

[54] YARN PROCESS

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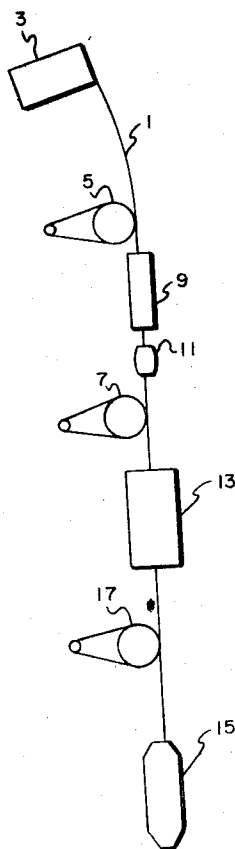
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[57] ABSTRACT

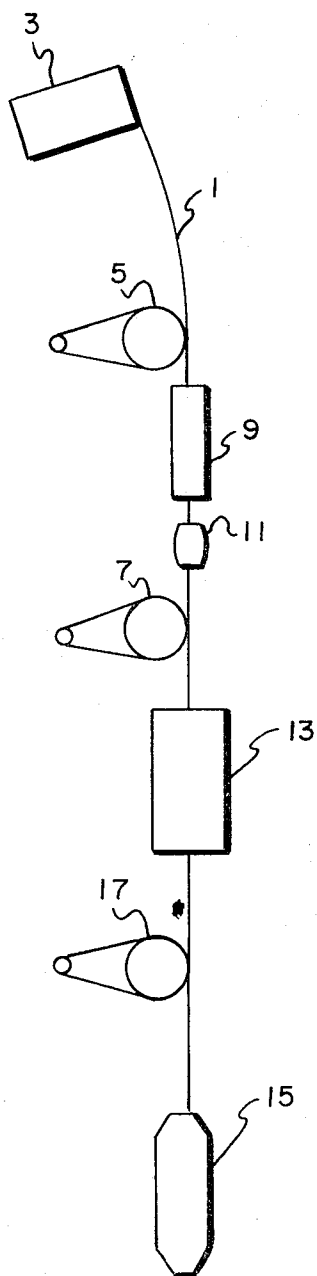
A process for stringing-up an operational simultaneous draw-false twist machine is disclosed. In the process, the feed roll is engaged first and then the false twister is engaged to insert a low level of false twist in the yarn before the draw roll is engaged by the yarn.

11 Claims, 1 Drawing Figure



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YARN PROCESS

The present invention relates to a process for initiating the simultaneous draw-texturing of spun yarn (for example, as described in Belgian Pat. No. 728,461) having a producer twist of less than about one turn per inch to produce, for example, a novel, draw-textured, stabilized polyester multifilament, textile denier, yarn suitable for fabric constructions, particularly knit and woven goods, requiring superior dimensional stability coupled with excellent yarn processability as claimed in copending commonly assigned application Ser. No. 110,985 filed Jan. 29, 1971.

In certain embodiments of the invention, the present invention relates to the production of such a yarn of the false twist crimped type having a total denier of at least 30; a tenacity of about 2.5 to 4.0 grams per denier; an elongation of about 20 to 35 percent; about 30 to 85 crimps per extended inch of filament, a linear shrinkage under hot, wet condition below about 15 percent, a liveliness factor of about 20 to 60 and a filamentation value of about below 0.4.

It has been recently suggested that the separate process stages involved in the production of false twist textured yarn can be combined into a simultaneous, sequential operation. Conventionally, a fiber producer spins a continuous filament yarn and then in a continuous or lagged operation therewith draws the yarn to a denier and tensile strength suitable for fabric construction. In a separate and distinct operation, the yarn is false twist crimped and then stabilized in continuous fashion by being overfed while subjected to heat and/or is stabilized in a separate operation by being wound loosely onto a package which is then steam autoclaved. (See British Pat. No. 787,619 and U.S. Pat. No. 3,316,705). In any event, stabilization is achieved by hot shrinkage of the yarn. These conventional texturing operations on drawn yarn are hereinafter referred to as "lagged operations" and the yarn thereby produced as "lagged operation yarn."

