United States Patent

Jennings

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[54] PROCESS FOR WINDING A YARN PACKAGE

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[52] **U.S. Cl.** **242/18.1**

[51] **Int. Cl.** **B65h 54/38**

[58] **Field of Search** ..... 242/18, 18 SC, 18 DD, 18.1, 242/43, 43.1, 159, 174; 57/94

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[57] **ABSTRACT**

A process for winding yarn into a cylindrical-bodied substantially straight-ended package wherein the yarn is traverse wound in layers of helical coils on a bobbin and the helix angles of the coils are cyclically varied from a minimum to a maximum and back to a minimum value during a spaced periodic excursion by periodically increasing the traverse rate to a value above that used for ribbon breaking. The maximum value of the helix angle in the excursion is greater than the maximum positive value used in the ribbon-breaking portion of the cycle. Thread line tension variations due to these wide variations in helix angles may be compensated for by periodically decreasing the rate of peripheral package winding speed coincidently with and proportional to the periodic increases in traverse rate.

1 Claims, 12 Drawing Figures

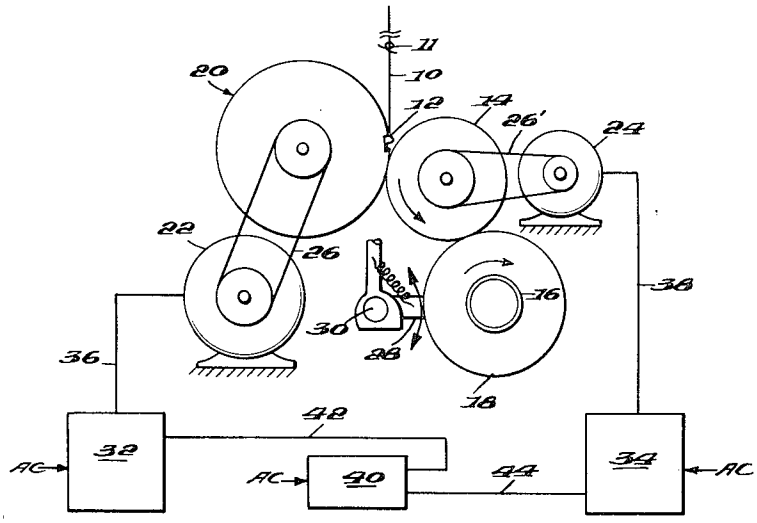


Fig. 1.

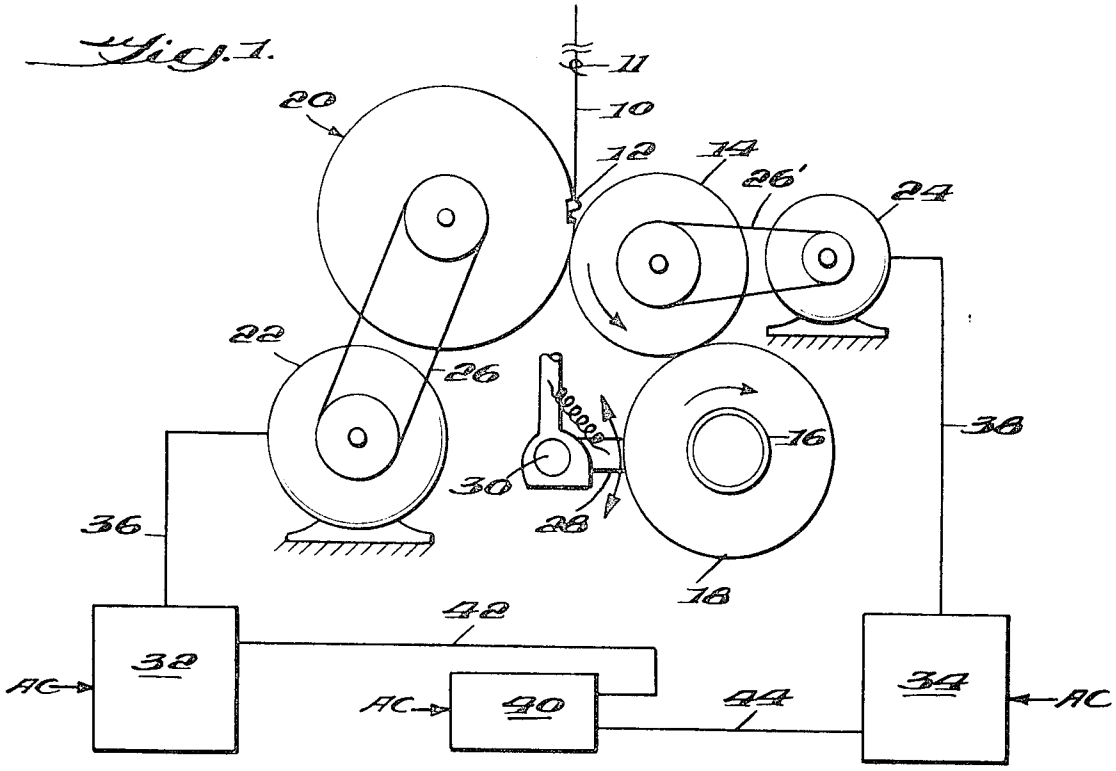


Fig. 2.

