

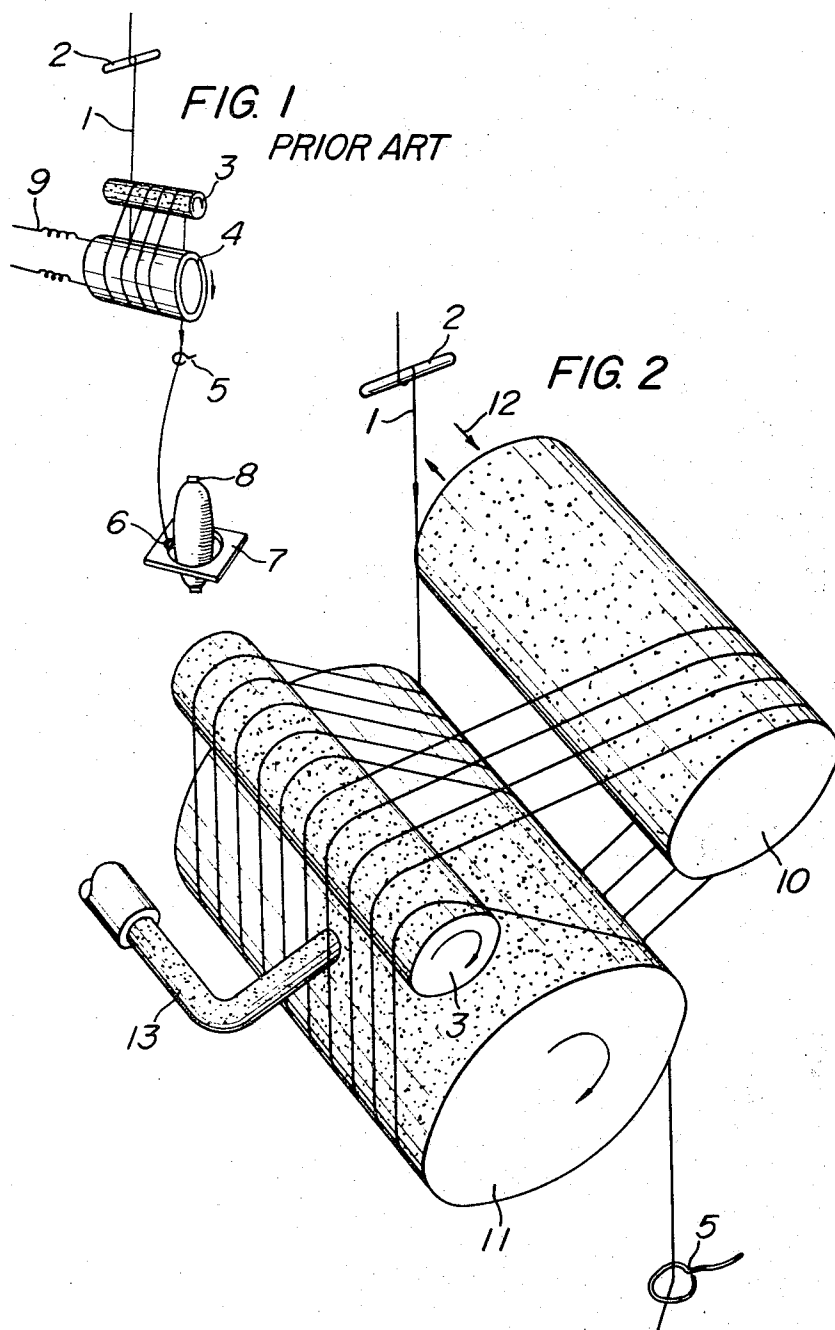
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NORBORU FUKUMA ET AL

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APPARATUS FOR HEAT-TREATING THERMO-PLASTIC SYNTHETIC FIBERS

Norboru Fukuma, Kazuo Jono, Toshihiko Kihara and Yuzo Midorikawa, Nobeoka-shi, Japan, assignors to Asahi Kasei Kogyo Kabushiki Kaisha, Kita-ku, Osaka, Japan, a corporation of Japan

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ABSTRACT OF THE DISCLOSURE

Apparatus for heat-treating thermoplastic synthetic fibers to improve the shrink characteristics thereof in which a traveling filamentary fiber is guidably advanced along a helical path in contact with the surface of a roller such that the fiber is cold stretched as it passes along a smooth surface portion of the roller, whereafter the thus stretched fiber is heat relaxed as it passes on a separate aventurine surface of the same roller.

This invention relates to methods and apparatus for continuously stretching and heat-treating filamentary thermoplastic synthetic fibers.

