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PROCESS FOR KNITTING

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The present invention relates to knitted fabrics, particularly hosiery, made from monofilament nylon yarn and possessing increased elasticity.

The elasticity of a knitted fabric is dependent on several characteristics of the fiber or fibers comprising the same and the fabric itself, namely, strength of fiber, longitudinal elasticity of fiber, angular or bending elasticity of fiber, the number and shape of loops or stitches in the fabric and position of loop in the fabric. Normally, a knitted hosiery fabric contains well rounded stitches or loops which lie flat in the fabric and, as a result of the loop formation, the fabric is limited in its stretch characteristics. For example, the stretch of full-fashioned nylon hosiery runs aproximately 70% in either direction. This stretch is known as fabric stretch and is due to the nature of the construction of fabric in that the loops become deformed when stress is applied. With nylon, or other yarn of good resiliency, the loops return to their normal shape when the stress applied to stretch the fabric is released.

Greater fabric stretch than 70% can be attained in nylon fabric if sufficient stress is applied thereto. However, under this condition, the yarn in the fabric is itself stretched excessively and the stress necessary to accomplish this is uncomfortable under actual wear condition. Furthermore, repeated stretching under such conditions as normally occurs, for example, in the case of ladies' hosiery, necessarily induces a loss of shape in the knitted fabric.

Co-pending applications, Serial No. 342,709, filed March 16, 1953, and Serial No. 367,776, filed July 7, 1953, both of which are hereby made a part of this disclosure, describe procedures for making knitted hosiery and the like of enhanced stretch characteristics. These procedures involve the steps of first presetting the nylon yarn, twisting a part of the yarn in one direction to impart a right twist torque thereto and twisting another part of the yarn in the opposite direction to impart a left twist torque thereto, sizing said twisted yarn to hold the torque therein dormant temporarily while knitting, forming a fabric from the twisted yarn by alternately knitting at least one course first with the yarn which has been twisted in one direction and then with the yarn which has been twisted in the other direction and, thereafter, removing the size from said fabric to release the torque in said twisted yarn.

In contrast to conventional knitted hosiery fabrics which possess a pattern of uniform loops or stitches that lie in a plane or flat surface, the loops or stitches in the resulting fabric turn over on edge when the size is removed, due to the torque in the yarn, and thus the face of the fabric shows a series of loop edges rather than open stitches. The torque of the yarn also causes a fabric torque, so that the chains of loops or wales move in a diagonal direction to regular or normal fabric. In other words, the loops in the fabric take a different position than in conventional knitted fabrics, due to the force of the torque and, as a result, more loops or stitches automatically form in a given area. Thus, for example, where a normal knitted fabric may finish five inches long, the fabric of Serial No. 342,709 and Serial No. 367,776, could reasonably finish only two and one-half inches long. However, the latter fabric has the ability to stretch up to 250%, whereas the stretch of the normal fabric is about 70%, as noted above.

As indicated, the yarn used in the procedures of Serial No. 342,709 and Serial No. 367,776 must be sized before the knitting operation. This sizing operation binds the filaments of the yarn together, deadens the liveliness thereof and restricts the action of the torque imparted thereto sufficiently to avoid kinking in the knitting operation. After the fabric has been knit, the size is removed in any conventional manner, e. g., by scouring, and the fabric which, up to this point, has the appearance of conventional knitted fabric, assumes a herringbone pattern, due to the release of the torque in the yarn.

The procedures of Serial No. 342,709 and Serial No. 367,776 produce highly desirable knitted fabrics from multifilament nylon yarn. However, with monofilament nylon yarn, it is not possible to get sufficient size on the yarn to deaden the twist therein, and the yarn cannot, therefore, be satisfactorily knitted without kinking.

It would normally be assumed that the tendency of monofilament yarn, or for that matter any type of yarn, to kink could be eliminated if sufficient tension were applied to the yarn between the supply package and the knitting machine. Unfortunately, however, very little tension can be applied to the yarn as it is fed to the machine because, once in the machine, the tension is greatly magnified and will break the yarn. Accordingly, in conventional practice, the supply bobbin or package delivers the yarn to the head of the knitting machine freely and easily. Consequently, where the yarn is lively, as in the case of twisted monofilament nylon yarn or unsized, twisted multifilament nylon yarn, it springs off the package several circumferences at a time, thus leaving the yarn substantially without tension at that particular point, and the torque created by the twist will cause the yarn to kink and give a defective product.