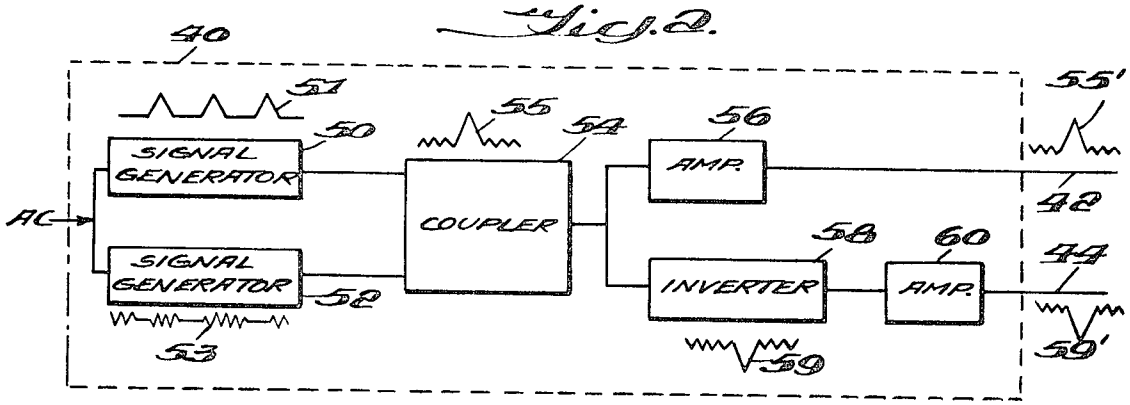


Fig. 4.

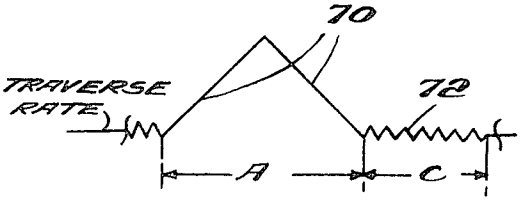
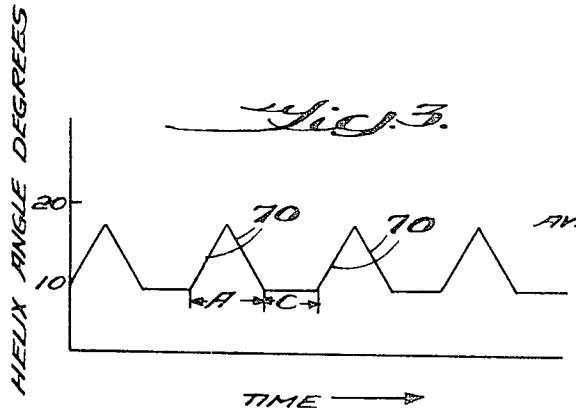
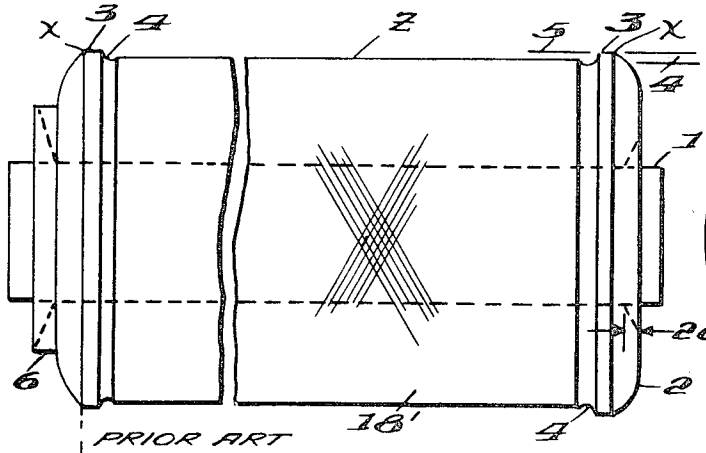


Fig. 3.



PRIOR ART Fig. 5.



PRIOR ART

PRIOR ART Fig. 7.

