METHOD AND APPARATUS FOR CRIMPING YARN

Fig. 2.

Fig. 3.

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METHOD AND APPARATUS FOR CRIMPING YARN


Filed July 28, 1966, Ser. No. 568,531

Claims priority, application Great Britain, Aug. 6, 1965, 33,733/65

Int. Cl. D02g 1/00

U.S. Cl. 28—1.3

10 Claims

ABSTRACT OF THE DISCLOSURE

Yarn is gear-crimped by passing it from nip rolls over a heated smooching pin to two meshing zones defined by three gear wheels. The resulting crimp consists of a primary, high-frequency crimp and a secondary, low-frequency crimp. Enhanced secondary crimp is imparted by cooling the yarn between the meshing zones and by pulling the yarn through the second meshing zone, as with a draw roll, under sufficient tension to effect drawing of the yarn.

The invention is concerned with crimped yarn and its manufacture.

Crimped yarns of e.g. synthetic polymer filaments are those bulked yarns whose bulk is brought about by mechanical crimping means, as for instance gear wheels, twisting devices or sharp edges. They are useful in a wide variety of textile articles, from the sheeniest fabrics, like women's stockings, to thick fabrics of the kind used for outer wear. Pile fabrics, for e.g. tufted carpets, are also made from crimped continuous filament yarns.

The invention is concerned with the particular means of crimping that employs gear wheels. The matter is expressed in this way to avoid the wrong inference being drawn that the crimped yarn of the invention is one having regular sinusoidal crimps of the standard gear-crimped variety.

In a variety of gear-crimped yarn, the crimp in each of the filaments is regular and tends, as between filaments, to be in phase. Hence, the bulk of the yarn is not as great as the individual filament distortion would suggest to be possible; and garments knitted from the yarn, for instance, have a rather lean handle in consequence. Furthermore, the appearance of the fabric is somewhat unattractive aesthetically, as the light reflected from in-phase crimps gives a uniform speckled effect in fabric.

In our British patent specification No. 984,922, we have described and claimed a method of crimping using driven gearheels, in which method also the yarn is pulled under tension through the meshing zone of the gear wheels. This method enables the two requirements, for synthetic filament yarns, of drawing and crimping to be carried out very conveniently in combination, in that the yarn can be pulled through the gear wheels by a draw roll under a total tension before and after the gear wheels, sufficient for drawing. The crimp in the thus-crimped yarn is suitable for use in many textile articles, owing to the peculiar nature of the combined process; but some de-phasing of the crimp, as between filaments of the yarn, may be beneficial for some purposes. One proposal for achieving this is to apply a low degree of false twist to the crimped yarn.

We have now found that a novel and very useful crimped yarn consists of a bulked multifilament yarn having in each of its filaments both a primary wave-like crimp and a secondary crimp characterised by a random, three-dimensional curvilinear configuration of low frequency and high amplitude. This bulked yarn, therefore, comprises the present invention in its broadest terms.

The nature of the above bulked yarn can be expressed in another way, that it consists of a composite crimp in each of the filaments made up of primary crimp induced by crimping in a meshing zone of gear wheels and secondary crimp induced by pulling the already gear-crimped yarn under tension through another meshing zone of gear wheels. The primary crimp may be of much higher crimp frequency than the secondary crimp.

The yarn of the invention may be produced by a process in which yarn is crimped by passage through the meshing zone of two gear wheels, one of which drives the other, and by subsequent passage through the meshing zone of said driving one of said gear wheels and a third gear wheel also driven thereby.

Preferably, the yarn is fed to the gear wheel assembly as undrawn yarn, the undrawn yarn is heated and is drawn by, or whilst passing through, the gear wheel assembly.

A greater degree of secondary crimp can be achieved, especially with heavy denier yarns (e.g. of 400 denier and above), if the yarn is cooled on passage between the two meshing zones. The primary crimp is inserted whilst the yarn is hot on passing through the first meshing zone.

