PROCESS FOR PRODUCING CRIMPED YARNS

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This invention relates to a process for making perma-
ment crimped yarn of synthetic polymerized organic
material.

Processes for producing crimped yarn by high twisting,
setting and detwisting are known. Yarns treated by these
known methods have been found to have varying physical
characteristics.

The principal object of the present invention is to con-
trol the characteristics of such yarns and to produce yarns
which shall possess characteristics desired for knitting and
otherwise.

The invention comprises the novel products as well as
the novel processes and steps of processes according to
which such products are manufactured, the specific
embodiments of which are described hereinafter by way of
example and in accordance with which we now prefer
to practice the invention.

It has been found in accordance with the present in-
vention that crimped yarns will vary in accordance with
the amount of high twist given the yarn, but when the
yarn is twisted in accordance with the equation given
below, a superior crimped yarn is produced which is rela-
tively permanent, is voluminous and has generally plea-
sing appearance. It also has a relatively high "total per-
centage elongation" and a low "percentage tension," the
latter being referred to hereinafter as "fiber elon-
gation." Under "total percentage elongation" we under-
stand the elongation of the yarn on applying a defined
stress, this elongation being composed of the stretching
out of the crimp and of the strain of the fibrous material
itself. Under fiber elongation we understand the strain of
the fibrous material itself. These last-mentioned and
quoted characteristics are further determined in conec-
tion with formulae which will be given below.

The above-mentioned equation is as follows:

\[ T = \frac{275,000}{D + \frac{66}{400}} \]

whereby \( T \) means the optimum number of twists and \( D \)
the denier number of the yarn. By means of this simple
technical equation the optimum number of twists for
different yarn titres can be easily obtained with the nece-
sary accuracy, whereby the wearsome empiric deter-
mination of the number of twists is avoided. It has been
found in employing this equation that it is particularly
effective in establishing the proper number of twists to
be given the yarn for yarns of 20 to 450 denier.

The present invention refers especially to fibers of
polyamides, as for instance polyhexamethylene adipam-
ide or the polymerization product of epsilon-caprolactam.
It, however, may be employed also with other synthetic
polymerized organic textile fibers, filaments or yarns
such as polyesters or polyvinyl compounds.

Yarns made in accordance with the present process are
permanently crimped, have a round cross section and are
voluminous. They possess a high "total percentage elon-
gation" and a low fiber elongation. The "total per-
centage elongation" is obtained by use of the following
equation:

\[ \frac{b-a}{a} \times 100 = \text{up to} \ 400\% \]

where \( b \) is the yarn length measured at a load of .002
gram/denier, and \( a \) is the yarn length measured at a
load of 0.8 gram/denier. The fiber elongation is calculated
as follows:

\[ \frac{b_1-b_2}{b_2} \times 100 = 5 - 90\% \]

for the most suitable twists as a rule about 5 - 12% where
\( b_1 \) is the yarn length measured at a load of 0.1
gram/denier, and \( b_2 \) is the yarn length measured at a
load of 0.8 gram/denier.

The following are examples of the process as it is now
desired to practice it in accordance with the invention.

(1) A starting material yarn made of the linear
poly condensation product hexamethylenediamide is
used, which is well known in the market under the name of
nylon. It consists of 10 filaments and shows a total
titre of 30 denier. According to the above equation the
optimum twist for the high-twisting can be obtained as
follows.

\[ 275,000 + 800 = 2900 \text{T/m} \]

\[ \frac{275,000}{30 + 60} \]

\[ \frac{800}{2900} = \text{to} \ 1560 \text{T/m} \]

\[ \begin{array}{c}
\text{1 3/4 of the yarn quantity are high-twisted to} 3860 \text{T/m S,}
\text{3/4 to} 3860 \text{T/m Z. Then it is steamed to set it for half}
\text{an hour at 2.7 atmospheres.}
\end{array} \]

The yarn which is high twisted in the S-direction is detwisted to 150 T/m Z,
the yarn which is high twisted in the Z-direction is detwisted to 150 T/m S, and finally the two yarns of
150 T/m Z, plus one yarn of 150 T/m S are twisted
together to 100 T/m S. In order to facilitate the mechanical
workup, the twist of three-ply yarns usually are sized
afterwards with an aqueous solution of polyvinyl alcohol
plus glycercine. After washing out the sizing, the fiber
material has an intensive, uniform crimp or curliness,
the thread becomes considerably more voluminous and
is very elastic. The "total percentage elongation" is of
the order of 400% and the fiber elongation is of the order
of 12%. Knitted and woven goods of this yarn show
a completely new character in textiles and an outstand-
ing heat retention capacity.

(2) Nylon yarn according to example 1 of a total
titre of 70 den., consisting of 23 filaments, is high-twisted
to

\[ 275,000 \]

\[ \frac{70 + 60}{800} = \text{2900 T/m} \]

half of the quantity each in Z and S direction. The high-
twisting is carried out on a ring twisting frame, and the
yarn is then wound onto aluminum tubes. The high-
twisted yarn is steamed on the rigid aluminum tubes for
45 minutes at 2 atmospheres. Then the yarn is detwisted
to 100 T/m S resp. to 100 T/m Z and thereafter one
yarn each of S and Z direction is twisted together to
100 T/m Z, and finally reeled. After a short steaming
without pressure there results an extraordinary and very
uniform, crimped, voluminous twist of a soft and wool-
like head of high elasticity and of an outstanding warmth
retention. The crimp is washproof. The "total per-
centage elongation" was 225% and the fiber elongation
was 9.8%.