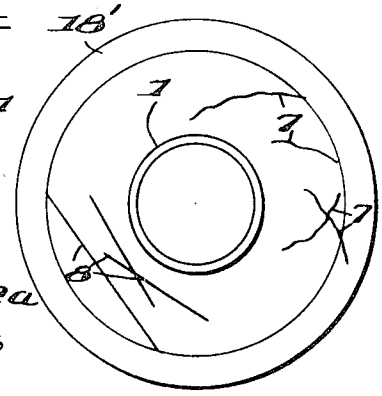


Fig. 6.

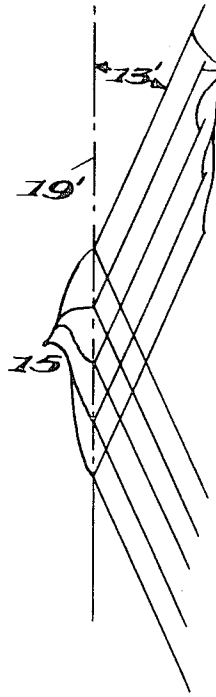


Fig. 8.

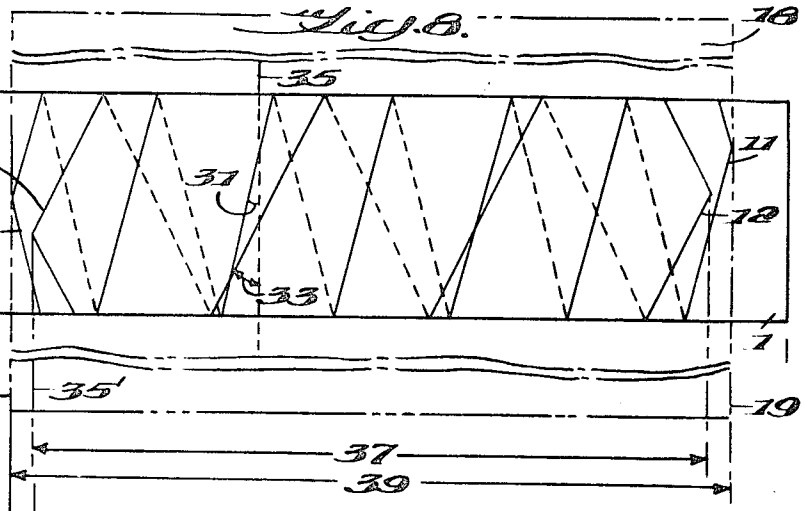


Fig. 9.

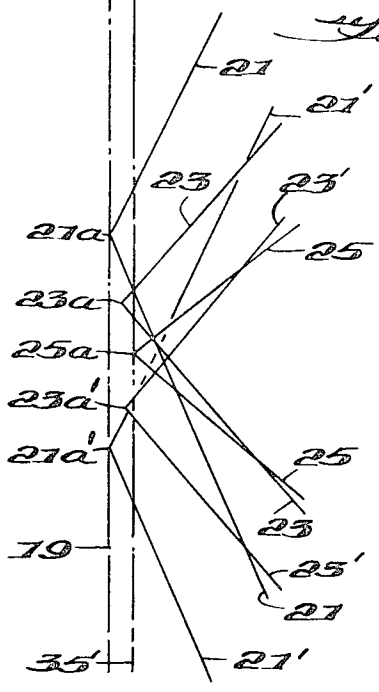


Fig. 10.

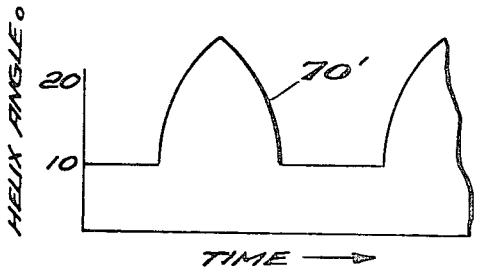


Fig. 11.