The yarn of the invention, owing to the combination of the specified primary and secondary crimp, is characterised by an absence of in-phase crimp even over short lengths of the yarn, and a fuller, loftier handle, which is most desirable in articles of knitted outerwear, than yarn produced using only two gear wheels.

As in the case of the two gear wheels described and claimed in British patent specification No. 984,922, the shape of the teeth of the gear wheels is preferably involute, to ensure smooth transmission of the drive from the driving gear wheel to the gear wheels driven thereby and by contact through the yarn. For maximum yarn bulk, the gears should be set as near to the maximum extent of intermesh as possible, short of damaging the filaments of the yarn. The gears are preferably of stainless steel, and the tips of the teeth may be squared-off, so that the clearance between the tips and the bottoms of the grooves between teeth of the meshing gear wheels, is greater than the clearance between the sides of adjacent teeth. Alternatively, the tips may be rounded, to fit more closely into the bottoms of the grooves between the opposing teeth. The driving gear may be of greater diameter than the two driven gears, say 5 inches compared with 1 inch, or 4 inches compared with 2 inches; and, in general, the smaller the gear diameter(s), the greater will be the bulk in the yarn crimped thereby.

A convenient angle, between the lines joining the axis of the driving gear wheel and the axes of each of the two gear wheels driven thereby, is 68°, allowing for a sufficient length of arc of the periphery of the driven gear wheel, around which the yarn progresses between the two meshing zones, to enable the yarn to be adequately cooled by a cooling blast of air directed at said arc of the periphery.
The preferred process, in which undrawn yarn supply is pulled through the gear wheel assembly under a total tension, before and after the assembly, sufficient to draw the yarn, is similar to that described in the aforementioned British patent specification save for the use of the 3-gear system in place of the 2-gear one. Thus, undrawn yarn is withdrawn from a supply package, e.g. spinning cylinder, thereof, or from the undrawn zone of a melt-spinning machine directly after extrusion, by driven nip rolls and is passed thereby at a fixed linear speed into a drawing zone. The yarn is drawn by a draw roll and separator roll driven at an appropriately higher peripheral speed than that of the nip rolls, the yarn being first passed around a heated (e.g. at 160°C) snap-up pin and hence through the 3-gear-wheel assembly, the driving gear of which is driven preferably at a slightly lower peripheral speed than the draw roll, before arriving at the draw roll. From the draw roll, the yarn is collected in an orderly fashion, as by being wound-up in conventional manner, e.g. by a ring spindle wind-up mechanism. As the yarn temperature at the gear wheel assembly is an important parameter of the process, it is necessary, for ease of control, to have a distance between the undrawn yarn and the nearest of the gear wheels of the gear wheel assembly to a minimum, say 3 inches. Within the useful range of temperatures, the higher the temperature, the greater will be the bulk in the yarn.

The preferred processes are those in which firstly, the gear assembly actually functions as the draw roll, and, secondly, the yarn supplied to the gear assembly is already substantially fully drawn. In both instances, neither the amount of primary crimp nor that of secondary crimp are as great as when the yarn is either pulled through the gears, or supplied in undrawn state, respectively, as will be shown later in the examples.

A plurality of yarns may be crimped together in the gear assembly, and then separated and wound up individually.

The nature of the "finish," or "dressing" on the yarn to be crimped by the 3-gear assembly is significant to the amount of secondary crimp obtainable, and has therefore to be selected with the care for the particular material of the yarn. A type of finish should be effected which does not cause the filaments to be lightly stuck together on the yarns, but pass freely through the gear wheel assembly.

The invention will now be described by reference to the accompanying drawings, in which

FIGURE 1 is exemplary of a short length of filament taken from a bulked multi-filament yarn according to the invention;

FIGURE 2 is a thread-line diagram of the preferred process of the invention;

FIGURE 3 is a thread-like diagram of an alternative process according to the invention;

FIGURE 4 is an enlarged elevational view of the three-gear assembly according to the invention; and

FIGURE 5 is a still further enlarged sectional view of a portion of the meshing zone of two of the gears of the assembly of FIGURE 5.