More particularly, the present invention relates to methods and apparatus for continuously stretching and heat-treating filamentary synthetic fibers, so as to improve their shrink characteristic by use of a combination of an unheated driven roll member with a heated nonrotating member, an unheated follower roll member and a separating guide rod.

Filamentary synthetic fibers are industrially produced by wet, dry and melt spinning processes and particularly such fibers as nylon, polyester and polypropylene fibers are largely produced by the melt spinning process. At the stage of spinning, these synthetic fibers are not satisfactorily oriented in their internal structure and must subsequently be stretched so as to be oriented to obtain satisfactory mechanical properties.

The stretching or drawing of such synthetic fibers is performed by passing them through two sets of rolls differing in speed under heated or unheated conditions. The yarns thus stretched are usually wound on a so-called draw twister machine, which winds the yarn as it is drawn from the stretching rolls while slightly twisting it by means of a ring and traveller, or alternatively on a so-called draw winder, which simply winds the yarn as it is drawn from the rolls.

In general, the synthetic fiber partly shrinks with substantial rapidity when released after it has been stretched. The yarn is wound on a bobbin while being allowed to shrink freely under a tension of the order of 0.15 gr./denier as measured at the outlet of the stretching roll. The yarn tension is controlled by adjustment of the weight of the traveller in the draw twister machine or by adjustment of the speed ratio between the stretching roll and the take-up bobbin and/or by adjusting the number of traverses of the yarn guide in the draw winder machine. On this occasion, the shrinkage obtained amounts to 3% or thereabout. That portion of the yarn which cannot shrink to any substantial extent before it is wound, that is, for which it takes a considerably long time to shrink, shrinks on the bobbin, after it has been wound thereon, increasing the hardness of the wound mass of yarn. Therefore, in the case where yarn is wound into a square-end

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form, the wound mass of yarn tends to deform beyond a certain radical thickness, because the intermediate layers in the wound mass bulge edgewise under the shrinking pressure of the outer layers successively wound thereon. To overcome this tendency, yarn is preferably wound into a taper-end form, but this involves economical disadvantages, for a taper-end winding makes the winding mechanism complicated and reduces the winding amount. In the case where yarn is wound on a bobbin to form a spindle-shaped "pirn," the yarn is usually subject to a shrinkage of 2% or thereabout when it is unwound and left free from tension at room temperature. The shrinkage, however, varies with the different pirn portions, radially as well as axially, and forms an unfavorable factor in the processing of nylon textile. In other words, it makes it difficult to obtain textile products of high quality, causing such defects as an undesirable pattern of stripes on the woven fabric, undulations along the selvages, and local strains of the fabric yarns. These defects are generally known as "pirn barré" and can be alleviated by employing a preparatory step of rewinding the pirn yarn under an extremely low tension to expedite its further shrinkage thereby to obtain a uniform total shrink. This, however, takes considerable time, constituting a serious disadvantage in the textile processing.

As apparent from the foregoing, the shrink characteristics of synthetic fibers cause various difficulties in their manufacture and processing and, in attempting to overcome such difficulties, the inventors have discovered the following facts.

In order to prevent any deformation of the square-end wound mass of yarn or to improve the shrink characteristic of the yarn to be processed into woven fabric, it is necessary to maintain the percent of retraction, i.e., the shrinkage of the unwound pirn yarn, held 24 hrs. free from tension at room temperature (20° C., 65% R.H.), at 0.5% or under. In this case, the percent of retraction is a value as measured 24 hours after the yarn has been stretched and is used as a functional parameter. Such percent of retraction is subject to change after stretching, gradually decreasing for about one week to a definite value. The extent of decrease is from approximately 0.2% to 1.0%, depending upon the processing to which the yarn is subjected after it has been stretched. Other characteristic values related to the percent of retraction include a shrinkage in boiling water. Lower values of such shrinkage do not always correspond to lower percentages of retraction, but yarns which exhibit a percent of retraction of 0.5% or under are always reduced in shrinkage in boiling water. Though reduction of shrinkage in boiling water can be obtained by a heat-stretching process or by heat treatment under tension after the cold-stretching process, reduction in percent of retraction to 0.5% or under, necessitates heat treatment of the stretched yarn in a relaxed state and its winding under tension of not more than 0.1 gr./denier. This heat-treating process has previously included electrical heating of the stretching roll.

Description will now be made with reference to the accompanying drawing, in which:

FIG. 1 is a fragmentary perspective view illustrating the conventional heat-treating method; and

FIG. 2 is a view similar to FIG. 1, illustrating the principles of the present invention.