In order to improve the overall process efficiency as well as to make a better product, a process was conceived wherein undrawn yarn of textile denier would be fed into a false twist zone consisting sequentially of a heater, a false twister and a draw roll, the latter operating at a speed sufficient to draw the yarn at the desired draw ratio. The false twist backs up into the heated zone through a draw neck point located therein, wherein the twist is set into the yarn. The yarn is then sequentially, and in a continuous manner, overfed through a heated zone and packaged (See Belgian Pat. No. 728,461).

Although sound in principle, it was quickly found that the product of the improved process was different in certain respects as compared with yarn made by the lagged draw texture procedure, even though processing conditions were as closely tuned to the lagged process conditions as reasonably feasible. Most notably, the new yarn performed poorly during fabric construction.

It was found that a polyester multifilament yarn of a total denier of at least about 30, but generally below 200, and preferably 40 to 175, and a denier per filament of about 0.5 to 10, preferably 3 to 5.5, could be produced of somewhat lower tenacity where desired than lagged operation yarn but being characterized by superior fabric construction processability coupled with excellent dimensional stability in converted form. The invention disclosed in copending application Ser.

No. 110,985, filed Jan. 29, 1971, and commonly assigned herewith, relates to this novel product and a process by which it can be produced.

However, problems were encountered during the start-up of the simultaneous draw-texturing machine, particularly when polyester yarn, e.g., polyethylene terephthalate yarn, was to be draw-textured. As-spun, that is undrawn, polyester yarn of the type suitable for textile grade end uses generally has a tenacity in the range of about 0 to 0.5 grams per denier at the elevated temperatures employed in the draw-texturing process. The yarn breaks quite easily at a temperature of about 150° C and tensile properties deteriorate further in the 190° to 240° C range at which the heater (9 of the Drawing) is usually operated. Under these conditions, it would seem logical to attempt to initiate drawing between rolls 5 and 7 of the Drawing before engaging the false twister (11 of the Drawing). When such a procedure is tried, severe filamentation occurs at the entrance of the false twister and adjacent the upstream side of the twist trap component of the false twister. Eventually a bundle of splayed and broken filaments form and the threadline breaks. The insertion of twist into the yarn holds the filaments together with sufficient coherency to prevent filamentation at the twister, but the impact of a high twist level on the undrawn or partially drawn yarn breaks the threadline. Machine string-up must be achieved by a process which allows the introduction of heat, twist and drawing to the threadline without causing threadline breaks and/or excessive filamentation.

A method to initiate a simultaneous draw-texturing operation has now been discovered for use with false-twist texturing machines; particularly of the spindle twister type wherein a twist trap pin is present across the entrance or interior of a hollow rotatable tube, or of the friction type wherein one or more friction surfaces, i.e., a plurality of disc-like surfaces, is arranged for sequential yarn contact and where desired in two or more planes for alternating sequential yarn contact with the yarn making perpendicular or other angular contact with the friction surface; which overcomes the aforementioned problems while enabling rapid, efficient machine start-up.

More particularly, the string-up method of the invention comprises the sequential steps of engaging the feed roll; forwarding yarn into the draw-texturing zone (an aspirator or the like waste collecting means is desirably employed during the string-up procedure); starting the false twister at slow speed to false twist the yarn at a low level of twist insertion; engaging the draw roll while having the yarn sufficiently close to the heater (where a plate-type heater is employed) for enough heat input into the yarn to enable the drawing of the yarn (usually a yarn temperature above the second order transition temperature of the fiber-forming polymer) while inserting said low level of twist; raising the twister speed to operating level and fully engaging the heater. At this point the draw-texturing operation will be running smoothly and in the preferred embodiments of the preferred embodiments of the invention, the yarn is passed into a second heat treatment stage (a continuous post-treatment process) prior to yarn collection. When other types of heaters are employed, the important consideration is that the yarn is heated to a temperature at which it will draw, but below a temperature at which the as-spun yarn breaks.

