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(54) Improved partially oriented nylon yarn and process.

(57) In a partially oriented nylon feed yarn for drawtexturing, the filaments have high RV sheaths and low RV cores. Exceptional crimp development is achieved in the resulting textured yarn.

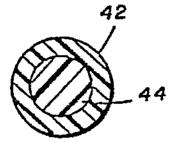

FIG. 2.

EP 0 200 701 A2

Croydon Printing Company Ltd.

IMPROVED PARTIALLY ORIENTED NYLON YARN AND PROCESS

SPECIFICATION

As used in the specification and claims, the term "nylon 66" shall mean those synthetic linear polyamides containing in the polymer molecule at least 85% by weight of recurring structural units of the formula

$$\left[\overset{\overset{\displaystyle O}{\|}}{C} - (CH_2)_4 - \overset{\overset{\displaystyle O}{\|}}{C} - \overset{\overset{\displaystyle H}{|}}{N} - (CH_2)_6 - \overset{\overset{\displaystyle H}{|}}{N} \right]$$

Historically, certain nylon 66 apparel yarns were spun at low speeds of up to about 1400 meters per minute and packaged. The spun yarns were then drawn on a second machine and packaged again. The drawn yarn was then false-twist textured at slow speeds of the order of 55-230 meters per minute by the pin-twist method, yielding a very high quality stretch yarn suitable for stretch garments such as leotards. An exemplary false-twisting element for the pin-twist texturing process is disclosed in Racshle U.S. 3,475,895.

More recently, various other types of false twisting apparatus have come into commercial use, and are collectively referred to as "friction-twist". Some of the most widely used of these include a disc aggregate of the general type illustrated in Yu U.S. 3,973,383, Fishback U.S. 4,012,896 or Schuster U.S. 3,885,378. Friction-twisting permits considerably higher texturing speeds than pin-twisting, with yarn speeds currently at about 700-900 mpm. Such high texturing speeds are more economical than those attained by the pin-twist process.

Along with the shift to friction-twisting has come a shift to partially-oriented nylon 66 (PON) yarns as the feeder yarns for the friction-twist process. In the conventional PON spinning process, the winding speed is merely increased from the previous standard of about 900-1500 meters per minute to speeds generally in the 2750-4000 meters per minute range, resulting in a PON yarn. PON yarn performs better in the high speed friction-twist texturing process than either the earlier drawn yarn or the low-speed spun yarn mentioned above. However, heretofore yarns textured by the friction-twist process were of distinctly lower quality in terms of crimp development than yarns textured by the pin-twist process. The apparel nylon 66 false-twist textured yarn market is accordingly in essentially two distinct segments: the older, expensive, high quality pin-twist yarns, and the newer, less costly, lower quality friction-twist yarns.

PON feeder yarns for false-twist texturing have had RV's in the range from the middle or upper thirties to the low forties, as indicated by U.S. 3,994,121. Such yarns have more than adequate tenacity for conventional apparel end uses. With conventional nylon 66 polymerization techniques, increasing the polymer RV is expensive and leads to increased rates of gel formation, with consequent shortening of spinning pack (filter) life. High RV polymer is therefore ordinarily not used unless required for some special purpose, such as when high yarn tenacity is required.

It has recently been discovered that high RV PON feeder yarns permit manufacture of friction-twist yarns having increased crimp development, in some cases comparable to that of pin-twist yarns. This increased crimp development provides a substantial increase in fabric covering power as compared to fabrics made from friction-twist yarns made from PON feeder yarns as disclosed by Adams U.S. 3,994,121. Accordingly, less textured yarn is required to provide a fabric of equivalent covering power. Increased productivity in spinning and texturing is also provided by high RV PON yarns.

According to the present invention, a further and substantial improvement in the art is provided by a novel PON feeder yarn, permitting formation of a friction-twist textured yarn having in some cases markedly higher crimp development than even pin-twist yarns. This permits either or both of increased stretching capability in a fabric or use of even less yarn to provide a fabric of equivalent covering power, even as compared to pin-twist yarns.

The yarns of the invention are, broadly, false-twist texturing feed yarns spun at high speeds and characterized by a sheath-core conjugate structure, with the sheaths formed from nylon 66 polymer having a higher melt viscosity at 284°C. than the polymer forming the cores. The mechanism or precise reason for the improved results of the present invention are not entirely understood.

According to a first principal aspect of the invention, there is provided a sheath-core filament spun at a spinning speed of at least 2200 MPM, the filament having a nylon 66 sheath component surrounding a polymeric core component, the sheath component having a higher melt viscosity at 284°C. than that of the core component.