In FIGS. 1 and 2 the axial dimensions of the respective members are elongated for the purpose of clearly showing the running state of the fiber, and the stippled portions are intended to depict aventurine surfaces on the respective rolls.

Referring to the accompanying drawing and first to FIG. 1, reference numeral 4 indicates a heated driven roll member in the form of a stretching roll 4 indirectly heated by electrical means 9 and used in combination with an unheated follower roll member taking the form of a separator roll 3 of approximately 20 mm. diameter having an aventurine surface. The yarn first proceeds to the stretching roll 4 over a stretching pin 2 while being stretched therebetween and is passed onto the stretching and separator rolls 4 and 3 for several windings in a manner such as not to overlap one another. The yarn thus heat-treated in a relaxed state further proceeds, in case of a draw twister machine, through a lappet guide 5 and a traveller 6 to be wound on a bobbin 8. Reference numeral 7 indicates a ring holder. In case of a draw winder machine, the heat-treated yarn proceeds also through a lappet guide 5 and then through a yarn guide, which oscillates laterally or fore and aft, to be wound on a bobbin.

In general, the heated type driven roll member has a structure including a stationary electrical heating element and a rotatable tubular roll body covering the heating element, this structure involves a number of deficiencies. Firstly, it is difficult to properly adjust the spacing between the heater and the tubular roll body, and temperature control of an indirect heating system is difficult. Any small variation in the spacing results in a widely differing surface temperature of the roll, making the structure disadvantageous from a practical viewpoint.

Secondly, this structure is disadvantageous in thermal efficiency since its rotation gives rise to air currents effective to cool the roll body.

Thirdly, measurement or detection of the surface temperature of the roll is troublesome, necessitating a rather complicated mechanism and cannot be made with any significant accuracy.

Fourthly, the machine specifications must be widely varied according to whether the stretching roll is heated or not. In other words, the stretching roll, if heated, must itself have a larger width because of requirement of the larger volume, and such machine components as a feed roll, spindle and traverse yarn guide must be different in position from those of a machine not employing a heated stretching roll. For this reason, it is often necessary to change the design of the entire machine. A further deficiency of this type of machine is its high cost.

The inventors have conducted intensive research to eliminate the above deficiencies and based thereon propose a novel method and apparatus for heat-treating filamentary thermoplastic synthetic fibers, as diagrammatically illustrated in FIG. 2.

Referring to FIG. 2, the present invention is designed to improve the shrink characteristics of such fibers by employing a combination of an unheated driven roll member 11 with a heated non-rotating member 10, an unheated follower roll member 3 and a separating guide rod 13.

The heated non-rotating member 10 is generally cylindrical in shape and, if required, may be elliptical or non-circular in cross section. The diameter of the cylindrical member may be of the order of 60 mm. and its width of the order of 40 mm. The surface of the cylindrical member is of aventurine finish and honed with carborundum to reduce its friction relative to the running yarn. The roughness of the cylindrical surface appropriately ranges from 1S to 12S and any excessively low roughness or excessive smoothness causes an excessive frictional resistance to the running yarn, which impairs yarn slippage making it impossible to treat the yarn in its relaxed state. Any excessively high roughness, on the other hand, involves the danger of yarn breakage. For the surface material of the cylindrical member, hard chromium plating is recommendable. The roughness represented above in S units corresponds to the height, expressed in μ units, of the raised portions of the aventurine surface rel-

ative to its depressed portions i.e. S is a measure of its unevenness or roughness. The roughness of the aventurine finish on the surfaces of the rolls and the coefficient of friction of the fiber on such surfaces are in a unique relation, in which the coefficient of friction of the fiber becomes smallest with a certain roughness of the surfaces. In the present invention, the roughness of the aventurine-finished surfaces is from 1 to 12S and the coefficient of friction of the surfaces is smaller than that of a polished mirror surface, although the roughness of the former is greater than the latter. When the roughness exceeds 12S, the frictional force increases sharply, resulting in breakage of the filament. The nonrotatable member is arranged so that a heating medium such as saturated steam or Dowtherm can flow directly into its interior, as indicated at 12. Alternatively, an electrical heating element may be inserted into the nonrotatable member. Taking account of the heat consumption due to the yarn travel over the member, however, saturated steam or Dowtherm, having a larger heat capacity, is preferred to the electrical heating, which is limited in heat capacity. The surface temperature of the nonrotating member is in the range of from 100° C. to 190° C., depending upon the kind of travelling yarn.