In FIGURES 1 to 5, the high frequency primary crimp is clearly shown all along the filament, which filament is looped and curled in a random manner, actually three-dimensional, according to the secondary crimp present in it.

The portions of yarns shown at A and B are from crimp-developed yarn from the three-gear and the two-gear assemblies respectively; whilst the portions of yarns shown at C and D are from yarn from the respective two types of assembly of which yarn the crimp has not been developed.

It will be evident that the bulk of the crimped yarns, whether in crimp-developed or undeveloped condition, is greatly enhanced by the presence of secondary crimp according to the invention.

In FIGURE 2, undrawn yarn 1 is shown being withdrawn over one end of cylinder 3 from a package 5 of wound yarn. Withdrawal is effected by rotation of the pair of nip-rolls 7 constituting the feed rolls of a draw-twister; and the yarn passes through pig-tail guide 9 positioned on the axis of the cylinder, and thence around pre-tensioning rods 11.

The undrawn yarn then enters the drawing span by positive feed from nip-rolls 7. Drawing is effected by rotation of draw roll 13 at a peripheral speed several times that of the nip-rolls 7. Separator roll 15 serves axially to separate the several wraps needed to be taken around the draw roll to prevent slippage of the yarn thereon.

Positioned sequentially along the thread-line within the drawing span are electrically heated snapping pin 17 and a three-gear crimping assembly 19 comprising driving gear 21 and driven gears 23, 25.

On leaving the periphery of the draw roll 13, the yarn, now in drawn and latently crimped condition, passes through balloon-guide 27 and is then wound up by a through balloon-guide 27 and is then wound up by a ring spindle device incorporating a ring 29 and traveller (not shown) thereon and a bobbin 31 mounted on an upright spindle (not shown) within the ring. The yarn is wound in a double-taper package 33 according to a desired build.

The arrangement depicted in FIGURE 3 is similar to that of FIGURE 2 (and the parts of apparatus have the same reference numbers), save that the draw roll 13 (and separator roll 15) are omitted from the apparatus. Hence, the gear assembly 19 is responsible for imposing the drawing tension on the yarn 1, in this particular instance. Also in FIGURE 3, the driving gear 21 is of greater diameter than the driven gears 23, 25.

FIGURE 4 shows more clearly the path of the yarn 1 from the snapping pin 17 to the meshing zone between driving gear 21 and driven gear 23, thence around a portion of the periphery of driving gear 21 before entering the meshing zone between driving gear 21 and driven gear 25. An air pipe 40 for cooling the yarn between the two meshing zones may also be included.

FIGURE 5 shows, greatly enlarged, a portion of the meshing zone between the driving gear 21 and the driven gear 23 (or 25). Clearly shown are the involute shape of the teeth 35 and the near-maximum extent of intermeshing of the teeth. The tips 37 of the teeth 35 are shown as being squared off.

The invention will now be more specifically described in the following examples of processes performed according to it, using gear wheels of outside diameter of about 3 inches.

The references to "skeln lengths" L in inches with numerals appended, are measures of the primary and secondary crimp in the yarn determined by a test method in which a certain number of wraps (45 for singles yarn, 15 for 3-fold heavy denier yarn) of yarn are taken around a 1-metre reel, the skeln so wound is suspended in hot water (60°C) and the length of the skeln measured under two different loadings, the first being large enough to pull out the secondary crimp (but allow the primary crimp to be manifested or developed) and the second being insufficient to pull out the secondary crimp (the actual loads depending on the size of the yarn in question and being 20 and 5 grams respectively for the lower denier (400 denier) yarns, and 60 and 10 grams respectively for the higher denier (1640 denier) yarns).

**EXAMPLE 1**

This example demonstrates the improvement brought about by the use of a 3-gear assembly, compared with a 2-gear one, and also the improvement in regard to secondary crimp when the yarn is cooled between the two meshing zones of the 3-gear assembly.