It is highly desirable to employ a plate type heater in the draw-texturing zone in order that the yarn can be maintained relatively close to the hot surface for the initiation of drawing but without exposing the spun yarn to the heat input utilized during operating conditions. (It would be unduly inefficient to cool and reheat the heater each time string-up is needed, especially on a multi-position texturing machine having banks of threadlines and a corresponding number of heater plates.) Retractable guides and the like are conveniently used to hold the yarn a fraction of an inch, for example 1/16 to 1 inch, off of the heater during string-up, as is well known to those skilled in the art of drawing synthetic polymer multifilament yarns.

Considering the draw-texturing process in greater detail, filamentation during the draw-texturing process is most prone to occur between the spindle and the draw roll. This is because the highest tensions to which the yarn is subjected during draw texturing occur in that region of the operation wherein drawing tension is compounded by tension imposed by the spindle. In the usual lagged operation sequence, wherein the yarn is not being simultaneously drawn and false twist textured, the yarn is not under drawing tension and 50 to 60 turns per inch (*tpi*) of false twist are inserted into the yarn. Thus, the yarn has been drawn at its optimized draw ratio, say about 3.65 for polyethylene terephthalate yarn, of spun birefringence about 5.8×10^{-3} and spun inherent viscosity (I.V.) about 0.63 and then separately false twist textured. However, when these conditions are combined in simultaneous draw texturing, tenacity drops slightly but filamentation of the yarn significantly increases at the conventional lagged operation twist insertion level of about 55 *tpi*.

Filamentation can be eliminated by significant draw ratio reduction i.e., 3.2 but with corresponding deterioration in tenacity i.e., 2.5 grams per denier. However, it has been quite unexpectedly found that in the simultaneous draw texturing operation, actual tension as measured along the yarn longitudinally decreases with increase in twist level which results in improved tensile properties, particularly tenacity, by enabling the use of a higher draw ratio and reduced filamentation. In fact, filamentation value without deleteriously influencing tenacity and elongation, can be decreased from about 10 to 30 at about 55 *tpi*; to about 0 to 0.4 at the higher twist frequency levels based on 150 to 170 denier yarn.

In fact, yarn filamentation decreases to where it is below that of the lagged operation yarn as determined by filamentation value, disclosed more fully hereinafter. Although not entirely understood, it is believed that higher twist translates a greater proportion of the total drawing and false twister induced tension into a force vector perpendicular or tangential to the longitudinal axis of the yarn, thereby reducing the tension component which the yarn must bear in the lengthwise direction. Thus, higher draw ratios corresponding to higher filament tensions can be employed, i.e., ratios approaching the optimized draw ratio of about 3.60 to 3.70 can be employed, i.e., 3.40 to 3.55. Heretofore, to avoid excessive filamentation, draw ratios in the simultaneous draw texturing process of the order of about 3.2 were believed to be about the highest usable in practice.

Filamentation value characterizes the yarn not only in a physical sense but is indicative of its improved performance properties, as will be apparent. This is be-

cause the characteristic relates directly to the number of times a fabric construction machine, in this case a knitting machine, will be stopped per unit length of fabric due to yarn filamentation. In other words, the theoretical and visual improvement by selection of yarn processing conditions translates into improved fabric construction efficiency.

Filamentation value is based on knot-free yarn and is the actual number of machine stops due to filamentation (most usually a loose filament caught underneath adjacent layers of yarn on the feed package) per 30 feeds (30 feed packages) per 10 fabric yards on a Fouquet Interlock Knitter. The knitting machine is set to 15 to 18 rotations per minute with the machine stop mechanism being set at medium sensitivity.

The yarn of the invention has a filamentation value below 0.4, usually about 0.1 to 0.3. Yarn produced by draw texturing at the low twist insertion levels but at draw ratios sufficient for a tenacity of at least about 3.0, has a filamentation value of about 10.0 to 30.0; lagged operation yarn has a filamentation, value of about 0.4 to 1.0.

The following Example illustrates the invention.

EXAMPLE

An as-spun 510/36 yarn of linear fiber-formable polyethylene terephthalate (having an intrinsic viscosity of about 0.63, a birefringence of about 5.7×10^{-3} , polymerized from polyester monomer produced by the direct esterification of terephthalic acid with ethylene glycol, such polymer having a free glycol content of less than about 2.25 mol percent) is strung-up and then draw textured in a continuous operation in accordance with the following process conditions and with reference to the Drawing.