According to a second principal aspect of the invention there is provided a process for spinning a sheath-core filament, comprising generating a molten stream comprising a nylon 66 sheath component having a higher melt viscosity at 284°C. than that of the core component, extruding the stream through a spinneret capillary, quenching the stream into a filament, and withdrawing the filament at a spinning speed of at least 2200 MPM.

According to a third principal aspect of the invention there is provided a process for producing a textured yarn, comprising simultaneously drawing and friction-twist texturing a sheath-core filament spun at a spinning speed of at least 2200 MPM, the filament having a nylon 66 shealth component surrounding a polymeric core component, the sheath component having a higher melt viscosity at 284°C. than the core component.

In accordance with each of the above principal aspects, the core component is preferably nylon 66. Preferably the RV of the sheath component is at least 10 RV units higher than the RV of the core component, and optimally the RV of the sheath component is at least 20 units higher than the RV of the core component. It is preferred that the RV of the sheath component be at least 50, with a sheath component RV of at least 60 being most desirable. Preferably the shealth-core volumetric ratio optimally being about 3 to 7. For best results the spinning speed is selected such that the filament has an elongation lower than 150%, with the range between 50% to 120% being particularly advantageous.

Other aspects of the invention will in part appear hereinafter and will in part be obvious from the following detailed description taken together with the accompanying drawing, wherein:

FIGURE 1 is a schematic front elevation of an examplary apparatus for spinning the yarns of the invention; and

FIGURE 2 is a cross-section of an exemplary filament according to the invention.

As shown in FIGURE 1, molten polymer streams 20 are extruded through capillaries in spinneret 22 downwardly into quench zone 24 supplied with transversely directed quenching air at room temperature. Streams 20 solidify into filaments 26 at some distance below the spinneret within the quench zone. Filaments 26 are converged to form yarn 28 and pass through interfloor conditioner tube 30. A conventional spin-finish is applied to yarn 28 by finish roll 32. Yarn 28 next passes in partial wraps about godets 34 and 36 and is wound on package 38. The filaments may be entangled if desired, as by pneumatic tangle chamber 40.

Ordinarily, godets 34 and 36 perform the functions of withdrawing filaments 26 from streams 20 at a spinning speed determined by the peripheral speed of godet 34, and of reducing the tension in yarn 28 from the rather high level just prior to godet 34 to an acceptable level for winding onto package 38. Winding tensions within the range of 0.03 to 0.25 grams per denier are preferred, with tensions of about 0.1 grams per denier being particularly preferred. Godets 34 and 36 may be dispensed with if the yarn winding tension immediately prior to the winder in the absence of the godets is within the yarn tension ranges indicated in this paragraph. "Winding tension" as used herein means the yarn tension as measured just prior to the yarn traversing and winding mechanism. Some commercially available winders include an auxiliary roll designed to both assist in yarn traversing and to permit reducing the yarn tension as the yarn is wound onto the bobbin or package. Such winders may be of assistance when using the upper portions of the yarn tension ranges indicated in this paragraph.

Description of the Prior Art

Example 1

This is an example within the range of present conventional practice. Nylon 66 polymer having an RV of 39 is extruded through a conventional spinning pack and spinneret at a melt temperature of 285°C. Spinneret 22 contains 34 capillaries having lengths of 0.012" (0.3 mm.) and diameters of 0.009" (0.229 mm.) Quench zone 24 is 35 inches (60.96 to 88.9 cm) in height, and is supplied with 20°C. quench air having an average horizontal velocity of 1 foot (30.5 cm.) per second. Filaments 26 are converged into yarn 28 approximately 36 inches (91.4 cm.) below the spinneret. Conditioner tube 30 is 72 inches (183 cm.) long and is of the type disclosed in Koschinek U.S. 4,181,697, i.e., a steamless tube heated to 120°C. through which yarn 28 passes. The speed of godets 34 and 36 are 4100 meters per minute and 4140 meters per minutes, respectively, to prevent the yarn from wrapping on godet 36. The polymer metering rate is selected such that the yarn wound has a denier of 89. The winder used is the Toray 601, and the winder speed is adjusted to provide a winding tension of 0.1 grams per denier. The yarn has an elongation-to-break of 65-68% and an RV of 41 (about 700 poise calculated zero shear rate viscosity at 284°C).