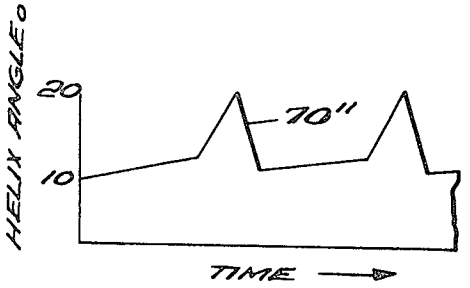
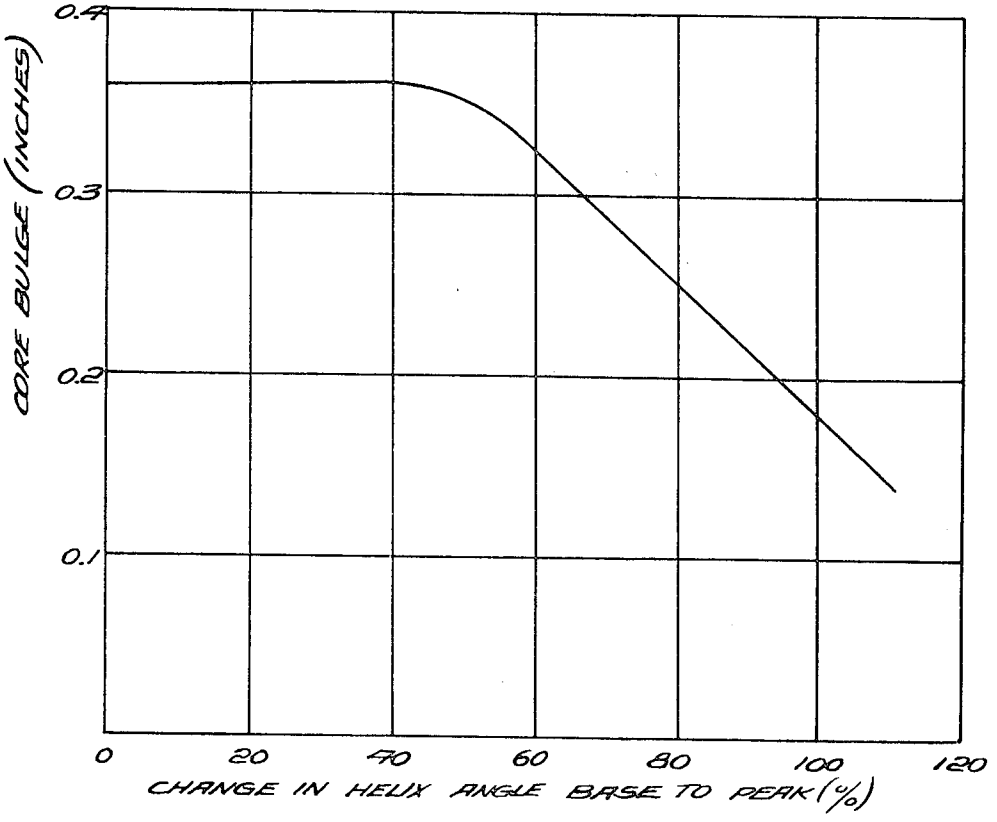


Fig. 12.



PROCESS FOR WINDING A YARN PACKAGE

BACKGROUND OF THE INVENTION

This invention relates to the crosswinding of yarns and more particularly to the winding of yarn packages with improved formation and stability.

It is desirable for economic reasons to wind large packages of yarn at high-thread line speeds. A cylindrical flat-ended package is preferred because more pounds of yarn can be wound in a given package diameter. Such packages are commonly formed by windups employing a surface drive. The drive roll is operated at a constant speed thus maintaining a constant surface velocity of the driven package despite the growth of the package as the filamentous material is wound thereon. A cam-actuated reciprocating traverse guide may be used to lay the yarn onto the bobbin in layers of helical coils either directly or by means of a print roll.

Currently used high-speed, i.e., 1,500 y.p.m. or higher, winding techniques do not give satisfactory package formation seriously limiting the size of packages wound. Attempts to achieve increased package size or higher windup speeds are accompanied by an increase in package defects. Major defects detracting from good package aesthetics include bulge, spiral fans, overthrown ends, and high shoulders. All of these appear to be related in some way to yarn laydown at the reversals, i.e., the points at which the yarn changes direction at the ends of a cylindrical straight-ended package.

Heretofore, means have been devised to improve yarn distribution at and near the package ends, such as by superimposing an axial reciprocation on the primary traverse stroke or by changing the length of the stroke cyclically by mechanical means with essentially no change in yarn helix angle to spread out or disperse the yarn laydown at the package ends or shoulders. These and other approaches provide very limited dispersion pattern or because of mechanical limitations are not applicable to high-winding speeds.

It is also a common practice in crosswinding to vary traverse speeds in a regular cycled fashion between a positive value and a negative value about a predetermined traversal rate for the purpose of preventing ribbons, which are a buildup of superimposed yarn windings laid approximately one on top of the other. These speed fluctuations however are relatively small and have little effect on the yarn laydown pattern at the reversals.

It is known that increases in traverse rate, that is, winding at larger helix angles may be used to reduce package bulge and move the yarn reversals on the package inward. However, the use of high-helix angles per se is restricted by the problem of overthrown ends. It is also known that overthrown ends can be reduced by slower, more stable reversals at the end of the traverse stroke, but this leads to excessively high and hard shoulders on the package. No completely satisfactory balance of conditions for high-speed winding exists with the currently known winding concepts.