The yarns were produced according to the above-described preferred process, in which the yarn is pulled
under tension through the gear assembly and is drawn at the same time, under the following conditions:

Yarn (drawn denier) 400 denier/50-filament nylon 66.
Feed roll speed 385 feet/min.
Snubbing-pin wraps 2.
Snubbing-pin temperature 160° C.
Gears 20 teeth per inch.
Gear-wheel outside diameter 3.0445 in.
Gear internesh 0.0265 in.

(max: internesh = 0.029 in.)

Draw roll speed 1500 feet/min.
Draw roll wraps 3.
Spindle speed 6000 r.p.m.

<table>
<thead>
<tr>
<th>Gears</th>
<th>Yarn Cooling (r.p.m.)</th>
<th>L5 (inches)</th>
<th>L10 (inches)</th>
<th>L20-L5 (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,000</td>
<td>16.5</td>
<td>16.25</td>
<td>0.75</td>
</tr>
<tr>
<td>2</td>
<td>1,000</td>
<td>15.0</td>
<td>15.25</td>
<td>1.25</td>
</tr>
<tr>
<td>3</td>
<td>1,000</td>
<td>13.5</td>
<td>14.75</td>
<td>3.25</td>
</tr>
</tbody>
</table>

Table 1

Table 1 is it apparent that when using two gears only (i.e., not according to the process of the invention) the secondary crimp present in the yarn (represented by L20-L5) is practically insignificant in that it represents less than 1 inch in skin length. Further, it is apparent that cooling of the yarn between the two meshing zones of the gears improves the amount of secondary crimp (represented by 3.25 inches of skin length), compared with a 3-gear system without cooling (1.25 inches of skin length).

**EXAMPLE II**

This example demonstrates a similar improvement in a 3-gear system when cooling air is applied as that shown in Example I, but for 1040 denier/68 filament tri-lobal cross-section nylon 66 yarn (drawn denier).

The process was again used, with a draw roll speed of 2000 feet/min. and at a draw ratio of 3.7, the other significant conditions, for the purposes of the comparison, as shown in Table 2.

<table>
<thead>
<tr>
<th>Gears</th>
<th>Cooling (r.p.m.)</th>
<th>L5 (inches)</th>
<th>L10 (inches)</th>
<th>L20-L5 (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nil</td>
<td>17.25</td>
<td>15.5</td>
<td>1.75</td>
</tr>
<tr>
<td>2</td>
<td>0.0055</td>
<td>17.5</td>
<td>13.25</td>
<td>4.25</td>
</tr>
</tbody>
</table>

Table 2

It is again apparent from Table 2 that the amount of secondary crimp present is improved, this time by 2.5 inches.

**EXAMPLE III**

This example shows the inferior, but still useful, performance of the process in the invention when drawn yarn is used as the supply yarn.

The yarns compared were 400 denier 50 filament nylon 66 yarn, processed according to the preferred process. The feed rolls were by-passed when processing the drawn supply yarn.

The conditions of processing were:

Snubbing-pin temperature 160° C.
Snubbing-pin wraps 2.
Draw roll speed 1000 feet/min.
Draw roll wraps 3.

Table 3

<table>
<thead>
<tr>
<th>Gears</th>
<th>Yarn Supply (r.p.m.)</th>
<th>L20 (inches)</th>
<th>L5 (inches)</th>
<th>L20-L5 (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>870</td>
<td>17.0</td>
<td>16.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>1,400</td>
<td>16.75</td>
<td>13.5</td>
<td>3.25</td>
</tr>
<tr>
<td>3</td>
<td>2,200</td>
<td>18.0</td>
<td>18.0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3

It will be apparent from Table 3 by a comparison of the drawn supply yarn figures with those for the control that a drawn supply yarn does not have the propensity for very pronounced primary or secondary crimp. The comparison with the yarn that is supplied in undrawn state (Draw ratio = 3.9) shows that both the primary and secondary crimp of the latter to that of the former is in the ratio 2.25:1.

**EXAMPLE IV**

This is a similar example to Example III, save that the yarn was 1040 denier/68 filament in drawn condition, 4 wraps were taken round the snubbing-pin and 63 litres of air per minute were directed on to the yarn between the two meshing zones, to cool it. The draw roll speed was 600 feet/min.

