that a highly twisted cellulose acetate yarn whose filaments are relatively low in strength having a tenacity of about 1.3 grams per denier, is a very desirable "no-slash" warp.

Continuous filament yarns comprising essentially the following materials were modified with respect to the above described properties and woven as low-twist "no-slash" warp: nylon (polyhexamethylene adipamide), polyvinylchloride, polyvinylidene chloride, polyacrylonitrile, and cellulose acetate.

It is contemplated that in the method of this invention the "no-slash" warp yarn be woven on an automatic power loom with standard accessories for weaving continuous filament warp yarns. The looms are operated at the same rates of speed as those at which looms in commercial weaving mills are operated. Rates of from about 100 to 200 R. P. M. are satisfactory for the method of this invention.

The following table sets forth a number of examples of "no-slash" continuous filament regenerated cellulose yarns. On the right are examples of prior art high-twist rayon yarns for which $E$, calculated as hereinabove described, corresponds to the calculated values of $E$ for the low-twist yarns on the left.

### Table 1

<table>
<thead>
<tr>
<th>Ex. No.</th>
<th>Yarn Denier</th>
<th>Filament Denier</th>
<th>T. P. I.</th>
<th>$E_a$</th>
<th>Yarn Denier</th>
<th>Filament Denier</th>
<th>T. P. I.</th>
<th>$E_a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>600</td>
<td>30</td>
<td>4</td>
<td>16×10^6</td>
<td>4.2×10^6</td>
<td>100</td>
<td>3.75</td>
<td>0.6×10^6</td>
</tr>
<tr>
<td>2</td>
<td>600</td>
<td>20</td>
<td>4.5</td>
<td>6.6×10^6</td>
<td>2.9×10^6</td>
<td>150</td>
<td>3.75</td>
<td>0.6×10^6</td>
</tr>
<tr>
<td>3</td>
<td>600</td>
<td>10</td>
<td>5</td>
<td>8.1×10^6</td>
<td>3.2×10^6</td>
<td>170</td>
<td>3.75</td>
<td>0.6×10^6</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>30</td>
<td>5</td>
<td>8.1×10^6</td>
<td>3.2×10^6</td>
<td>170</td>
<td>3.75</td>
<td>0.6×10^6</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>20</td>
<td>5.5</td>
<td>8.1×10^6</td>
<td>3.2×10^6</td>
<td>170</td>
<td>3.75</td>
<td>0.6×10^6</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>10</td>
<td>6.5</td>
<td>8.1×10^6</td>
<td>3.2×10^6</td>
<td>170</td>
<td>3.75</td>
<td>0.6×10^6</td>
</tr>
<tr>
<td>7</td>
<td>100</td>
<td>10</td>
<td>6.5</td>
<td>8.1×10^6</td>
<td>3.2×10^6</td>
<td>170</td>
<td>3.75</td>
<td>0.6×10^6</td>
</tr>
<tr>
<td>8</td>
<td>100</td>
<td>10</td>
<td>6.5</td>
<td>8.1×10^6</td>
<td>3.2×10^6</td>
<td>170</td>
<td>3.75</td>
<td>0.6×10^6</td>
</tr>
<tr>
<td>9</td>
<td>100</td>
<td>10</td>
<td>6.5</td>
<td>8.1×10^6</td>
<td>3.2×10^6</td>
<td>170</td>
<td>3.75</td>
<td>0.6×10^6</td>
</tr>
</tbody>
</table>

The results in actual practice of the above examples corresponded to those predicted by using the formula

$$E = E_a \left(\text{specific gravity}\right)^3$$

as described above. The tests were carried out on a Crompton Knowles S-6 loom as well as on an XK and XD Draper. In all tests the loom was operated at from 100 to 200 R. P. M. and with standard accessories for continuous filament yarn. Different types of yarn were used as wefts including rayon, wool, and hair with no observed difference in the efficiency with which a fabric was woven.

In addition to the advantages of a low-twist "no-slash" warp yarn stated hereinabove, a fabric woven by the method of this invention from viscose rayon warp yarn made up of filaments of from eight to fifty denier shows unusual warp dimensional stability to laundering. These fabrics also unexpectedly respond to the sanforizing process. This dimensional stability is attributable at least in part to the fact that no strain is introduced into the yarn by swelling and stretching the warp yarns in the slashing process. As an example of this stability, a fabric was woven from a continuous filament viscose rayon warp yarn of 600 denier (4.5 T. P. I.) made up of 20 denier filaments without slashing the same yarn as weft.

After five washings in hot (140° F.) soapy water in a relaxed condition, the fabric shrunk less than 2% warpfwise and stretched less than 1% in the weft.

Another advantage of the new method of weaving described herein is that the weaving efficiency of the warp yarn can be improved by immersing the cake or cone of yarn in a sizing solution. The "cake-sizing" of a warp yarn having relatively small filaments is not effective protection against the loom although the yarn is not stretched as it is sovelled. With yarns which almost meet the requirements of construction in this invention, however as well as yarns which on the average meet the standards but have numerous defects, the "cake-sizing" process which does not strain the yarn may be effectively employed.

It is to be understood that changes and variations may be made in the aforesaid examples and illustrations without departing from the spirit and scope of the invention as defined in the appended claims.

I claim:

1. A method of manufacturing a woven fabric which comprises weaving an unsized continuous filament yarn as a warp on an automatic power loom, said yarn having a value of at least $0.6\times10^6$ for $E_a$ which is determined by the formula

$$E = E_a \left(\text{specific gravity}\right)^3$$

wherein $E_a$ is calculated according to the equation.

$$E = (\text{yarn denier}) \times (\text{filament denier})^3 \times \left(\text{t}, \text{urns per inch}\right)^4$$
the yarn having a denier of at least 50, a twist of from one half to 10 turns per inch and made up of at least three filaments of from 8 to 50 denier.

2. The method of claim 1 wherein the continuous filament yarn comprises regenerated cellulose.

3. The method of claim 1, wherein the continuous filament yarn comprises nylon.

4. The method of claim 1, wherein the continuous filament yarn comprises polyvinylidenechloride.

5. The method of claim 1, wherein the continuous filament yarn comprises polyacrylonitrite.

6. The method of claim 1, wherein the continuous filament yarn comprises cellulose acetate.

7. A method of manufacturing a woven fabric which comprises weaving an unsized continuous filament yarn as a warp on an automatic power loom operated at from about 50 to 200 R. P. M., said yarn having a value of at least $2.0 \times 10^7$ for $E_s$ which is determined according to the formula

$$E_s = E \left(\frac{1}{\text{specific gravity}}\right)^3$$

wherein $E$ is calculated according to the equation.

$$E = (\text{yarn denier}) \times (\text{filament denier})^2 \times \left(\frac{1}{\text{turns per inch}}\right)^4$$

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