SUMMARY OF THE INVENTION

It is a primary object of this invention to provide a method of winding which produces substantial improvements in package formation. Another object of this invention is to provide a yarn-winding process adapted to produce large yarn packages with improved stability in handling and shipping. Another object is to provide a method of controlling yarn tensions in winding. A further object is to provide improved packages of yarn wound under high tension. A further object is to provide yarn packages with low variations in surface hardness.

These and other desirable objectives are accomplished in a process for winding yarn into a cylindrical-bodied substantially straight-ended yarn package wherein the yarn is forwarded at an essentially constant thread line speed and is wound on a bobbin in layers of helical coils at a substantially constant helix angle to form the package. During winding, the package is rotated at a substantially constant peripheral rate

of speed while the yarn is traversed back and forth axially across the package at a substantially constant traversal rate. According to the invention, the improvement comprises increasing the traversal rate in spaced repeating periods throughout the winding of the package. The linear speed of traversing is regulated in a predetermined pattern over short-spaced repeating periods greater than the period of one traverse cycle such that the helix angle is held substantially constant then is varied cyclically to a helix angle significantly larger than the maximum helix angle attained during the period of winding at substantially constant helix angle. Tension fluctuations in the winding yarn caused by cyclically varying the helix angle may be compensated for by varying the peripheral package winding speed coincident with and in an inverse relationship with respect to the traverse speed.

According to another aspect, the invention comprises a cylindrical-bodied substantially straight-ended yarn package wound on a bobbin in layers of helical coils characterized by the helix angle of the coils in the package being varied in spaced repeating periods throughout the package from a minimum value to a maximum value and back to the minimum value in each period. The helix angle of the coils is varied cyclically in spaced periods throughout the package from a base helix angle through a range of helix angles such that the maximum helix angle is substantially larger than the maximum positive helix angle in the intervening base periods, and the point at which the yarn reverses direction at or near the end of the package in a helical coil is displaced axially inward from the end of the package in direct relationship to the helix angle in that helical coil.

In the subject method of winding a yarn into a package the yarn laydown at the reversal points is dispersed inward away from the package ends during the period of changing helix or excursion because, with no change being made in the actual length of the transverse stroke, the effective stroke length is reduced when yarn at essentially constant thread line speed is laid down at higher helix angles and then increased when yarn is again laid down at lower helix angles. Using the variable-helix winding method of the invention, overthrown ends are not obtained at the higher helix angles because the package ends or walls are defined by the yarn laid down during the period of low-helix traversing. The minimum or base angle in the helix angle cycle is generally selected to be at or near the optimum angle which would be selected for good winding at essentially constant helix angle with particular regard to minimizing overthrown ends. Higher maximum helix angles can be tolerated and thus higher average helix angles can be obtained because winding at the minimum or base angle establishes the package walls.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation of the yarn being wound into a cylindrical crosswound package.

FIG. 2 is a block diagram of a control system used to vary the traverse and winding speeds according to the invention.

FIG. 3 is a graph of helix angle vs. time for an embodiment of the invention.

FIG. 4 is an enlarged portion of the graph of FIG. 3 showing ribbon-breaking cycle added.

FIGS. 5 and 7 are end and front views of a package illustrating package defects encountered in prior art winding.

FIG. 6 is a schematic illustration of a yarn laydown pattern at the reversal showing a substantially constant helix angle as used in prior art winding.

FIG. 8 is a schematic illustration of yarn laydown according to the invention; single traverse strokes of high- and low-helix angles are shown, as well as the final package buildup.

FIG. 9 is a schematic illustration of yarn laydown pattern at one end of a package according to the invention.

FIGS. 10 and 11 are graphs of helix angle vs. time representing helix angle cycles which may be used in practice of the invention.

FIG. 12 is a graph of change in helix angle vs. core bulge for an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1 it will be seen that the windup chosen for purposes of illustration generally includes, as components thereof, a traverse cam 20, a surface drive roll 14, swing arm 28 mounted for relative rotation about pivot 30 and rotatably supporting bobbin 16, a reciprocating traverse guide 12 through which yarn 10 from a source (not shown) advances from guide 11 under drive roll 14 to a package 18 on bobbin 16. Suitable means such as motors 22, 24 along with belts 26, 26' are used to drive traverse cam 20 and drive roll 14 respectively.

Motors 22, 24 are synchronous motors and their speeds are individually controlled by solid-state power supplies 32, 34 connected to the motors through leads 36, 38. These power supplies vary motor speed by varying the frequency of the voltage supplied to the motors. A function generator 40 is connected to power supplies 32, 34 through leads 42, 44 respectively.