Another feature of the present invention is the construction of the unheated driven roll member, which is in the form of an ordinary stretching roll with a diameter of 90-130 mm. and a length L of 50-60 mm., having a portion A with a mirror finish to a roughness of 0.5 S or under, and a portion B extending over a distance of approximately 25 mm. from the roll end, of aventurine finish with a roughness of from 1S to 12S. Such a division of the surface of the unheated driven roll member into two portions differing in roughness has an important significance in the present invention. That is, the yarn passing over the driven roll member is first stretched to the desired denier while it travels over the highly frictional mirror-finished portion of the roll surface without any slippage relative thereto and is then shifted onto the much less frictional aventurine surface portion. It will be apparent that the thus stretched yarn proceeds over the aventurine surface portion slipping relative thereto and in this manner is heat-treated in a fully relaxed state.

If the unheated driven roll member had a yarn-engaging surface entirely mirror-finished, it would be impossible to heat-treat the yarn in its relaxed state and the yarn separation from the member would be neither free nor smooth. Contrariwise, if the roll surface is made entirely aventurine, the slippage of yarn would be excessive, making it impossible to obtain a yarn of the desired denier.

Next, the unheated follower roll member 3 has an aventurine surface of a roughness of from 1S to 12S, its diameter is about 20 mm. and its length is 50-60 mm. These three members, i.e. the heated nonrotating member 10, the unheated driven roll member and the unheated follower roll member 3 are arranged more or less out of parallel with each other so that the yarn may pass for several windings onto these members. In general, the distance of the centers of the unheated driven roll and the unheated follower roll is 80-110 mm. For such arrangement, any ordinary existing draw twister machine or draw winder machine can be readily converted by simply arranging the heated nonrotating member in appropriate position to enable practice of the method of the present invention.

The separating guide rod 13 constitutes another feature of the present invention, and functions as follows:

When the yarn passes onto the unheated driven roll member 11 for many windings, the travelling yarn tends at all times to irregularly oscillate axially along the roll surface. This tendency is intensified as the stretching conditions are varied toward higher speeds. With the driven roll member, having a yarn engaging surface divided into two portions differing in roughness as described herein-

before, the yarn travelling on the surface ordinarily frequently traverses across the boundary between the mirror-finished and the aventurine surface portions, which exhibit different frictional resistances to the yarn. As a result, the movement of the travelling yarn is disturbed, and causes many troubles including "loose yarn" and breakage of yarn or its filament. This difficulty can be avoided by the provision of a separating guide rod according to the invention, which serves to separate the travelling yarn from the roll surface along the boundary between its mirror-finished and aventurine portions. The guide rod can also be mounted in position with ease and has a diameter of from 2 to 8 mm. The rod may be made of metal or ceramic and should have a surface roughness of from 1S to 12S from the viewpoint of frictional resistance and yarn breakage.

The present invention will next be described in detail with reference to FIG. 2.

The travelling yarn 1 is stretched to from 2.5 to 5.5 times its initial length between the stretching pin 2 and unheated driven roll member 11 and is then passed for two to five turns onto the mirror-finished portion of the latter and the unheated follower roll member 3. Subsequently, the yarn runs past the separating guide rod member 13 onto the aventurine surface of the unheated driven roll member 11 and is then passed for two to five turns onto the combined roll assembly including the heated nonrotating member 10. Finally the yarn leaving the unheated follower roll member 3 proceeds on unheated driven roll member 11 to the lappet guide 5 to be stored in a desired form on an appropriate bobbin. The tension of the travelling yarn between the unheated driven roll member 11 and lappet guide 5 is adjusted to the order of 0.05 gr./denier. The manner in which the yarn is passed onto the four members may be modified in various ways to give different physical properties to the yarn. For example, the yarn may be heat-set under tension by passing the yarn from the mirror-finished portion of the unheated driven roll member 11 to the heated nonrotating member 10 and next from the heated nonrotating member 10 to the mirror-finished portion of the unheated driven roll member 11, and then may be heat-treated under relaxed condition between the aventurine portion of the unheated driven roll member 11 and the heated nonrotating member 10. Also, the final passage of the yarn over the unheated follower roll member 3 may be omitted to properly control the tension under which the yarn is wound on a bobbin.

The present invention has, among others, the following advantages: Firstly, it is very easy to control the surface temperature of the nonrotating member 10. Secondly, the member 10 is not cooled by any air currents because of its nonrotating character and it has a high thermal efficiency. Thirdly, the surface temperature can be measured with accuracy and ease. Fourthly, the heated nonrotating member 10 and the separating guide rod 13 can be mounted with ease on any ordinary existing draw twister machine and draw winder machine. Finally, the apparatus can be produced with reduced cost because of its simple construction.

