United States Patent

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[54] **PROCESS FOR WINDING POLYAMIDE YARN PACKAGES WITH TAPERED END-PORTIONS**
2 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** 57/157, 57/55.5, 57/94, 242/26.2
[51] **Int. Cl.** **D01h 1/36**, B65h 54/36
[50] **Field of Search** ..... 57/34 HS, 55.5, 157, 156, 157 S, 93—98; 28/71.3; 242/159, 26.1—26.4

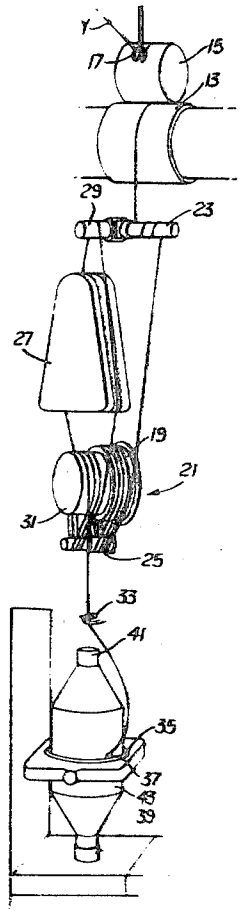
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ABSTRACT: A method of producing low barré heat relaxed polyamide yarn packages with long-to-short build by means of a programmed central feed which maintains a constant traveler speed and correspondingly reduces the balloon tension.



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SHEET 1 OF 2

FIG. Ia

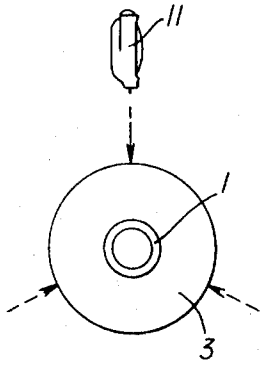
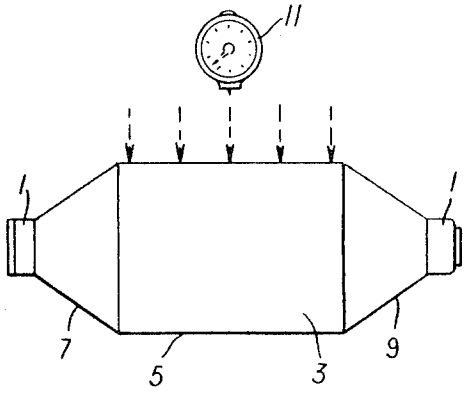


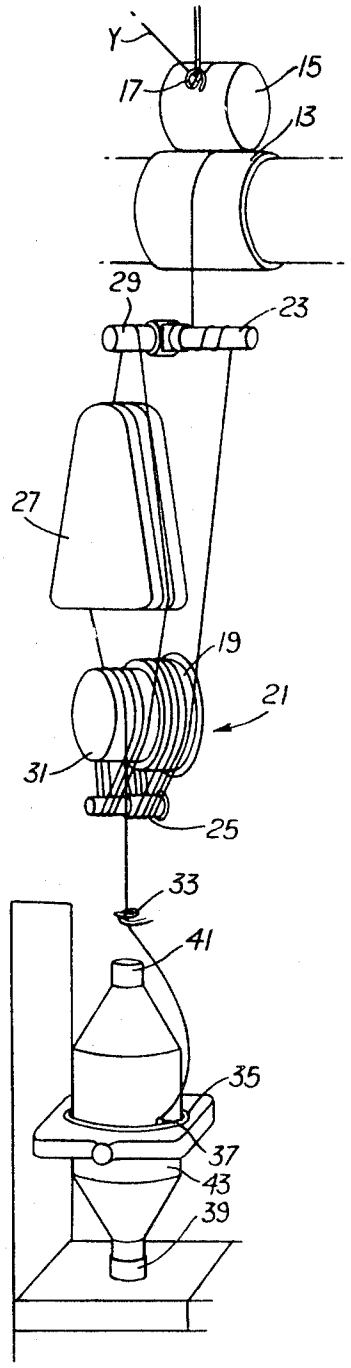
FIG. Ib



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Fig. 2.



