PROCESS FOR PREPARING AN UNDRAWN, LOW BIREFRAINGENCE POLYAMIDE YARN

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This invention relates to an improved process for production of polyamide yarns and filaments.

Commercially available nylon yarn is usually produced by melt-spinning polyamide filaments, by winding the undrawn yarn into a package and subsequently drawing the yarn on a draw-winder or draw-winder. It has therefore been highly desirable to subject the filaments, after quenching and prior to winding, to a steam treatment to increase satisfactory package formation in winding. Such a process is disclosed in Babcock in U.S. 2,289,860. In this process the filaments, after quenching, are subjected to heat and high humidity (including steam), preferably for a period of at least 0.04 second before winding.

It has now been found that unexpected process and product advantages can be gained by critical adjustment of the steaming process whereby the filaments enter the steaming zone at a higher than normal filament temperature and in duration of steaming is greatly reduced. In accordance with the present invention, an undrawn polyamide yarn of low birefringence is produced by a process which comprises extruding a molten synthetic fiber-forming polyamide in the form of filaments; cooling the extruded filaments to a temperature sufficient to at least partially solidify them, the said temperature being at least about 15° C. above the force-to-draw transition temperature of the filaments; applying steam to the said filaments for a period of no longer than about 0.02 second and winding the filaments into a package.

Filaments produced by this process exhibit a low orientation in the undrawn state, as indicated by low birefringence, and consequently may be drawn at a high draw ratio to produce yarn of the same tenacity and elongation as conventional yarns prepared at a lower draw ratio. This means that the undrawn yarn denier may be increased without affecting the final yarn denier and the productivity of the spinning unit is thereby increased. In addition it is found that yarns produced by the process of this invention dye more deeply under the same conditions than do conventionally processed yarns.

The invention will be more readily understood by reference to the drawings.

FIGURE 1 is a schematic drawing showing the various steps of the process of the present invention.

FIGURE 2 is a series of curves referred to more specifically in Example 1 wherein yarn birefringence as ordinate is plotted against yarn temperature for four different periods of steaming.

The values for the force-to-draw transition temperatures, as reported herein, are determined by measuring the force-to-draw at different yarn temperatures and plotting a curve of force-to-draw vs. yarn temperature. The temperature at which a definite break in the curve is observed is taken as the transition temperature for the particular yarn. Since the force-to-draw transition temperature for nylon varies with the degree of crystallinity, orientation and moisture content, the force-to-draw is determined by passing yarn directly after quenching to a heated feed roll of 6.72 inches diameter, passing the yarn around the feed roll for 16 turns to insure temperature equilibration, then passing the yarn to a draw roll and drawing to a 2.2 draw ratio.

The surface temperature of the filaments is determined with a compensating thermocouple arrangement in which one of a pair of thermocouples is placed in contact with the running filament and the other thermocouple is heated electronically until the two are in balance. A commercially available instrument manufactured by the Hastings-Radist Co. is used in measuring the filament temperature reported herein.

The term "birefringence" as used herein refers to the absolute difference in refractive indices along and perpendicular to the axis of a filament in an unswollen condition. The term birefringence as applied to multifilament yarns or strands refers to the birefringence of the filaments in those yarns or strands. The birefringence of the filaments is determined from observation of representative filaments between crossed plane-polarizing elements (e.g., Nicol prisms) using a Soleil compensator for accuracy. The method is described in detail by Heyn in Textile Research Journal 22, 5—13 (1952).