Referring now to FIG. 2 function generator 40 is seen to include signal generators 50, 52 connected to a coupler 54, which combines the signals 51, 53 generated by generators 50, 52 into a single waveform 55 which in turn is fed to amplifier 56, and inverter 58. Amplifier 56 amplifies signal 55 to form signal 55' which is fed over lead 42 to solid-state power supply 32. Inverter 58 inverts signal 55 to form signal 59 which is then amplified as desired in amplifier 60 to signal 59' that is fed over lead 44 to solid-state power supply 34. Signals 55' and 59' serve to modify the output voltage frequency of power supplies 32, 34 and the rotational speeds of motors 22, 24 are changed accordingly. The resultant speed changes vary the traversing rate and consequently the package helix angle and the peripheral package speed in a predetermined pattern in accordance with the output of function generator 40. The yarn package 18 is driven at a peripheral speed, varied in accordance with the inverted output signal 59', by contact with drive roll 14 which acts also as a print roll in forwarding to the package 18 the yarn laid down from traverse guide 12. As yarn builds on package 18, spring-loaded pivot arm 28 is urged away from the surface of roll 14 to permit the increase in package diameter. Throughout the course of winding the helix angle at which the yarn is laid on the package 18 is varied cyclically by controlling the rate of the traverse guide 12. The throw of the traverse guide, i.e., the distance that the guide 12 moves, is not changed. The length of the yarn laydown pattern is affected by changing the angle at which the yarn is laid down. It will also be realized that, the extent of change in length of the pattern on the yarn package will depend on part on yarn friction and retraction properties, and on roll surface friction.

FIG. 8 shows schematically a single yarn coil 21, traversed at low-helix angle 31 and a second single yarn coil 25 traversed at a higher helix angle 33. The change in laydown length (37 vs. 39) is related to the yarn lag existing between the traverse guide motion and the yarn laydown on the print roll or package, and on yarn reversal slippage on the print roll or package.

Other winding parameters being held constant, the laydown pattern is shortest at the larger helix angle 33 and longest at the smallest helix angle 31. This means that the package ends 19 are defined as the yarn is wound at lowest helix angle 31 in the helix angle cycle. The helix angle cycle is the cycle of helix angle vs. time (FIGS. 3, 4, 10, 11) and is not to be confused with the cycling of the traverse guide in one back and forth displacement of the yarn across the bobbin and herein referred to as the transverse cycle. Helix angles will be understood to be the angles measured at the package surface between the yarn coils 21, 25 and a plane 35 perpendicular to the package axis away from the package end 19.

As shown schematically in FIG. 9, coils 21, 23, 25 laid down at different angles will show a disperse pattern (i.e., dispersion) at and near the package end 19. This area will be called the package shoulder. The reversal 21a of coil 21 at lowest helix angle defines the package end 19. The reversal 23a of coil 23 wound at a higher helix angle is displaced inward slightly toward the center of the package and the reversal 25a of coil 25 wound at the maximum helix angle is displaced inward a maximum distance indicated by dotted line 35'. In periods of winding at changing helix angles, recurring disperse pattern is attained. This pattern from the beginning to the end of a period of changing helix angles may be compared with that produced by a conventional winding shown in FIG. 6 in which the reversals 15 of all the coils 17 with a constant helix angle 13 are laid down essentially at the package end 19'. In practice in such a laydown pattern, more yarn is laid at the package end or edge than elsewhere because the reversals are not instantaneous and package defects associated with prior art winding are developed.

FIGS. 5, 7 illustrate the defects that are encountered using prior art winding techniques. For example, package 18' includes bulging 2, high shoulders 3, spiral fans 7 and overthrown ends 8. Also illustrated are the accompanying defects of dish 5, dip 4, and telescoping 6. However, telescoping is most likely to occur during package shipment rather than during the winding of the package.

To overcome these defects, a cycle incorporating changing helix angles is selected to provide regulated yarn laydown at the package shoulder. A helix angle cycle used in a preferred embodiment of the invention is displayed in FIG. 3 showing equal accelerating and decelerating rate changes 70 of helix angle during time period A spaced by a time period C of traversing at essentially constant helix angle. This latter period is necessary to achieve adequate firmness at the package shoulder. Accelerating and decelerating rate changes as shown in FIG. 10 (70') may also be used. By the period, C, of winding at substantially constant helix angle is meant that period during which either no change in traverse rate is made or relatively small changes between a positive value and a negative value about a predetermined traverse rate commonly used for ribbon breaking, may be made. The latter is a period during which the speed of traversing over several seconds varies only a small percentage from the average speed in that period. Such a period is indicated in FIG. 4 as including a regularly cycled variation 72, which is a typical cycle in which a ribbon making motion (usually about ± 2 or 3 percent around the mean traverse rate) is imposed during the "constant helix" period of the cycle. The ratio (A/C) of the time period of changing helix angle 70 to the time period of essentially constant helix winding C (in FIG. 3) is preferably in the range of from one-seventh to three-seconds.