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PROCESS FOR WINDING POLYAMIDE YARN PACKAGES WITH TAPERED END-PORTIONS

This is a division of Ser. No. 648,685, filed June 26, 1967, now U.S. Letters Pat. No. 3,450,371.

The invention is concerned with improvements in or relating to polyamide yarn packages with tapered end portions and their production.

Polyamide yarn packages wound over end on, e.g. a ring spindle windup of a draw-twist machine are known to be prone to give rise to the phenomenon of barré in fabric woven from the yarn as weft.

This phenomenon can take several forms, all comprising bars or stripes and being of a pattern dependent on the frequency of the regular variation in physical characteristics of the yarn in short lengths thereof.

For the lessening of the latent propensity in yarn towards barré and for other reasons, it is known to induce linear contraction of the yarn by heating it after drawing but prior to winding. Such a hot-relaxing treatment reduces the residual shrinkage of the yarn, upon which the intensity of barré is at least in part dependent.

Greater economy of operation both for the yarn producer and his customer, resides in the production of the highest weight of yarn in a package of given container (i.e. bobbin, tube or other type of former) dimensions, provided that other conditions of production are not prejudiced thereby.

A strategem that is widely employed to improve the stability, as well as the yarn takeoff characteristics, of polyamide yarn packages wound over end on a draw-twist machine is that of tilting the axis of the ring with respect to the axis of the spindle, to induce a high speed variation in the angle of lay of the yarn on the package, the coils of yarn thus being laid with a wavy motion.

Such winding with ring tilt, e.g. of an angle of 3°, does indeed improve the stability of polyamide yarn packages from all kinds of yarn up to a certain weight of yarn per length of container; but difficulty, due to sloughing of coils on the tapered end portions of the package may occur after winding a certain weight of hot-relaxed yarn, due mainly to the low tension of winding combined with the occurrence of regions of patterning in the lay of the yarn, i.e. regions where adjacent coils exactly interfere as to lay.

Whilst it is possible by various means to overcome or obviate such patterning, these means are generally undesirable, for instance when seeking to wind a polyamide yarn package having a low propensity to barré, when short term variations in the winding conditions are not easily tolerable.

A difficulty that has been experienced heretofore, therefore, lies in the production of stable large weight packages of heat-relaxed polyamide yarn, which yarn on withdrawal from the package has a low propensity to barré.

It has now been found that, in addition to the yarn having to be iow low residual shrinkage, it is necessary so to control the conditions of winding that the package has not only substantially uniform hardness along the several strata thereof, but also certain maxima for the hardness at the outside of the package and at the level of winding inside the package where the propensity to barré is greatest.

Accordingly the invention comprises a polyamide yarn package, whose yarn on withdrawal from the package has a low residual shrinkage and a low propensity to barré as hereinafter defined, said package consisting of successive and at least substantially parallel layers of coils of yarn wound on a tube or other solid former in a build having tapered end portions, the hardness of the package decreasing from inside to outside thereof and being substantially uniform as measured along the axial length of any of said layers and having a value at the outside of the package of not greater than 65° on the Shore 'A' Scale, and a value at one third of the full weight of the package of not greater than 80° on said scale.

By "substantially uniform" we mean within ±3° on the Shore 'A' scale.

Such a polyamide yarn package can with stability contain a greater weight of barré free yarn, per length of the longest layer of coils of yarn wound, compared with known packages of such yarn. In other words, a greater thickness of yarn package can be wound. As exemplary of the improvement, in one yarn package a stable package of 3.2 inches yarn thickness is possible according to the invention; whereas only 1.7 inches thickness could be tolerated according to known techniques without the introduction of winding faults conductive to instability and/or to barré inducement. By a "low residual" we mean that the residual shrinkage is of the order of half that of normal polyamide yarn of the same type, e.g. 7—8 percent compared with 12—13 percent.