<table>
<thead>
<tr>
<th>Gears</th>
<th>Yarn Supply (r.p.m.)</th>
<th>L20 (inches)</th>
<th>L5 (inches)</th>
<th>L20-L5 (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>500</td>
<td>18.0</td>
<td>17.5</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>500</td>
<td>16.0</td>
<td>12.75</td>
<td>3.25</td>
</tr>
<tr>
<td>3</td>
<td>500</td>
<td>18.5</td>
<td>18.5</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 4

Again, the improvement brought about by using the supply yarn in undrawn state and drawing it (Draw ratio = 3.7) whilst crimping is demonstrated.

**EXAMPLE V**

This example is intended to indicate the different performance of a 3-gear gar wheel system when such is used to apply the actual force required to draw an undrawn supply yarn.

The process used was one in which an undrawn yarn was fed by positive-feed nip rolls to a drawing zone, from which zone it was wound up by a positively driven constant-speed wind-up. In the drawing zone, the yarn was passed around a snubbing-pin and thence through the meshing zones of a 3-gear crimping assembly. When the gear speed was such that there was no tension in the yarn between the assembly and the wind-up, it was assumed that the total drawing force was being applied by the assembly. Otherwise, the gear wheels were driven at a lesser speed, such being the preferred state-of-affairs.

The yarn was 1600/400 denier 50 filament nylon 66 drawn to a ratio of 3.9 at a constant wind-up speed of 2000 feet/min.

<table>
<thead>
<tr>
<th>Gears</th>
<th>Tension below (grams)</th>
<th>L20 (inches)</th>
<th>L10 (inches)</th>
<th>L20-L5 (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3,220</td>
<td>17.25</td>
<td>16.0</td>
<td>1.25</td>
</tr>
<tr>
<td>2</td>
<td>1,500</td>
<td>16.8</td>
<td>15.0</td>
<td>1.5</td>
</tr>
<tr>
<td>3</td>
<td>1,750</td>
<td>15.25</td>
<td>11.5</td>
<td>3.75</td>
</tr>
<tr>
<td>4</td>
<td>1,900</td>
<td>16.5</td>
<td>14.0</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Table 5

From Table 5 it can be seen that the amount of secondary crimp is rather low, at a skin length figure of 1.25, when the gear wheel assembly is imparting the total drawing force; and that it increases markedly as the tension below the gears begins to increase, reaching an optimum figure (at a well-defined graphical peak) at a tension of 190 grams.

Although not so much secondary crimp is imparted, nevertheless what there is tends to be semi-developed (manifested) when the yarn is delivered from the gear wheel assembly at zero tension to the wind-up.

The invention has been described with reference to nylon 66 yarns, but it will be appreciated that the yarn of the invention can be produced from a supply yarn of any type capable of accepting a crimp and retaining it to a useful degree. Naturally, the most obvious supply
yarns to be used will be those of the synthetic linear polymers, such as the polyamides, polyesters and polypropylenes, which are readily and relatively permanently crimpable. A compound crimp effect can be obtained by utilizing two-component filaments (so-called "heterofilaments") as the supply yarn filaments.

Although the invention has been described in connection with continuous crimping, it is within its scope to carry out the crimping discontinuously so as to produce intermittently crimped yarn. Further, the teeth of gear wheels may be so disposed around its periphery, i.e., with gaps, that a random crimp is produced. A periodic secondary crimp, superimposed on a continuous primary crimp, is also within the scope of the invention; and can be produced by arranging for some slight eccentricity of the axis of the driven gear wheel. Normally, such eccentricity of mounting of any of the gear wheels is disadvantageous; and any effects of it in regard to the periodicity of the crimp can be minimised by selecting gear wheels differing greatly in their diameters, as indicated to be possible hereinbefore.

Specific crimp-development (manifestation) treatment, by heating the yarn in relaxed condition, may be performed on the yarn between the draw-roll and the wind-up. This may be achieved by injecting the yarn by means of a steam injector into a steam relaxing tube. Alternatively, crimp-development may be achieved, and the crimp stabilized, by over-feeding the yarn, say at 20% overfeed, on to a take-up package, and then treating the package in steam.