The undrawn yarn having a producer twist of about zero turns per inch is supplied from supply package 3 to the draw texturing operation. Prior to string-up hot plate 9 is brought up to normal operating temperature. Then the yarn is passed from the supply package 3 through the various stationary guide arrangements that may be present and through stationary hollow tube spindle false twister 11, being wrapped once around a sapphire twist trap pin centrally located therein and then introduced into an air suction tube (not shown) leading to waste. The various yarn engaging speed devices are at operating speed but are not engaging the yarn. The yarn is then threaded through two retractable guides one-eighth inch above heater plate 9 which can retract into the heater plate, placing the yarn into a grooved track thereon. Then the feed roll 5 is engaged by the yarn. Next the spindle 11 is started and rotated at about 2,500 rpm. A rotational speed corresponding to a range of about 0.2 to 1.0 *tpi*, preferably about 0.4 to 0.6 *tpi* can be used during this stage of the string-up procedure. With the twist being inserted at about 0.5 *tpi* into the running threadline, the draw roll 7 is engaged by the yarn followed immediately by raising spindle speed to the normal operational value. The yarn is then placed directly onto the surface of heater 9 by means of lowering the retractable guides and a free end thereof is broken off below the draw roll and threaded through the second stage heater 13, onto relax roll 17 and finally package 15.

The draw-texturing process is then operating with the yarn being pulled off of the supply cheese by positively controlled feed roll 5. Draw roll 7 is operated at a pe-

ripheral speed so that the yarn is drawn 3.45 times, based on feed and draw roll surface linear speeds in the drawing zone between feed roll 5 and draw roll 7. HOT plate 9, heated by internal steam generating means and 3.25 feet long, is maintained at about 230° C. False twist spindle 11 being of the tube type having a centrally located sapphire pin about which the yarn is wrapped once, is rotated by means not shown at about 370,000 rotations per minute. Yarn speed around the draw roll is about 440 feet per minute, so that about 70 tpi (turns per inch) of twist is put into the yarn upstream of spindle 11 while the same amount of twist is taken out of the yarn downstream of the spindle, in accordance with conventional false twisting principles. The 70 tpi runs back from the spindle, along the yarn as it passes across the heater to the draw point, which is located about 2.5 inches below the top of the heater plate 9, thus setting the yarn in the twisted configuration. The draw point is precisely located without the use of external means such as a draw pin by the dynamic conditions of the draw texturing process. Because of the change in yarn denier at the draw point, tpi above the draw point is no more than about 15 to 20 and gradually dissipates as it runs back toward the feed roll 5. From the drawing texturing zone, the yarn, now about 150/36, passes immediately and sequentially into a 3-foot long hot air chamber 13 maintained at about 190° C. at a 16 percent overfeed as measured between draw roll 7 and relax roll 17. In the relaxation zone, the drawn, crimped, torque lively yarn is stabilized for subsequent use in knit and woven fabric constructions requiring dimensional stability, stitch definition and the like properties often not obtainable with "stretch yarns" that have not been stabilized. The yarn is then fed to package 15 at about 7 percent underfeed to form a firm package construction suitable as a feed package for knitting and weaving processes. The yarn has the following characteristics:

Tenacity	3.2 gpd
Elongation	22%
Linear Shrinkage	5%
Liveliness Factor	32
Self-twisting Tendency	1.6
Torque Wrap Number	20
Filamentation Value	0.2
Dynamic Cycle test	
Stretch Value	2.1
*Crimp Frequency	34 crimps per extended inch of filament

*Five individual filaments are removed from the yarn bundle at points spaced from the outside to the center thereof. Each filament is extended fully, but not stretched, and the number of crimps per extended inch counted. The average of the five values is the crimps per inch of the yarn based on extended filaments which is about 30 to 35 for the yarn of the invention. (30 to 45 for 145 denier and above and where desired 45 to 85 for the lower denier yarns)

Linear shrinkage is measured after 30 minutes in boiling water as linear shrinkage per unit length under a tension of 0.045 grams per denier. Preferably, the yarn of the invention has a linear shrinkage below 10 percent, most preferably below about 5 percent.