By "low propensity to barré," we mean that in a fabric woven from the yarn as weft no barré is discernable to the human eye. It should be remarked that, whereas the state of the yarn as unwound from the package is basically important to such barré freedom, it is possible for a latent barré propensity to be introduced subsequently, during the various manipulations of the yarn between its unwinding from the package and its appearance in the fabric.

Hence, if a fabric is found to be barré free, it can be said with certainty that the yarn in the package had no, or a low, latent propensity to barré; whereas a yarn tested for barré propensity on withdrawal from the package, for instance by apparatus continuously measuring tension at constant extension e.g. of 4 percent, and found to have characteristics of low barré propensity, may nevertheless be responsible for the appearance of barré in the fabric owing to improper manipulation, e.g. at pirning or during weaving, at a subsequent stage.

Uniformity of hardness of the package along any given layer thereof is important so as not to allow any taper-to-barrel differential to arise such as might cause barré. The specified hardness gradient from the outside to the middle yarn layers is required because of the need, now appreciated, for the outer layers to be so loosely wound as not to compress the middle layers to as great an extent as the middle layers themselves compress the inner layers. The propensity to barré is partly dependent on the extent to which the yarn in the barrel (i.e. cylindrical) portion of the package is constrained and is able to contract linearly whilst in the packages. If the contraction taking place on the package is high in the barrel portion of any given layer, then the differential between that contraction and the contraction in the tapers will be likely to be large; and such differential is a cause of barré. Whereas the inner layers are not disposed to contract very much due to the unyielding nature of the tube on which they are wound, they are, despite the substantially relaxed nature of the hot-relaxed yarn, constrained to contract a certain amount by the compression of the layers wound on top of them in the middle of the package; but contrarily, the middle layers are disposed to contract a substantial amount due to the yielding nature of the underlayers on which they are wound, as indeed are the outer layers, and consequently it is not desirable that the middle layers should also be compressed to any great extent by the outer layers, as that would mean that they would have a too great linear contraction.

The outer layers, not being themselves compressed but being wound on yielding underlayers, will be disposed to contract quite readily, i.e. to the same extent as the inner layers are forced to by compression, and to the same extent as the middle layers, according to the invention, are disposed to and are forced to by virtue of the layers inside and outside of them.

The invention, therefore, in regard to the feature of package hardness, evinces a proper balance throughout the package; and ensure that, at the most sensitive portion of the package so far as barré propensity is concerned, which occurs after about one third of the full weight of yarn has been wound, the hardness shall not exceed the relatively "soft" value of 80°.

The uniformity of package hardness as measured along any given layer can be achieved by winding with, for instance, a long-to-short build, i.e. a package build in which the initial traverse stroke is the longest one, and the final traverse stroke

is the shortest one, in the package, the length of the stroke gradually decreasing by the moving inwardly of the end-reversal points at both ends of the stroke. Such a build may have either a constant-time, or a constant-velocity, traverse motion; and, if desired, a low degree of conicity may be afforded to the barrel portion of the build by accelerating the traverse in its upward travel and decelerating it during its downward travel. Normally, however, the barrel portion of the build will be formed parallel to the tube surface, whether the tube be right cylindrical, as usual, or slightly conical, in shape.

Preferably, in order to achieve the highest volumetric efficiency i.e. the greatest weight of yarn per length of package, the lay of the coils of yarn should not deviate by more than, say½° either side of a straight helix. This is surprising, in view of the generally accepted stratagem of winding with ring tilt in order to provide the coils with a slightly wavy lay, inter alia to improve stability of the lower tapered end portion of the package. In accordance with the invention, however, the polyamide yarn package of the invention should preferably not be wound with deliberately induced ring tilt, whereby the coils of yarn in any given layer are substantially parallel to each other. In practice, this means that the rings should be set at least to within ±½° of the horizontal (or perpendicular to the spindle).