It has now been found that with certain modifications of the procedures described in Serial No. 342,709 and Serial No. 367,776, knitted fabric possessing excellent stretchability and other desirable properties can be obtained without kinking from monofilament nylon yarn. As a result, it is now possible for the first time to make such products as full-fashioned women's hosiery which are adapted to cover a wide range of leg and foot sizes and yet possess the finest sheer and other desirable qualities of the best hosiery commercially available.

Accordingly, the principal object of the present invention is to provide a novel process for making "elasticized" knitted fabric, and especially hosiery fabric, using monofilament nylon yarn.

Additional objects include the provision of:

(1) Fabric which, by virtue of its stretchability or elasticity, is peculiarly adapted for use in making women's hosiery.

(2) New techniques in knitting twisted monofilament nylon yarn which prevent kinking of the yarn, and related disadvantages, during the knitting operation.

Other more specific objects will also be hereinafter apparent.

As in the procedures of the above mentioned applications, the process of the present invention includes the steps of twisting monofilament nylon yarn in one direction, e. g., to the left (or in the Z direction), twisting another yarn in the opposite direction, i. e., to the right (or in the S direction) and then knitting the desired fabric by alternately knitting at least one course first with one yarn and then with the other. In the present process,

however, the yarn is not sized, since this is of no advantage, as noted above. Instead, after the twisting step, and before the knitting operation, the yarn is wound in a unique way which prevents the yarn from kinking on its way to the knitting machine. Specifically, each of the twisted yarns is wound onto a bobbin in a direction opposite to its twist, i. e., the yarn with Z-twist is wound onto the bobbin in a clockwise manner and the S-twist yarn wound up in counterclockwise fashion. Additionally, the yarn is wound along only a part of the bobbin (commonly called a filling wind) so as to leave part of the bobbin, e. g., one-quarter the length thereof, free of yarn. With such an arrangement, when the yarn is fed off the free end of the bobbin to the knitting machine, the torque present in the yarn causes it to turn in towards the tube and cleave to, or embrace, the free end of the bobbin. Accordingly, the torque which would normally cause kinking of the yarn at this point is utilized to effectively obviate this disadvantage.

By way of clarification, it might be pointed out that the statements in the foregoing paragraph, with respect to the direction in which the yarn is wound, are to some extent dependent on the direction from which the winding operation is viewed. It is obvious that a clockwise direction, when viewed from the top, will appear as a counterclockwise direction when viewed from the bottom. In the conventional knitting operation, the yarn is taken off from the top of the bobbin, and it is therefore convenient to view the winding and unwinding operation from the top, as we have done. However, it is apparent that the same result would be achieved by either of the following procedures:

(*a*) Winding the yarn in the same direction as the twist, where the bobbin is viewed from underneath, or

(*b*) Winding the yarn in the same direction as the twist, where the bobbin is viewed from the top, and then inverting the bobbin prior to unwinding.

The bobbin onto which the yarn is wound and fed to the knitting machine may be made of any material conventionally utilized. Preferably, however, the bobbin is of wood, or other material which permits a static field to bet set up between the bobbin and the yarn being withdrawn therefrom, including any one of a number of uniformly dense laminated thermo-setting plastics made with various types of filler materials such as cotton fabrics, papers, asbestos paper, asbestos cloth, woven fiber, glass cloth, nylon fabric, etc., all impregnated with phenolic or melanine resins and then laminated under heat and pressure, sold under the trademark "Synthane." In this way, adherence or cleavage of the yarn to the bobbin is facilitated.

As indicated, the process of the invention is particularly desirable for use in the production of sheer full-fashioned hosiery. It has been found in this connection that especially attractive results are obtained if one of the yarns is preset prior to twisting and the other yarn is not preset. It will be recognized, however, that both of the yarns may be preset or neither preset, to give desirable products. Generally speaking, if hosiery fabric is made using one yarn which has been preset before twisting and another which has simply been twisted without presetting the fabric possesses excellent elasticity (of the order of 150 to 250% elongation) and a clearly defined stitch or pattern. When using two unset yarns, the stretch characteristics of the resulting fabric are somewhat lower but the pattern is substantially the same as that obtained with only a single preset yarn. On the other hand, when both yarns are preset, the fabric obtained has elastic properties equivalent to the fabric containing the single preset yarn although the fabric is somewhat distorted, i. e., it has a crepy appearance.