Example 1

Polyhexamethylene adipamide having a relative viscosity of 36—37 is prepared in the conventional manner and melt extruded to form 34 filaments. The filaments are quenched by cross flow air following the procedure of Heckert U.S. 2,273,105, dated February 17, 1942. The filaments, at various temperatures are passed at 1500 y.p.m. through a streamer for periods of 0.091, 0.018, 0.013 and 0.0044 second, and then wound, undrawn, into a package. The yarn is thereafter drawn to a denier of approximately 70. The process is schematically illustrated at FIGURE 1 wherein filaments I freshly extruded from spinneret 2 pass into cooling chimney 3 where they are contacted by cross flow air. Convergence guide 5, adjustable in position to assist control of filament temperature as described hereinafter, leads the filament, at the desired temperature out of chimney 3 and into steamer 6 where a cross flow of steam 7 contacts the still hot filaments. The filaments in the undrawn condition are thereafter passed by suitable guides 8 onto a package 9.

The duration of steaming is varied by using steamers of various lengths, (i.e. 82, 16, 12 and 4 inches respectively to provide the various steaming periods at the yarn speed indicated). The 82-inch steamer is of the type described in Babcock U.S. 2,289,860, dated July 14, 1942. The shorter steamers are of the type described in co-pending application S.N. 420,547 filed in the name of James C. Davis on the same day as this application. The latter design is used for the shorter steamers in order to provide a less turbulent steam flow as is found desirable when applying steam to the yarn at higher yarn temperatures to prevent variations in yarn denier. The yarn temperature at which the steam is varied by changing the steamer location relative to the spinneret and by converging the filaments with an additional guide at various locations in the chimney (the rate of cooling is decreased by converging the filaments). The results are indicated in the curves of FIGURE 2, the various curves A, B, C and D representing results obtained with steaming periods of 0.09, 0.018, 0.013 and 0.0044 second respectively. It will be observed that a sharp decrease in birefringence occurs when steam is applied to yarns at a yarn temperature above about 75° C. Furthermore, birefringence increases when the contact with steam is lengthened. A period of contact of from about 0.001 second to about 0.09 second is operable with a period of from about 0.004 second to about 0.02 second being preferred. In Table I birefringence values for various steaming periods at a constant yarn temperature of 85° C. are tabulated. The force-to-draw transition temperature is determined, as previously described, for the various yarns and found to be 59° C. The yarn steamed for 0.013 second at 85° C. is tested for dyeability using anthraquinone blue SW and is found to dye 8—10 shades deeper than the conven-
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70-denier 34-filament yarns were prepared following the general procedure of Example I. The birefringence of the undrawn yarn is varied as shown in Table 2 by using different steamer exposure periods and yarn temperatures. The yarn with the higher birefringence is prepared by steaming for 0.091 second, the distance between the steamer and spinneret being adjusted to give the yarn a temperature of 52°C. at the point of entry into the steamer. The yarn with the lower birefringence is prepared by steaming for 0.018 second, the steamer being raised to give a yarn temperature of 85°C. as the yarn enters the steamer. When the yarn is drawn it is found that the draw ratio of the yarn having the lower birefringence can be increased to 2.95 as compared to 2.86 for the other yarn while the denier and elongation of the yarn are substantially equivalent. This increase in draw ratio represents an increase in productivity for the spinning machine of about 3%. Also, as shown in the table, the coefficient of variation of the denier of the yarn is lower for the yarn having the lower birefringence.

### Table 2

<table>
<thead>
<tr>
<th>Birefringence</th>
<th>Draw Ratio</th>
<th>Denier</th>
<th>Elongation, Percent</th>
<th>CV*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0290</td>
<td>2.95</td>
<td>72.1</td>
<td>25.5</td>
<td>1.88</td>
</tr>
<tr>
<td>0.0259</td>
<td>2.96</td>
<td>72.0</td>
<td>25.8</td>
<td>1.25</td>
</tr>
</tbody>
</table>

*Coefficient of variation of yarn denier along length of yarn

As demonstrated above, the process of the present invention by producing a modest change in birefringence permits a 3.5% increase in draw ratio and therefore in productivity. Such an increase in the commercial production of many millions of pounds of fiber per year will be readily apparent. Under optimum conditions, an increase in spinning machine productivity, after corrections are made for differences in elongation and denier, of as much as 10.5% may be attained.