In the preferred winding process the ribbon breaking cycles are periodically interrupted by excursions in helix angle (70, FIG. 4) whose maximum value is greater than the maximum positive value used in the ribbon breaking portion of the cycle. While as stated above that usually ribbon breaking cycles are about a ±2 or 3 percent variation it should be understood that larger variations in ribbon breaking may be made providing the largest helix angle reached in ribbon breaking does not exceed the value at which yarn slippage at the reversals is incipient for a particular set of winding conditions and beyond which continued operation is impossible because of instability and collapse of the package shoulder.* (*An excursion in helix angle is any change which exceeds that magnitude at which slippage is incipient.) In addition, the rate of change of helix angle in degrees per second in both excursions and ribbon breaking such as illustrated in periods A and C respectively in FIG. 4 should be of sufficient magnitude to separate successive wraps (helical coils) by at least one splay width, i.e., the centerline-to-centerline distance between successive wraps should at least equal the width of a yarn bundle when wrapped under winding tension around a cylindrical surface of minimum package diameter.

The period C between excursions of rapidly changing helix angle need not be at a constant average angle but may be increased slightly or decreasing slightly as indicated in FIG. 11. Additionally, successive periods C need not be of constant length, i.e., equispaced nor does the peak angle reached need to remain constant throughout package winding.

The relatively large changes in helix angle required to achieve dispersion lead to small changes in thread line speed, and consequent fluctuations in thread line tension. To eliminate these fluctuations and achieve uniform tension in winding, small compensating changes are made in drive roll speed coinciding with the time at which changes are made in traverse rate. In the usual case these drive roll speed changes as the maximum helix angle is reached, are on the order of about 2 percent of the average winding speed during the period of winding at constant helix angle. As helix angle increases, thus tending to increase yarn thread line speed, drive roll speed is reduced in unison to counteract the speed change and thus to keep thread line tension relatively constant in spite of the changing helix angle. Tension control leads to the desired dyeing uniformity in the yarn.

By varying the helix angle cyclically throughout the package, a higher average helix angle obtained from the variable helix period provides a more stable package structure to resist bulge of the package. When the helix angle of the yarn is greater, the yarn can more easily prevent axial movement in the yarn coil. At the same time dispersion of yarn laydown at the reversals is obtained with the result that package density at the shoulders is regulated and the package defects occurring in prior art winding associated with yarn laydown at the reversals are largely eliminated. Thus, substantially any size package with minimum defects may be wound. Variable helix winding is particularly advantageous at high winding speeds. It is not dependent on the operation of complex mechanical devices subject to inordinate wear or breakdown.

In a preferred embodiment, the helix angle of winding is varied between about 8° and about 15° (87.5 percent) and cycled at periods (A plus C, FIG. 3) of from about 5 to about 60 seconds.

As the cyclic period (A+C) is extended, ridges tend to appear on the package ends which, unless slight, are generally considered to be objectionable. The time required for buildup of an objectionable ridge will depend, of course, on several factors including yarn denier and winding speed. Objectionable ridges appear on the package ends when the period of the cycle is more than about t minutes where

$$t=\frac{12\times 10^5}{\text{yarn denier}\times\text{winding speed in yards per minute}}$$

The maximum value to which the helix angle may be periodically cycled to obtain useful amounts of dispersion is about 110 percent greater than the base helix angle established by averaging the traverse rate during the substantially constant helix period.

A preferred condition +70 percent of base at 30 seconds total period (A+C) (for some yarn counts) is represented by the package as shown in FIG. 8. Peak angles of greater than about 110 percent above the base angle for good constant helix winding generally begin to build a circumferential ridge inboard of each shoulder, however, resulting packages are still much improved compared to prior art packages.

The shape of the cyclic pattern of changes in helix angle will be determined by the type of package characteristics desired. The shape of the cycle curve shown in FIGS. 3, 4 while desirable for some packages will not necessarily be optimum for all packages. The shape and the amplitude of the variable helix portion of the helix angle vs. time curve and the relationship of period A to the period C can vary over wide limits without departing from the spirit of this invention.

EXAMPLE I

A continuous filament nylon yarn of 40 denier and 13 filaments is wound up at a nominal thread line speed of 3,000 y.p.m. into 4-pound packages 7 inches long. The speed of the traverse guide is varied over a period of 13 seconds and is then held relatively constant for a period of 19 seconds, the complete helix angle cycle being repeated each 32 seconds. The helix angle in the yarn layers laid down during the period of changing traverse speed varies between 8½° and 15°, and is about 8½° through the period of relatively constant traverse speed. A conventional ribbon-breaking cycle (±2½ percent change in traverse speed) used during this period changes the helix angle by less than ±0.25°. The yarn packages thus formed are identified as item C in table 1.