The spun yarn is then simultaneously drawn and friction-twist textured on a Barmag FK6-L900 texturing machine using a 2-1/2 meter primary heater and a Barmag disc-aggregate with Kyocera ceramic discs in a draw zone between a feed and draw or mid roll. The heater temperature is 225°C., and the ratio of the peripheral speed of the discs to draw roll speed (the D/Y ratio) is 1.95. The draw roll speed is set at 750 meters per minute, and the feed roll speed is adjusted to some lower speed to control the draw ratio and hence the draw-texturing tension (the yarn tension between the exit of the heater and the aggregate). In order to maximize the crimp development, the draw ratio is changed by adjustment of the feed roll speed so that the draw-texturing tension is high enough for stability in the false twist zone and yet low enough that the filaments are not broken, this being the operable texturing tension range. Within the operable tension range, the "maximum texturing tension" is defined as the tension producing the maximum initial crimp development without an unacceptable level of broken filaments (frays). More than 10 broken filaments per kilogram are unacceptable in commercial use.

With the Example 1 yarn, the operable texturing tension range is quite narow when draw-texturing at 750 meters per minute. The maximum texturing tension is found to be about 0.43 grams per draw roll denier, and the aged crimp development (yarn stored on the bobbin two weeks after texturing) is about 13-15%. The draw roll denier is defined as the spun yarn denier divided by the mechanical draw ratio provided by the different surface speeds of the feed roll feeding the yarn to the heater and of the draw or mid roll just downstream of the false-twist device. When the texturing tension is more than 0.45 grams per draw roll denier, an unacceptable level of broken filaments is produced. An attempt to increase initial crimp development by increase in heater temperature much above 225°C. also leads to an unacceptable level of broken filaments. The textured yarn denier is about 70.

Example 2

This is an example of high RV PON yarn. The spinning process of the first paragraph of Example 1 is repeated, except the polymer is selected and dried so that the yarn RV is about 70 (about 2200 poise calculated zero shear rate viscosity at 284°C). The PON yarn denier is 98, and the yarn has an elongation-to-break of 88%. When the spun yarn of this paragraph is draw-textured (245°C. heater), its maximum texturing tension is found to be 0.54 grams per draw roll denier and the operable range of yarn tensions in the false-twist zone is broader than in the case of Example 1 above. The textured yarn has a denier of 70 and an aged crimp development of about 18%. Finished fabrics formed from the textured yarn of this example have greater covering power and stretch than similar fabrics formed from the textured yarn of Example 1, and are comparable to those made from pin-twist yarns.

Further increases in texturing tension do no appreciably affect the crimp development, but merely result in broken filaments or yarn breaks.

THE INVENTION

FIGURE 2 illustrates the preferred sheath-core filament according to the invention, with sheath 40 surrounding core 42. Spinneret pack designs for forming such sheath-core filaments are well known in the art. According to the invention, sheath 40 is nylon 66 spun at a lower temperature than core 42 and the spinning speed is at least 2200 MPM.

Example 3

This is an example according to the invention. The apparatus described in Example 1 is used except the spinneret pack used in Examples 1 and 2 above is replaced by a spinneret pack designed to produce 34 sheath-core filaments. A batch of nylon 66 polymer is dried to produce nominal 75 yarn RV (about 2570 poise calculated zero shear rate viscosity at 284°C.), and a second batch of nylon 66 polymer is dried to produce nominal 41 yarn RV (about 700 poise calculated zero shear rate viscosity at 284°C.). The polymers are spun under the conditions set forth in Example 1 above as sheath-core filaments with the high RV polymer forming the sheaths and the low polymer forming the cores, the sheath-core volumetric ratio being 2 to 3. That is, 40% by volume of the filament is formed by the sheath component, with the remaining 60% being formed by the core. The PON yarn denier is 108 and the elongation is 79%.

When the PON yarn is drawtextured by the friction-twist method at its maximum texturing tension, the resulting textured yarn has a denier of 70 and an aged crimp development of about 23%. This is substantially greater than the crimp development levels achieved by friction-twist texturing of any other known yarn, and even exceeds levels achieved by various applications of the pin-twist method. The increased crimp development provides for greater stretch and covering power in fabrics made from the textured yarn of the invention as compared to all known prior art yarns textured by the friction-twist method.

Example 4

It has been discovered that a small amount of draw (between 1.05 and 2.0 draw ratio) prior to winding gives improved results in some instances. Example 3 is repeated, except godet 34 is run at 3154 MPM, to provide a draw ratio of about 1.3. The PON has a denier of 100 and an elongation of 64, and the aged crimp development of the resulting 70 denier textured yarn is 24%.