For purposes of presetting, as discussed above, conventional techniques may be used. It is, however, preferred that no shrinkage of the yarn be permitted; otherwise, the yarn denier changes and results in a fabric of less desirable appearance. Accordingly, when the yarn is preset, it is preferably wound on rigid cylinders and exposed to steam at 230 to 260° F. for from 15 to 30 minutes. Hot water may also be used.

As for operating details, monofilament nylon yarn of any denier can be utilized although, as noted above, one of the principal advantages of the invention is that it makes possible for the first time stretchable hosiery of the finest sheer. Typically suitable yarn sizes are 10, 12, and 15 denier yarns which are the most readily available.

The amount of twist given to the yarn can be varied but should not be outside the range of 5 to 40 turns per inch. Preferably, the yarn is twisted sufficiently to have 10 to 20 turns per inch, and each yarn should be twisted to the same degree. Conventional twisting apparatus may be used to carry out this step.

After the yarns have been twisted and wound in the manner prescribed above, the desired fabric can be knitted using a full-fashioned hosiery knitting machine or like apparatus capable of alternately knitting one or more courses first with one yarn and then with the other. In the case of full-fashioned hosiery, no more than four consecutive courses of the same yarn should be knit, at least insofar as the leg portion of the stocking is concerned, since more than four such courses will form bands, i. e., areas of different shades in the stocking.

The welt of the stocking may take any form, i. e., it may be knit in the manner of the invention similar to the leg portion described above, or it may be made of multifilaments by the procedures described in Serial No. 342,709 and Serial No. 367,776. A conventional type welt using, for example, 40 denier yarn, may also be utilized or, if desired, an untwisted monofilament nylon yarn of the same or different denier or a multifilament yarn may be incorporated therein with alternate courses of oppositely twisted multifilament or monofilament yarn. Similarly, an untwisted nylon yarn of the same or different denier may be used to form the leg portion of the stocking. For example, a stocking may be made by alternately knitting two courses with 15 denier right twist monofilament nylon yarn having 20 turns per inch, 15 denier left twist monofilament nylon yarn having 20 turns per inch and a 15 denier untwisted monofilament nylon yarn.

After the stocking fabric has been knit, it must be relaxed by standing free from tension at room temperature for at least 2 to 6 hours, and preferably, 24 hours. This step permits the torque in the yarn to turn the stitch loops over on their edges into a relaxed position which gives a more or less washboard appearance to the fabric.

After relaxing, the fabric is partially set in the relaxed condition for the purpose of fixing the stitch formation in the relaxed position. This can be accomplished in any convenient manner, e. g., by placing the fabric in loose form in a steambox and exposing it to wet heat at 170 to 210° F. wet and 170 to 210° F. dry, relative humidity between 70 and 100% for from 15 to 60 minutes. Preferably wet heat at 188° F. wet, 205° F. dry, relative humidity 70% for 50 minutes is utilized. Thereafter the fabric can be scoured, dyed and boarded in conventional manner. In this connection, it will be recognized that, since the fabric is rather substantially contracted, it must be boarded on a proportionately smaller board than normally utilized; otherwise, most of the elasticity of the fabric is dissipated. As an illustration, a size 9½ woman's stocking normally measures 31" long and is boarded on a form of the same length. On the other hand, a stocking made according to the present invention and designed to fit a size 9½ might measure only 18–24 inches long and, as noted, should be finished on a board of that length and otherwise proportionately smaller in width, etc., since boarding on the conventional size boards would destroy the elasticity imparted.

The invention is illustrated by the following examples:

Example 1

This example is illustrative of the process where both yarns are preset.

15 denier monofilament nylon yarn was first preset without permitting shrinkage to occur by winding same onto a metal bobbin or cylinder capable of withstanding high steam temperature, and then the package of nylon yarn was placed in a retort and subjected to steam pressure of 25 pounds for at least 15 minutes. This presetting treatment insures against setting of the twist to be inserted by subsequent steam treatment of the yarn and retains the necessary torque in yarn to create the desired fabric as previously described. It should be noted that while presetting yarn on a rigid cylinder is the preferred method, satisfactory results can be attained by treating the yarn with steam or hot water in skein or cake formation so as to permit shrinkage.

After the presetting operation, a twist of 10 turns per inch is inserted into yarn to create the necessary torque to produce the flexible fabric, half the yarn being twisted in the S direction and the other half in the Z direction. The number of turns required is primarily dependent on size or denier of yarn and the degree of fabric stretch desired. Generally speaking, however, the 15 denier yarn of this example should be given from 5 to 10 turns.