The specified through package hardness characteristics of the polyamide yarn package of the invention can be brought about by so "programming" the winding conditions that the yarn is wound with a gradually decreasing tension from the start to the finish of winding.

Normally, such "programming" will be applied by e.g. a cam to the spindle drive, to cause the spindle to be rotated at an appropriately decreasing rotational speed during the full period of winding.

Equipment so to program the spindle speed is now available from a number of sources: for instance, the Rieter hydraulic draw-twister can be fitted with a Kopp variator unit fed from the main drive motor, or be fitted with a separate DC motor for the the spindle drive controlled by a "Varimag" controller. In either case, a "program," on card or from a cam, is fed into the variator unit where it is compared with signals fed from a tachometer, e.g. a tachogenerator connected to the shaft of the DC motor. Equally, the Zinser draw twister is fitted with plastic card programming of a servomotor controlling a separate motor for the spindle drive.

Preferably, the startup and slowdown periods of a machine's running time are themselves programmed, to take account of the low momentum of the draw rolls compared with that of the spindles with tubes mounted thereon, and hence to compensate for the different times which the several parts of a drawtwisting machine take to run up to speed, or slowdown to a stop, so as to cause them to reach running speed, or become stationary, as the case may be, sufficiently simultaneously so as to avoid breaks in, or looping of, the yarn respectively.

Preferably, also, the draw rolls are driven through a slipping clutch, so as further to guard against the occurrence of breaks during the startup period (which only extends over some 10—20 seconds), due to too high acceleration of the draw rolls.

Basically, the reasons why the polyamide yarn packages of the invention are able to contain a greater weight of yarn than those previously wound with ring tilt are, firstly, the surprising discovery that a significantly higher taper angle can be tolerated, e.g. for 60 denier up to 30° compared with 22°, especially under conditions of substantially zero ring tilt, and secondly the fact that stability can further be enhanced for certain deniers, at least under the specified conditions of winding as to package hardness, by the use of heavier travellers on the ring than normally can be tolerated in the production of heat-relaxed yarns.

The polyamide yarn packages according to the invention may be wound by a process according to another aspect of the invention, in which process undrawn polyamide yarn whether in monofilament or multifilament form, is drawn, the drawn yarn is immediately heat-relaxed, and the drawn heat-relaxed yarn is wound into a package by a ring-spindle windup in such manner that the speed of rotation of the traveller is substantially constant throughout the period of winding and with a build whose traverse stroke decreases gradually in length from inside to outside of the package.

Preferably, the relative dispositions of the respective parts of the apparatus are such that the plane of the traveller ring is within ±½° of the perpendicular to the spindle.

The achievement of constant or at least substantially constant traveller speed can be effected by a "programmed" reduction in the spindle speed throughout the period of winding; and the necessary effect of this "program" is a gradual reduction in the balloon tension, whereby the prescribed hardness gradient in the package is brought about. The tension reduces, for instance, when winding 60 denier/20 filament yarn from 0.1 grams per denier at the start of winding to 0.04 grams per denier at the finish; and from 0.08 g.p.d. to 0.04 g.p.d. when winding 205 denier/34 filament yarn.

Since the traveller speed is constant, the profile of the cam controlling the spindle speed reduction is a function only of the rate of change of diameter as he package grow, and hence for a given build shape the same theoretical cam profile can be used for all deniers and speeds. However, it is sometimes more convenient to use, say, one cam for speeds lower than a certain median winding speed and another, with ordinates a multiple (e.g. twice) those of the former, for speeds higher than the median speed. This is because, at the higher winding speed, a greater range of spindle speed variation is required; and the control arrangements of the machine are more readily able to cope with both the lesser and the greater ranges of variation of spindle speed, without the need for electrical adjustment, by using the two different cams.