To achieve a substantial improvement in productivity, the surface temperature of the filament entering the steaming zone should be at least 15°C. above the force-to-draw transition temperature and preferably at least 25°C. above this temperature. The upper temperature limit is not critical with regard to birefringence but is limited by the operability of the process. In general, temperatures more than 60°C. above the force-to-draw transition temperatures should not be employed and the preferred range is 25-40°C. above this temperature.

The surface temperature of the filaments may be adjusted to the desired level by modifying the quenching conditions, e.g., by adjustment of quenching air flow and/or temperature, adjusting the position of the steamer relative to the spinneret or by varying the point at which the filaments are converted into a yarn prior to entering the steamer. The preferred procedure is to adjust the distance between the spinneret and the steamer so that the yarn is at the proper temperature when it enters the steaming zone.

Further decreases in the birefringence of the undrawn yarn, and consequently greater improvements in productivity may be achieved by reducing the duration of steaming below that taught by Babcock in U.S. 2,289,860. This reduction in steaming time can only be done in combination with the higher yarn temperatures indicated above, since the use of such short steaming times at the lower yarn temperatures normally employed leads to unsatisfactory package formation as indicated by Babcock. Surprisingly, however, short steaming times may be used at the higher yarn temperatures without encountering problems due to poor package formation. The duration of steaming is desirably held to no more than about 0.02 second. With extremely short steaming times, some difficulty may be encountered due to steam turbulence which results in variation in filament denier and, consequently, for optimum results, times in the range of about 0.018 second are preferred. The steaming temperature, i.e., the temperature of the atmosphere in which the filaments are treated, is not highly critical but should be above 100°C. Steam pressures in the range of 5-50 pounds are suitable.

In addition to the increased spinning machine productivity attainable by the process of this invention, it is found that fabrics prepared from yarns processed according to this invention dye substantially deeper under equivalent conditions than conventional, split process nylon yarns. This is a decided advantage, both in the case of dyeing and in attaining deep shades which are not normally obtained with such fibers. Also, when the yarn is steamed with the apparatus described in copending application S.N. 420,547, the uniformity of the yarn and hence the fabric is markedly improved.

The yarn of this invention may be prepared from any polyamide which crystallizes readily in the presence of heat and moisture. The preferred polyamides are 6-6 and 6 nylon. Other suitable polyamides are disclosed in U.S. 2,071,253, U.S. 2,030,523, and U.S. 2,130,948. Polyamides which have a high force-to-draw transition temperature may of course be difficult to process and thus require special conditions to achieve satisfactory operability.

Many equivalent modifications will be apparent to those skilled in the art from a reading of the above without a departure from the inventive concept.

What is claimed is:

1. A process for preparing an undrawn, low birefringence polyamide yarn which comprises (1) extruding a molten, synthetic fiber-forming polyamide in the form of filaments, (2) cooling the said filaments to a temperature at least about 15°C. above the force-to-draw transition temperature of the said filaments and low enough to at least partially solidify the said filaments, (3) contacting the said filaments with steam for a period no longer than about 0.02 second and (4) forwarding the said filaments from the said contact with steam.

2. The process of claim 1 wherein the said filaments are cooled to a temperature above about 60°C. prior to application of steam.

3. The process of claim 2 wherein the said temperature above about 60°C. is between about 25-40°C. above the force-to-draw transition temperature of the said filaments.

4. The process of claim 1 wherein the said filaments are contacted with steam for a period of from about 0.001 second to about 0.09 second.

5. The process of claim 1 wherein the said filaments are contacted with steam for a period of from about 0.004 second to about 0.02 second.

6. The process of claim 1 wherein the said filaments are forwarded to windup after contact with steam.

References Cited by the Examiner

**UNITED STATES PATENTS**

2,289,860 7/1942 Babcock.

**FOREIGN PATENTS**

900,009 7/1962 Great Britain.

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