After the twisting operation, the oppositely twisted yarns were wound onto a wooden bobbin for delivery to a full-fashioned hosiery knitting machine in the manner explained above. The bobbins used were both 10 inches long and had a diameter of 1⅜ inches. The yarn was wound onto the bobbins from the bottom thereof using a filling wind and a two inch traverse. Approximately 2 inches were left at the upper end of the bobbin to serve as the "cleavage" zone.

Hosiery fabric was knitted without kinking using two carrier systems, one for each yarn and alternating two courses of Z-twist yarn with two courses of S-twist yarn to form the leg portion of a full-fashioned stocking. The welt was formed with 40 d. multifilament yarn (15 turns) according to the process of Serial No. 342,709.

When the fabric was taken off the machine, it was permitted to relax under the conditions prevailing in the knitting plant (82° F. and relative humidity of 52%) for twenty-four hours. The torque in the yarn effected a turning over of the stitch loops to give a fabric having a washboard effect. After setting, seaming, scouring, dyeing and boarding, a stocking was obtained which had a somewhat crepy appearance but possessed excellent elasticity, of the order of 135% its unstretched length.

Example 2

The process of Example 1 was repeated except that neither of the yarns was preset. The resulting stocking possessed a clearly defined stitch and herringbone pattern with somewhat reduced elasticity, namely 120% of the original unstretched length.

Example 3

The process of Example 1 was repeated except that only the Z-twist yarn was preset. The resulting stocking demonstrated a clearly defined stitch and herringbone pattern, stretch characteristics in the neighborhood of 150% and was soft and otherwise highly desirable.

Example 4

The process of Example 3 was repeated except that, instead of a two carrier system using two ends, a three carrier system was used to knit a stocking fabric from three ends, in this order, preset Z-twist yarn, non-preset S-twist yarn and a neutral 15 denier nylon yarn (unset and untwisted). The resulting fabric possessed satisfactory elasticity, the herringbone pattern being broken up by the neutral yarn. Numerous other three end combinations can be knit in this way. Best results with the three carrier system appear to be obtained when both twisted yarns are preset and the neutral yarn is unset and untwisted. However, the most outstanding results are obtained using two ends.

The amount of the bobbin left free of yarn, i. e., the extent of the "cleavage" zone, at the take-off end necessary to avoid kinking of the yarn varies over a wide range and depends upon the various other operating factors, such as amount of twist or torque in the yarn, diameter, length and smoothness of the bobbin, length and depth of yarn wound thereon, length of the winding traverse, nature of the material from which the bobbin is made, distance the yarn must pass to reach the first guide of the knitting machine, vibration of the machine, static field differentials and package density. However, the extent of this zone can be readily ascertained for any given set of operating conditions. Generally speaking, however, it has been found that since the torque in a preset yarn is greater than an unset yarn for the same amount of twist, the preset yarn requires a greater "cleavage zone." Also, as the twist is increased in the yarn, a greater "cleavage zone" is required.

Additionally, it has been found that the yarn in its delivery must have a surface contact to base of package in a diagonal direction of at least ¼ of circumference of package to prevent kinking and not more than ¾ of circumference, as beyond this it either knits too tight a stitch, or extra tension will cause the yarn to break. The most desired surface contact is ⅓ of the diameter of package.

As to bobbin diameter, it is preferred to use the Du Pont pirn on which the raw nylon is received. This pirn is made of maple wood and has a diameter of 1⅜" by 10" long. For best results from this package, the yarn should be wound on package, starting 1½" from bottom and laying yarn on pirn by "filling wind" up to 2" from top of pirn, using a 2" taper traverse. The distance of 2" from top is the necessary "cleavage zone" in starting of delivery from bottom to prevent kinking. As the yarn is delivered from the bobbin and moves toward the bottom, there is naturally more surface contact with base of bobbin, but this is not sufficient to cause any undue shortage of stitch, or cause breaking of yarn in knitting head. Packages with less than 1" in diameter tend to give this trouble and should be avoided.

It has also been found that a bobbin base of ¾" requires only ⅝" distance from top to yarn for "cleavage zone," but then it must be started higher than 1½" from the bottom as the yarn gets too much surface friction delivering from such a small diameter. Base diameters in the range of from 1" to 1¾" are adequate, but greater or lesser diameters can also be used successfully.