Subsequent crimping in a stuffer-box crimper serves to endorse the crimp produced according to the invention, should this be desired. Also, it may be desirable to fold two or three multfilament yarns, say of 400 denier, before making them into fabric.

What we claim is:

1. A process for producing a bulked multfilament yarn comprising heating the multfilament yarn, crimping the multfilament yarn in the meshing zone of gear-wheels so as to induce a primary wave-like crimp of high frequency and low amplitude in the filaments, cooling the filaments, and then pulling the thus-crimped yarn through another meshing zone of gear-wheels under tension so as to induce a secondary crimp of low frequency and high amplitude in the filaments.

2. A process according to claim 1 in which the meshing zones are provided by one driving gear-wheel and two gear-wheels driven thereby.

3. A process for producing a bulked multfilament yarn comprising a composite crimp consisting of a primary wave-like crimp of high frequency and low amplitude and a secondary crimp of low frequency and high amplitude, which process comprises the steps of:
   (a) forwarding undrawn multfilament yarn to a drawing zone which incorporates a heated snubbing-pin;
   (b) heating the yarn and localizing the point of drawing by passing the yarn around the heated snubbing-pin within the drawing zone;
   (c) pulling the yarn, under a total tension before and after two successive meshing zones of a gear-wheel assembly adequate to draw the yarn, through the said meshing zones by a draw-roll while cooling the yarn between said meshing zones; and
   (d) collecting the yarn in an orderly fashion.

4. A process according to claim 3 in which the gear-wheel assembly is driven at a peripheral speed less than that of the draw-roll,

5. A gear-wheel assembly for crimping yarn comprising a driving gear-wheel and two gear-wheels driven thereby by meshing engagement therewith to nearly the maximum extent, whereby to define two successive meshing zones the tips of the teeth on said gear-wheels being square, and the clearance between the tips of the teeth and the bottom of the grooves of the meshing gear-wheels is greater than the clearance between the sides of adjacent teeth.

6. A gear-wheel assembly for crimping yarn comprising a driving gear-wheel and two gear-wheels driven thereby by meshing engagement therewith to nearly the maximum extent, whereby to define two successive meshing zones, and means for cooling the yarn passing between said successive meshing zones.

7. A gear-wheel assembly for crimping yarn comprising a driving gear-wheel and two gear-wheels driven thereby by meshing engagement therewith to nearly the minimum extent, whereby to define two successive meshing zones, the driven gear-wheels being disposed such that the angle between lines joining the axis of the driving gear-wheel and the axes of each of the driven gear-wheels is about 68°.

8. A gear-wheel assembly for crimping yarn comprising a driving gear-wheel and two gear-wheels driven thereby by meshing engagement therewith to nearly the maximum extent, whereby to define two successive meshing zones, a heated snubbing pin over which the yarn passes before passing to said meshing zones and a draw roll for receiving the yarn after it leaves said meshing zones.

9. A process for producing a bulked multfilament yarn comprising crimping multfilament yarn in the meshing zone of gear-wheels so as to induce a primary wave-like crimp of high frequency and low amplitude in the filaments and then pulling the thus-crimped yarn through another meshing zone of gear-wheels under tension so as to induce a secondary crimp of low frequency and high amplitude in the filaments, and effecting crimp-development by passing the yarn through an atmosphere of steam in a relaxed condition to thereby heat the yarn.

10. A process for producing a bulked multfilament yarn comprising crimping multfilament yarn in the meshing zone of gear-wheels so as to induce a wave-like crimp of high frequency and low amplitude in the filaments and then pulling the thus-crimped yarn through another meshing zone of gear-wheels under tension so as to induce a secondary crimp of low frequency and high amplitude in the filaments, and effecting crimp-development by heating the yarn in a relaxed condition, the heating being carried out by loosely winding the yarn onto a take-up package and treating with steam.

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U.S. Cl. X.R.

28—1.8, 72.11, 72.15