The invention will now be described with reference to the accompanying drawings, of which

FIG. 1*a* is a diagrammatic end view, and

FIG. 1*b* is a diagrammatic side view, of a polyamide yarn package according to the invention, showing also the location of the hardness test points; and

FIG. 2 is a diagrammatic representation of the drawing and windup instrumentalities of a drawtwister for carrying out the process of the invention and for producing a polyamide yarn package according to the invention.

In FIGS. 1*a* and 1*b*, reference numeral 1 is the tube or container on which the package 3 is wound with a double-tapered build having a cylindrical or barrel portion 5 and tapered end portions 7, 9. Shown situated immediately above the middle of the package is a Bareiss "Exacta" hardness tester 11. The arrows in the two figures show the location of the 15 test points for testing hardness with this hardness tester, at three points spaced 120° around the circumference at each of five axially spaced locations.

The "Exacta" tester complies with the requirements of British Standard 903, A.S.T.M. D.676 and DIN.53505 (German); and the measured values are thus equivalent to those obtainable with a Wallace hardness meter. All measurements were made by the same operator in order to minimize load variability, which is estimated to lead to a maximum difference in hardness values of approximately 3° (Shore 'A') if different operators are called upon to take measurements on the same given package.

As hardness is also marginally time dependent, all packages were tested, and stripped and tested, within 1—2 hours of being wound, as to be described hereinafter.

In FIG. 2, feed roll 13 and nip roll 15 serve to feed the yarn, without slippage, to the drawing zone of the drawtwister. The yarn Y is wrapped once around nip roll 15, by means of pigtail guide 17, before proceeding through the nip of rolls 13, 15.

The yarn is then drawn by passage around the larger diameter portion 19 of stepped draw roll 21, which portion has a peripheral speed greater than that of feed roll 13 by an amount equivalent to the desired draw ratio. Drawing is localized by snubbing pin 23, around which the yarn is wrapped with two turns.

The yarn passes several times around portion **19** of draw roll **21** and the equivalent portion of stepped separator roll **25** before passing upwardly in contact with one side of pyramid heater **27**, around separator roll **29** therefor, and thence downwardly in contact with the other side of the heater, then to be wrapped around the smaller diameter portion **31** of the draw roll, and the equivalent portion of the separator roll **25**.

The ring spindle windup comprises balloon guide **33**, traversing ring **35**, traveller **37** thereon and rotatable spindle **39** on which the bobbin **41** is mounted for rotation therewith. The package of yarn **43** is wound thereon in a double-taper build of drawn, heat-relaxed yarn.

The ring **35** is subjected to a reciprocating motion by traverse control means (not shown) such as to produce a long to short build; and the spindle **39** is rotated at a gradually reducing rotational speed in accordance with a "program" to maintain the traveller speed constant, by "programming" means (not shown).

By way of exemplification of the invention, there will now be described two specific drawing and twisting processes producing polyamide yarn packages according to the invention.

EXAMPLE I

20-filament undrawn yarn of polyhexamethylene adipamide (undrawn denier 173) in the form of a cake wound on a spinning cylinder was used as the supply yarn for drawing and twisting to 0.25 Z-twist (nominal) on a Rieter I 5/5 hydraulic drawtwister fitted with a heat-relaxing hotplate positioned between the drawroll and the ring spindle windup.

The undrawn yarn was drawn at a draw ratio of 3.09 and at a drawing speed of 2650 feet/minute, to produce a product of 60 denier.

The hotplate was heated to 150° C. to heat wraps of the yarn whilst it was allowed to contract by 8 percent between the draw roll and a reduced diameter portion thereof.

The drawn and heat-relaxed yarn was twisted and wound up by the ring spindle wind-up apparatus on a cylindrical tube of 14½ in. length and 1.8 in. diameter. The package build was a long-to-short build, initial traverse length 12¼ in. traverse rate 0.5 in./sec., leading to a package of 4 lb. weight of yarn, with taper angles at top and bottom of 26°.