A desired depth of yarn on bobbin is generally from ¼" to ½", but it is possible to knit from a package that is more or less than this range. A traverse length of between 1½" to 2" has been found desirable and the distance from the top of the bobbin to the first guide on knitting machines can range from 2" to 8", although the distance is not critical. The package density varies with the amount of tension used in transferring yarn to bobbin. Normally, a fairly dense package for pirn wind is desirable and a package of 80 density has been found satisfactory.

It will be appreciated that various modifications may be made in the invention, in addition to those described herein. For example, as an alternative to or supplementing the "cleavage zone," a loosely fitting collar, ring or the like may be placed over the top of the package. Such means assist in avoiding kinking of the yarn as it is withdrawn from between these means and the bobbin and fed to the knitting machine.

While the invention is of particular advantage in connection with the production of full-fashioned hosiery,

it will be appreciated that the invention is broadly applicable to the production of any type of knitted nylon fabrics where increased elasticity or fabric stretch is a desirable characteristic. Likewise, it is to be understood that the term "nylon," as used herein, refers to the well-known synthetic linear polyamides, as exemplified in U. S. Patent No. 2,157,116, issued May 9, 1939, to Wallace H. Carothers.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that this invention is not to be limited to the specific embodiments thereof, except as defined in the appended claims.

This application is a division of our co-pending application Serial No. 454,204, filed September 3, 1954.

We claim:

1. A process for producing knitted fabric of substantial stretchability, which comprises twisting a monofilament nylon yarn to the right to impart substantial liveliness to said yarn, twisting another monofilament nylon yarn to the left to impart substantial liveliness to said yarn, winding the right twisted yarn on a bobbin in a counterclockwise direction, winding the left twisted yarn on a bobbin in a clockwise direction, knitting said right and left twisted yarns in alternation to form a fabric, relaxing the fabric, and heating the relaxed fabric in the presence of moisture to set the fabric in relaxed condition.

2. The process of claim 1, wherein one of said yarns is preset before twisting.

3. The process of claim 1, wherein both of said yarns are preset before twisting.

4. The process of claim 1, wherein neither of said yarns is preset prior to twisting.

5. The process of claim 1, wherein each yarn is wound onto a portion of a bobbin, leaving a zone near the take-off end of said bobbin free of said yarn, whereby said yarn as it is unwound cleaves to said zone.

6. A process for producing knitted hosiery fabric of substantial stretchability, which comprises twisting a first nylon yarn to the right to impart substantial liveliness to said yarn, twisting a second nylon yarn to the left to impart substantial liveliness to said yarn, at least one of said yarns having been preset prior to twisting, winding the right twisted yarn on a bobbin in a counter-clockwise direction, winding the left twisted yarn on a bobbin in a clockwise direction, and knitting said right and left twisted yarns in alternation to form a fabric.

7. The process of claim 6, wherein said first nylon yarn is twisted from 5 to 40 turns per inch.

8. The process of claim 6, wherein the number of turns of twist in said second nylon yarn is equal to the number of turns of twist in said first nylon yarn.

9. The process of claim 6, in which not more than four courses are knit from said right twisted yarn in alternation with not more than four courses from said left twisted yarn.

10. The process of claim 6, comprising relaxing the knit hosiery fabric to release the torque therein, heating the relaxed fabric in the presence of moisture to set the fabric in relaxed condition.

11. A method for producing a sheer, substantially stretchable and retractable nylon fabric comprising presetting and subsequently twisting one nylon yarn to the left, presetting and subsequently twisting another nylon yarn to the right, to produce left and right twist yarns of permanent substantial liveliness such that the yarns will kink if not controlled, winding the right twisted yarn in a counter-clockwise direction to form a package, winding the left twisted yarn in a clockwise direction to form a package, and knitting said right and left twisted yarns in alternation to form a fabric.

12. A process for producing a sheer, substantially stretchable and retractable nylon fabric comprising imparting an S twist to one nylon yarn, imparting a Z twist to another nylon yarn, to produce oppositely twisted yarns of substantial liveliness such that the yarns will kink if not controlled, winding each of said yarns in a direction opposite to the direction of twist in said yarn, to prevent kinking when the yarns are unwound for knitting, and knitting said oppositely twisted yarns in alternation to form said fabric, relaxing the fabric, and heating the relaxed fabric in the presence of moisture to set the fabric in relaxed condition.

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