With reference again to the drawing, the following is a more general disclosure of the process used to produce the improved yarn of the invention.

Heater 9 is maintained at a temperature of about 180° to 240° C. preferably 210° to 240° C. for enhanced dye uniformity. When a heater having a gradual temperature profile along its length is used, the temperature stated is the maximum measurable temperature. The heater may be of any suitable shape and form, as the grooved plate type or of the hot air box convection type. The plate type is preferred because with polyethylene terephthalate yarn, or with many other synthetic polymer yarns, the yarn will melt if heated in undrawn state above the second order transition temperature of the polymer (90° to 100° C. with polyethylene terephthalate). Drawn yarn can be subjected to the higher temperatures employed in the simultaneous draw-texturing process, but drawing will not take place unless the yarn is heated above ambient conditions. Thus, the yarn is held off but near the heater plate until draw texturing is taking place and is then placed in direct contact with the heater. Conductive heaters may be heated electrically or by other means such as by steam or hot air flowing through a tube positioned beneath the surface of the heater. The heater will be about 2 to 6 feet long, usually about 3.3 feet long.

The twister will generally be of a conventional spindle type. Preferred for balance purposes is a tubular spindlet having a twist trap pin centrally located across its diameter about which the yarn is wrapped once. The spindle is driven by a motor at speeds of about 300,000 to 600,000 rpm, and above, i.e., 800,000 rpm. Various threadline stabilizers, such as tubes and guides, many of which are well known in the art, can be positioned above and below the twister. With lower denier yarns, approaching the 40 denier area, friction false twistors such as one or more revolving bushes, flanges and cups arranged for sequential and/or simultaneous yarn contact can be employed. Two or more series of friction twistors arranged in different yarn contact planes for alternating yarn twist insertion can be employed with the higher denier yarns. Yarn speed is correlated with twister speed to insert the desired number of turns per inch into the yarn.

A spin finish of the type imparting good, that is low, fiber to twist trap pin friction characteristics to the yarn will be applied to the yarn prior to the draw texturing operation or therewith but prior to the first heater. This is done so that excessive tensions are not imposed on the yarn by the twister, which would contribute to filamentation. Finishes suitable for this purpose are those routinely employed in the art, for example those containing lubricants such as hexadecyl stearate, high viscosity mineral oil, polysilicones, and the like. The draw-texturing process should be operated so that the ratio of tension above the spindle to the tension below the spindle is about 1:1.5 to 1:2.5, preferably about 1:1.7 to 1:2.3. In preferred numerical values, the measurable tension along the strand path above the twister is about 0.118 to 0.180 grams per denier based on the drawn yarn denier and about 0.236 to 0.420 grams per denier below the twister, also based on drawn yarn denier. The feed and draw roll means are of a non-slipping, positively controlled type, for example a draw roll and spaced apart associated separation roll about which the yarn is wrapped a plurality of times, or of the endless belt "casablanca" type.

The second heater is conventionally of the enclosed convection type, although plate type heaters can be employed, and is maintained at about 150° to 240° C.,

preferably about 170° to 210° C. The second heater stabilizes the yarn and has a primary influence on the degree of bulk in the yarn on the package, which is relaxed about 10 percent to 30 percent, preferably about 12 to 20 percent as it passes through the second heater zone. Generally, the higher the first heater temperature and the lower the second heater temperature, the higher the bulk of the yarn on the take-up package. For practical purposes, degree of bulk on the package may be considered to be overfeed minus linear shrinkage, with greater linear shrinkage occurring at higher second heater temperatures. From the heat stabilization step, the yarn is underfed about 5 to 10 percent to the take-up package in order to form a package of sufficient hardness and stability suitable for use to feed yarn into knitting and weaving operation.

Various modifications of the invention will appear obvious to those skilled in the art. For example, although the invention has been exemplified with polyethylene terephthalate, fibers formed of other fiber-formable polyester, as well as fiber-forming polyamides and blends thereof are usable in conjunction with the present invention.