Packages of yarn are wound as above except that conventional variations in the traverse rate are used. Two conditions—a normal ribbon breaking cycle (±2½ percent speed fluctuation in traversing) (item A), and what represents an extremely large change as taught in the prior art (±10 percent speed fluctuation in traversing) (item B)—are used.

Package hardness and package defects listed in table 1 were determined by examination of 16 packages of yarn produced under each set of conditions.

TABLE 1

Item	Helix angle	Period (sec.)	Core bulge (in.)	Relative hardness at— X [1] (shoulder)	Relative hardness at— Z (mid-package)	Spiral fans per package
A	8½°±2½%	1.7	0.29	100	92	19
B	8½°±10%	4	0.32	100	93	16
C	8½° base, +76.5% max. (to 15°) and ±2½% at base.	[2]	0.16	97	94	7

[1] See Fig. 5 for locations of X and Z.
[2] 13 sec. at changing helix angle and 19 sec. at base.

Relative hardness was determined by comparing measurements made by a type "Q" Durometer manufactured by Shore Instrument Company, Jamaica N.Y., and the head recommended by the manufacturer for use with curved surfaces. The manufacturer's instruction for the test are followed as outlined instructions his Bulletin R-12 and in ASTM D2240.

The packages prepared by either of the prior art methods show very similar package conformation and defects. It will be seen from table 1 that the uniformity of the packages wound by the process embodying the invention are greatly superior to those wound according to the prior art as indicated by a low variation in surface hardness and reduced core bulge. Shoulders are relatively softer and differ less from the hardness at midpackage. Core bulge is reduced by a factor of about two and the number of spiral fans and the incidence of dip is much less. Core bulge, 2*a* in FIG. 5 is the difference in height between the crest of the bulge 2 and the innermost point of winding on the tube 1. All aspects of package formation are improved. Although the changes in traverse rate and thus in helix angle of winding are extreme by prior art teaching in item B of this example, they do not provide the dispersion at the laydown achieved by practice of the current invention.

EXAMPLE II

A 70-denier 17-filament nylon yarn is wound into 7 inch long packages weighing 6 pounds at a winding speed of 3,000 y.p.m. A base helix angle of 9° is used throughout winding, and peak helix angles are changed in a cycle similar to that represented in FIGS. 3, 4, period A being 12 seconds, period C being 18 seconds. The percentage that maximum helix angle exceeds the base angle is plotted against the core bulge measured on the yarn packages. The resulting curve, FIG. 12, shows the effect that increased helix angle change has on reducing core bulge. At these winding conditions this occurs above about 40 percent change.

Good packages are especially difficult to wind under high thread line tension. Generally, it is desirable to wind yarns under the lowest tension providing good continuity of winding. Bulge is accentuated when thread line tension is increased. However, when high tension winding is necessary, variable helix winding greatly reduces bulge and shoulders, and thus provides a unique method of achieving acceptable package formation. Thread line tensions up to several times normal tensions may be used.

The method of this invention has been found particularly useful in the packaging of yarns which require winding under high tension to develop and/or maintain desired yarn properties.

In practice the invention is most useful at essentially constant winding speeds. However, the change of helix angle in winding which would occur if thread line speed were cycled, e.g., decreased for a predetermined time, and the cam traverse rate held constant would provide similar dispersion at reversals and changing helix angles for increased package stability i.e., a decrease in thread line speed will displace the yarn reversal inwardly of the package. Also, both thread line speed and traverse speed can be regulated so as to provide variable helix winding for dispersed yarn laydown. Control of the length of yarn laydown by changing helix angle will be dependent in part on control of the distance between the transverse guide and the yarn laydown point. Control is simplest to maintain if this distance is kept constant.

It is also to be understood that the ribbon breaking cycle may be superimposed on the excursions (A, FIG. 4) in helix angle. Packages wound by the method of this invention show a much more uniform package density and have significantly improved appearance and a greatly reduced number of winding defects when compared to packages wound by prior art methods. Although surface drive windups will be commonly used in the practice of this invention, the invention is not necessarily limited to use with these types of windups. Other changes and modifications of a similar nature will occur to those skilled in the art without departing from the spirit of the present invention.

What is claimed is:

1. In a process for winding yarn into a cylindrical bodied substantially straight-ended yarn package wherein the yarn is wound in layers of helical coils at a substantially constant helix angle, including the steps of forwarding the yarn at an essentially constant thread line speed to the package, rotating the package at substantially constant peripheral rate of speed and traversing the yarn back and forth across the package at a substantially constant traversal rate, the improvement of which comprises; decreasing said constant thread line speed for a predetermined time in spaced repeating periods throughout the winding of the package.

* * * * *