Example 5

The experiment in Example 3 is repeated except that the spinneret is replaced with a similar spinneret designed to produce 68 rather than 34 filaments. The sheath polymer is nylon 66 having an RV of 70 (about 2200 poise calculated zero shear rate viscosity at 284°C.), while the core is nylon 66 having an RV of 39 (about 610 poise calculated zero shear rate viscosity at 384°C.). The sheath-core volumetric ratio is 2 to 3. The PON has a denier of 108 and an elongation of 76%, and the aged crimp development of the resulting 70 denier textured yarn is about 14%. This is comparable to the Example 1 yarn even though the denier per filament is half that of that in Example 1. Fabrics made from the textured yarn of this example have useful stretch properties comparable to similar fabrics made from the textured yarn in Example 1, and have greatly increased covering power and softness. Fabrics made from friction-twisted 40 RV yarns having 70 denier and 68 filaments, while having improved covering power as compared to fabrics formed from friction-twisted yarns having 70 denier and 34 filaments, do not have such useful stretch properties since they have aged crimp developments of about 8-10%.

Example 6

The experiment in Example 5 is repeated except that the spinning and winding speeds are reduced to 2000 MPM and the polymer metering rates are reduced to provide a yarn denier of 132 and an elongation of 132%. Aged crimp development of the resulting 70 denier textured yarn is 9-10%, illustrating that the major improvement in crimp development provided by the invention is available only at spinning speeds above about 2200 MPM.

Example 7

The preferred sheath-core volumetric ratio is less than 1 to 1, with a ratio of about 3 to 7 being especially preferred. Example 3 is modified to provide a sheath-core volumetric ratio of 3 to 7 (30% of the filament by volume being formed by the sheath polymer, and 70% by volume being formed by the core polymer). The PON has a denier of 114 and an elongation of 76%, and the aged crimp development of the resulting 70 denier textured yarn is about 23.4%, somewhat higher than that of Example 3 wherein the ratio is 2 to 3.

Test Methods

All yarn packages to be tested are conditioned at 21 degrees C. and 65% relative humidity for one day prior to testing.

The yarn elongation-to-break (commonly referred to as "elongation") is measured one week after spinning. Fifty yards of yarn are stripped from the bobbin and discarded. Elongation-to-break is determined using an Instron tensile testing instrument. The gage length (initial length) of yarn sample between clamps on the instrument) is 25 cm., and the crosshead speed is 30 cm. per minute. The yarn is extended until it breaks.
Elongation-to-break
is defined as the increase in sample length at the time of maximum load or force (stress) applied, expressed as a precentage of the original gage length (25 cm.).

Crimp development is measured as follows. Yarn is wound at a positive tension less than 2 grams on a Suter denier reel or equivalent to provide a 1-1/8 meter circumference skein. The number of reel revolutions is determined by 2840/yarn denier, to the nearest revolution. This provides a skein of approximately 5680 skein denier and an initial skein length of 9/16 meter. A 14.2 gram weight or load is suspended from the skein, and the loaded skein is placed in a forced-air oven maintained at 180°C. for 5 minutes. The skein is then removed from the oven and conditioned for 1 minute at room temperature with the 14.2 gram weight still suspended from the skein, at which time the skein lenght L2 is measured to the nearest 0.1 cm. The 14.2 gram weight is then replaced with a 650 gram weight. Thirty seconds after the 650 gram weight is applied to the skein, the skein length L3 is measured to the nearest 0.1 cm. Percentage crimp development is defined as L3-L2/L3 x 100. Crimp development decreases with time as the textured yarn ages on the bobbin, rapidly for the first hours and days, then more slowly. When "aged crimp development" is specified herein, the textured yarn is stored on its bobbin at room temperature, and measurement is made two weeks after texturing.

Relative viscosity (RV) is determined by ASTM D789-81, using 90% formic acid.

Broken filaments are determined visually, by counting the number of broken filaments on the exposed surfaces of the package.

What is claimed is:

1. A sheath-core filament spun at a spinning speed of at least 2200 MPM, said filament having a nylon 66 sheath component surrounding a polymeric core component, said sheath component having a higher melt viscosity at 284°C. than said core component.

2. The filament defined in claim 1, wherein said core component is nylon 66.

3. The filament defined in claim 2, wherein the RV of said sheath component is at least 10 RV units higher than the RV of said core component.

4. The filament defined in claim 3, wherein said RV of said sheath component is at least 20 RV units higher than said RV of said core component.