It will be further understood that while the Example describes a unitary operation involving passage through a second heater, the advantageous properties of the yarn of this invention induced by high-twist level simultaneous drawing and texturing may be secured in a lagged operation involving a separate autoclave step, or second heater and autoclaving steps might be usefully combined. For 145 to 170 denier yarn, about 60 to 80, preferably 68 to 75 tpi is inserted into the yarn in accordance with the inventive process. With decreasing denier yarns, twist insertion level can be raised even higher if yarn speed is accordingly sacrificed.

When a single machine is used having two heaters in series with the second heater being of the enclosed convention type, complete machine threading is facilitated by the use of a yarn threading tool movably located in the second heater. The yarn threading tool has a yarn engaging end which can be positioned to allow easy threading of the yarn therethrough near the upstream end of the heater. The tool is then capable of downward movement through the second heater, thereby pulling the yarn through the heater.

Liveliness factor (Q) is calculated by experimentally determining in a numerical fashion (1) the tendency of the yarn to twist upon itself when in a relaxed state (designated A) and (2) the torque wrap number of the yarn when under a low tension such as applied during knitting and weaving operations (designated B). Liveliness factor is the product of torque wrap number and self-twisting tendency ($Q = AB$).

To determine A , a 10-inch sample of yarn is attached between two clamps along a scale ruled to hundredths of an inch in a manner so that the yarn does not become free to untwist while being so placed and is under no tension. Then a tension hook applying 6.5×10^{-4} grams per denier (based on the denier of the yarn) stress is placed at a point midway between the two clamps. By releasing one clamp, slack is pulled from the yarn until it is parallel with the ruled edge. The tension hook is adjusted to the midpoint of the yarn's length, if necessary. One claim is then unlocked and slowly moved toward the stationary claim until the yarn twists or kinks

upon itself. The distance remaining between the claims is recorded. A or self-twisting tendency is equal to the average value over ten observations.

To determine B , or the torque wrap number, a 20-inch length of yarn is held vertically, secured at both ends, at 35 percent relative humidity at 70° F., but under no tension. A tension weight to apply 0.02 grams per denier to the yarn is then attached to the lower end of the yarn and that end is released. After the yarn reaches equilibrium, the number of twists in the 20-inch sample is counted and the torque wrap number is the number of twists minus any producer twist present. Again, an average of 10 samples is used in the Liveliness Factor equation.

What is claimed is:

1. A process for stringing-up an operating yarn simultaneous draw texturing machine comprising a heater and a yarn false twister positioned between a yarn feeding means and a yarn drawing means with the heater upstream of the false twister, whereby yarn having a coherency at most equal to a producer twist yarn can be simultaneously false twist crimped and drawn between said feeding means and said drawing means, which comprises the sequential steps of:

a. engaging the feeding means with the yarn;
b. engaging the false twister with the yarn and running the false twister at a slow speed to false twist the yarn at a low level of twist insertion sufficient to prevent filamentation of the yarn during string-up;

c. engaging the drawing means with the yarn while maintaining the yarn close to the heater so that the yarn reaches a temperature at which the yarn draws without breaking;

2. The process of claim 1 wherein the false twister is a hollow spindle false twister, said process including the step of threading the yarn through the spindle while the spindle is stationary prior to engaging the feeding means with the yarn.

3. The process of claim 2 including the step of wrapping the yarn about a twist trap pin located across the hollow rotatable spindle.

4. The process of claim 1 wherein polyester yarn is being false-twist crimped.

5. The process of claim 1 wherein nylon yarn is being false-twist crimped.

6. The process of claim 1 wherein the heater is a plate heater.

7. The process of claim 6 including drawing the yarn at a yarn necking point located on the heater plate.

8. The process of claim 1 including threading the yarn through a second stage heater to a relaxation roll.

9. The process of claim 1 which comprises operating the false twister in step (b) thereof to insert about 0.2 to 1.0 turns per inch of false twist into the yarn.

10. The process of claim 4 including maintaining the yarn temperature prior to step (e) thereof below about 150° C.

11. The process of claim 8 wherein said second stage heater is pre-threaded with a yarn threading tool having a yarn engaging end at the upstream side of said heater and then said yarn is engaged by said tool and is pulled through the heater by said tool.

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