(3) A polyamide yarn of type "Perlon" L or "Grilon,"
made of a spun polycondensation product of epsilon-
caprolactam, of a total titre of 300 den., is high-twisted to

\[ 275,000 \]

\[ \frac{300 + 60}{800} = 1560 \text{T/m} \]
and wound on rigid tubes in z-direction. Then the yarn is steamed on tubes for 30 minutes at 1.2 atmospheres, detwisted to 80 T/m, reeled and treated in hand form with aqueous steam for a short time. A very intensive and equal crimp of the fiber material will be obtained under heavy contraction. The yarn becomes very voluminous and elastic and shows an extraordinary soft and agreeable hand. The "total percentage elongation" is more than 200% and the fiber elongation is about 13%.

Yarns made in accordance with the above examples have a pleasing appearance and their properties with respect to the "total percentage elongation" and fiber elongation along with their rounded across section render them highly desirable for processing into knit wear.

The properties in the yarns are illustrated on the attached drawing forming part of this application. In this drawing the course of the elongation as compared with the load applied is shown for yarns of various titles. The load in grams per denier is shown as the ordinate y and the values of the abscissa x show the elongation percent. For each of the yarns shown a basic load of .002 gr./den. is chosen which corresponds with an elongation of 0%. Curves I-IV shown yarns of fibers made of the linear polycondensation product of hexamethylene adipamide (nylon), each consisting of double twists of yarns of various titles made in accordance with the above examples. Curve I refers to a 30/2 S-yarn (twist in S-direction of two single yarns of 30 den. each), curve II to a 40/2 S-yarn, curve III to a 70/2 S-yarn and curve IV to a 200/2 S-yarn.

From this drawing, as well as from the following chart which shows the single elongation values at the various loads for each yarn, it is evident that the new product shows a remarkably high elongation.

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.002</td>
<td>0</td>
<td>0.002</td>
<td>0</td>
<td>0.003</td>
<td>0</td>
<td>0.002</td>
<td>0</td>
</tr>
<tr>
<td>0.017</td>
<td>165</td>
<td>0.019</td>
<td>140</td>
<td>0.021</td>
<td>121</td>
<td>0.025</td>
<td>105</td>
</tr>
<tr>
<td>0.033</td>
<td>184</td>
<td>0.037</td>
<td>135</td>
<td>0.039</td>
<td>105</td>
<td>0.030</td>
<td>89</td>
</tr>
<tr>
<td>0.050</td>
<td>212</td>
<td>0.052</td>
<td>115</td>
<td>0.052</td>
<td>98</td>
<td>0.036</td>
<td>77</td>
</tr>
<tr>
<td>0.106</td>
<td>223</td>
<td>0.110</td>
<td>68</td>
<td>0.113</td>
<td>58</td>
<td>0.150</td>
<td>40</td>
</tr>
<tr>
<td>0.200</td>
<td>239</td>
<td>0.210</td>
<td>35</td>
<td>0.210</td>
<td>22</td>
<td>0.200</td>
<td>12</td>
</tr>
</tbody>
</table>

All elongations in the above table are expressed in percents.

Furthermore, if we figure out the strain of the fibrous material, i.e. fiber elongation, which means the proportionate elongation within 0.1 and 0.8 gr./den. load, expressed in percents of the total length of the yarn loaded with 0.8 gr./den., we get the following values:

<table>
<thead>
<tr>
<th>Percent</th>
<th>30/2 S-yarn</th>
<th>40/2 S-yarn</th>
<th>70/2 S-yarn</th>
<th>200/2 S-yarn</th>
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<tbody>
<tr>
<td>6.2</td>
<td>6.9</td>
<td>9.8</td>
<td>7.2</td>
<td></td>
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</tbody>
</table>

From these numerical values, we learn that the fiber elongation for the new product is comparatively small. What we claim is:

1. A process for producing a voluminous, permanently and uniformly crimped synthetic organic textile yarn having a high total elongation and a low fiber elongation, which consists of the steps of twisting in a single operation a yarn of a denier of 20 to 450 in accordance with the following equation:

\[ T = \frac{275,000}{D + \frac{60}{1-S}} \]

where \( T \) is the number of turns per meter twist and \( D \) is the denier of the yarn, setting the yarn, then unsetting the same to a normal twist, and plying said yarn with another similarly but oppositely twisted, set and untwisted yarn, the extent of twisting, setting and untwisting being such as to produce a piled yarn having a total elongation between 150 and 400% and a fiber elongation between about 5 and 20%.

2. A process as set forth in claim 1 wherein the yarn is so twisted, set and untwisted as to produce a piled yarn having a total elongation between 150 and 400% and a fiber elongation of 5 to 12%.

3. A process as set forth in claim 1 wherein the yarn is a polyamide yarn.

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