The traveller ring was set to within ±½° of the perpendicular to the spindle, and the traveller (No. 25 Nylon type A.R. 13 steel) speed was maintained constant at 3,000 r.p.m. during the whole period of winding, by a reduction in the spindle speed from 8,182 r.p.m. at the start to 4,928 r.p.m. at the finish of winding (running time 365 minutes).

The startup and slowdown sequences of the machine were also programmed; and the draw roll was fitted with a slipping clutch to offset the high acceleration effect.

The mean hardness at full weight varied between 61.5°, and 63.7° along the outer layer; and between 76.2° and 78.4° along the layer when stripped to 1½ lb. weight.

EXAMPLE II

A supply of yarn of 34 filament undrawn yarn of polyhexamethylene adipamide (undrawn denier 835) was drawn to a denier of 205 (draw ratio 4.36) and wound into a 4 lb. package of drawn, heat-relaxed yarn.

The apparatus was similar to that described in example I; and the conditions of drawing, heat-relaxing and winding were the same, with the exception of the following:

Drawing speed	1,100 feet/min.
Initial spindle speed	6,150 r.p.m.
Final spindle speed	4,810 r.p.m.
Traverse rate	0.4 in./sec.
Running time	256 min.
Traveller	No. 20 Nylon type A.R. 13 steel

The mean hardness at full weight varied between 60.8° and 61.3° along the outer layer; and between 72.0° and 74.3° along the layer when stripped to 1½ lb. weight.

The polyamide yarn packages of both the above exemplary processes were stable, despite being "soft"; and fabric woven from these yarns as weft was classed as free from barre defects of any kind.

In tests carried out on the hardness of polyamide yarn packages of hot-relaxed 60 denier and 205 denier respectively, a total of 18 packages wound according to the invention was tested at full weight and after each step of stripping by steps of ½ lb. weight, the packages varying only as to the weight of traveller used in the windup, whereby the hardness of the package was varied due to the difference in winding tension.

An analysis of the results showed conclusively that, despite "end" effects, the hardness was substantially uniform (i.e. within ±3°) along the layers at the various levels of stripping; and that all fabrics made from yarn wound off on to pirns when the packages had been stripped to the critical level of 1½ lb. weight could be classified as acceptable only when the outside value of hardness did not exceed 65° and the value at 1½ lb. did not exceed 80°.

For instance, with the 205 denier yarn, fabric was unacceptable if the traveller weight was such as to lead to a mean hardness at full weight of 77° and a mean hardness at 1½ lb. of 88.5°.

Likewise, with the 60 denier yarn, fabric was unacceptable if the hardness was 72° at full weight and 86° at 1½ lb.

The above are merely instances of comprehensive tests indicating a direct correlation between the respective prescribed maximum hardness values and the fabric's acceptability for barré.

In addition to its usefulness in the weft of woven fabrics, however, yarn from the polyamide yarn packages of the invention is useful also in the warps of woven and warp-knitted fabrics.

I claim:

1. In a process for producing a package of polyamide yarn, the yarn of which does not exhibit pirn taper barré when woven into fabrics, and wherein the yarn is freshly drawn, immediately relaxed and then wound into a long-to-short package by means of a ring-traveller-spindle windup, the improvement which comprises tilting the ring at most ½° from the perpendicular to the spindle; decreasing the hardness of said package from the inside to the outside of the package during the winding operation while maintaining a constant hardness along a given axial length of packages yarn and regulating said hardness gradient to obtain a mean value at the outside of the full package of not greater than 65° on the Shore A scale and a mean value at one-third of the full weight of the package of not greater than 80° on said scale.

2. The process of claim 1 wherein said gradient is obtained by gradually reducing the balloon tension on the yarn during the winding cycle by maintaining a constant traveller speed coupled with a decreasing spindle speed during the winding operation.