5. The filament defined in claim 2, wherein said RV of said sheath component is at least 50.

6. The filament defined in claim 5, wherein said RV of said sheath component is at least 60.

7. The filament defined in claim 2, wherein said sheath-core volumetric ratio is less than 1 to 1.

8. The filament defined in claim 7, wherein said sheath-core volumetric ratio is about 3 to 7.

9. The filament defined in claim 2, wherein said filament has an elongation lower than 150%.

10. The filament defined in claim 2, wherein said filament has an elongation between 40% and 120%.

11. The process for spinning a sheath-core filament, comprising:

a. generating a molten stream comprising a nylon 66 sheath component and a core component having a lower melt viscosity at 284°C. than said sheath component;
b. extruding said stream through a spinneret capillary;
c. quenching said stream into a filament, and
d. withdrawing said filament at a spinning speed of at least 2200 MPM.

12. The process defined in claim 11, wherein said core component is nylon 66.

13. The process defined in claim 12, wherein said sheath component is as defined in any of claims 3 to 6.

14. The process defined in claim 11, wherein said sheath-core volumetric ratio is as defined in either claim 7 or claim 8.

15. The process defined in claim 12, wherein said spinning speed is selected such that said filament has an elongation lower than 150%.

16. The process defined in claim 15, wherein said filament has an elongation between 40% and 120%.

17. The process defined in claim 12, wherein said filament is drawn and wound at a winding speed between 1.1 and 2 times as fast as said spinning speed.

18. A process for producing a textured yarn, comprising simultaneously drawing and friction-twist texturing a filament according to any of claims 1 to 10.

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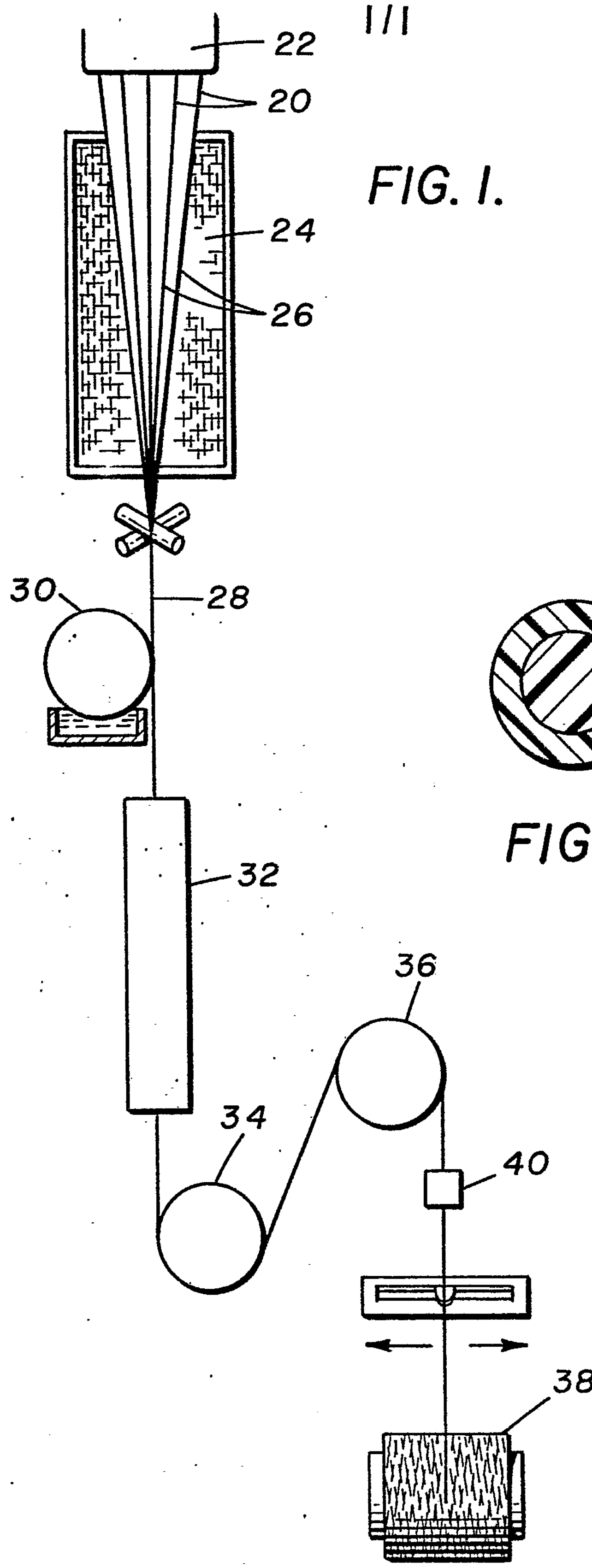

FIG. 1.

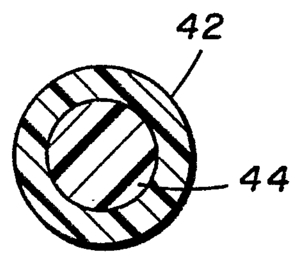

FIG. 2.