A few practical examples of the present invention will now be described. It is to be understood that we do not wish to be limited to the details set forth but the invention is of the full scope of the appended claims.

Example 1

Unstretched polycaprolactam fiber was cold-stretched on a draw twister machine at a stretching speed of 600 meters per minute to 3.5 times its initial length by way of stretching pin 2, as illustrated in FIG. 2. The stretched yarn of 70 deniers including 24 filaments was passed for three turns onto the mirror-finished portion (surface roughness: 0.5S) of the unheated driven roll member 11 and unheated follower roll member 3 (surface roughness: 2S), and then shifted by way of the separating guide

rod member 13 of 5 mm. diameter and 1.5S surface roughness onto the aventurine surface (of 5S roughness) of the unheated driven roll member 11 to be passed for three turns onto the latter and the unheated cylindrical nonrotating member 10 (surface roughness: 5S), which had a diameter of 50 mm. and was heated to 140° C. with steam. The yarn was finally passed for one turn onto the unheated driven roll member 11 and the unheated follower roll member 3 and, leaving the unheated driven roll member 11, proceeded through lappet guide 5 and a traveller to be wound on a bobbin. The yarn tension between the unheated driven roll member 11 and the lappet guide 5 was controlled to 0.05 gr./denier. The percent of retraction of the yarn treated in this manner was 0.2% compared with 2.0% retraction of the yarn when it was wound conventionally under tension of 0.05 gr./denier as measured ahead of the lappet guide 5. This means that the use of the heated nonrotating member 10 reduces the retraction by 90%.

The yarn obtained by the above process was used as a weft and the resulting woven fabric exhibited excellent qualities involving no undulations along the selvages and a pattern of stripes on the woven fabric.

In the case where the yarn was treated without use of the separating guide rod member 13, yarn breakage took place so frequently that the yarn could hardly be taken up.

Example 2

Unstretched polycaprolactam fiber was hot-stretched on a draw winder machine at a stretching speed of 600 meters per minute to four times its initial length in the same manner as in Example 1. The stretched yarn of 210 deniers including 15 filaments was heat-treated as in Example 1, led through the lappet guide 5 and through a yarn guide, which traverses laterally over a width of 140 mm., and wound on a Bakelite bobbin of 150 mm. width, which was of the surface drive type. The traversing rate was 80 times per minute; the ratio R of peripheral speeds of the unheated driven roll member 11 and the bobbin was 0.922; and the yarn tension ahead of the lappet guide 5 was set at 0.05 gr./denier. The yarn could be wound square-end form on the bobbin to form a 10-kg. package, which was of 140 mm. width, 370 mm. in outer diameter and had a specific gravity of 0.8. The percent of retraction of this yarn was 0.3%.

Without use of the separator guide rod member 13, yarn breakage occurred so frequently that it was almost impossible to wind the yarn. In the conventional process, when R was reduced with the intention of adjusting the yarn tension ahead of the lappet guide 5 to 0.05 gr./denier, the yarn loosened so that it could not be wound. With R of 0.945, the yarn tension was lowered to the order of 0.15 gr./denier and the yarn package on the bobbin collapsed when its weight reached about 2 kg. In addition, the Bakelite bobbin was so tightly bound that it could be withdrawn from the bobbin chuck only with great difficulty. The percent of the yarn in this case was 2.0%.

What is claimed is:

1. Apparatus for heat-treating thermoplastic synthetic fibers to improve the shrink characteristics thereof, said apparatus comprising a cylindrical non-rotatable member having an aventurine surface, means for heating said cylindrical non-rotatable member, a rotatable follower roll having an aventurine surface, a rotatable stretching roll including two adjacent cylindrical portions one having a smooth surface with a roughness less than 0.55 and the other an aventurine surface with a roughness between 1S and 12S, means for guidably passing several turns of a synthetic fiber around the surfaces of the rolls and the non-rotatable member such that the fiber first passes on one of said portions of the stretching roll and then on the other of the portions of the stretching roll, and a separating guide rod cooperating with the surface of the stretching roll to restrict the turns of the fiber to the respective surfaces of said two adjacent portions.

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2. Apparatus as claimed in claim 1, wherein said surfaces of said adjacent portions each occupies about half of the axial length of the stretching roll.

3. Apparatus as claimed in claim 2, wherein the guide rod is positioned at the juncture between said adjacent portions to separate several turns of the fiber which are passed around the stretching roll and follower roll and several turns of the fiber passing around the stretching roll and non-rotatable member.

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JULIUS FROME, *Primary Examiner.*

10 HERBERT MINTZ, *Assistant Examiner.*

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