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POLYESTER TOW PREHEATING AND DRAWING PROCESS

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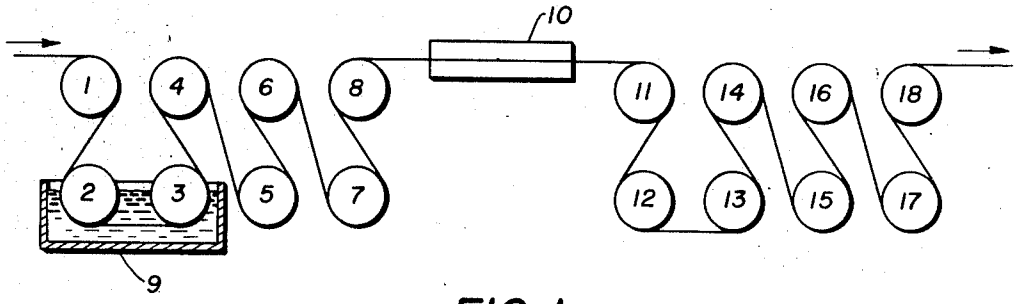


FIG. 1.

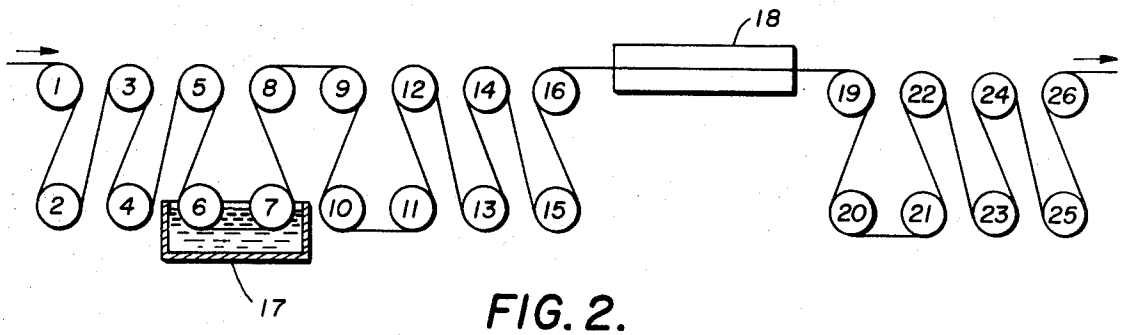


FIG. 2.

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POLYESTER TOW PREHEATING AND DRAWING PROCESS

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Continuation-in-part of application Ser. No. 734,632, June 5, 1968, which is a continuation-in-part of application Ser. No. 434,438, Feb. 23, 1965. This application May 19, 1969, Ser. No. 825,541

Int. Cl. D02j 1/22

U.S. Cl. 264—290 1 Claim

ABSTRACT OF THE DISCLOSURE

In a high speed continuous drawing process where polyester tows are preconditioned for drawing at speeds of greater than about 50 yards per minute, unoriented polyester tow is subjected to a first inert bath maintained at higher than the optimum pre-draw temperature; exposed to a cooling medium lower than the optimum pre-draw temperature, whereby the uniform optimum pre-draw temperature is obtained throughout the thickness of the tow, after which the tow is subjected to temperatures higher than that of the optimum pre-draw temperature while being drawn at least 2×. The first inert bath is maintained at 75–100° C. and dwell time is 0.2–5.0 seconds. The cooling medium is maintained at 40–60° C. and exposure time is 5–40 seconds. The optimum pre-draw temperature achieved is about 62° C. This processing results in improved tenacity, elongation and/or modulus of the tow.

This application is a continuation-in-part application of my application Ser. No. 734,632, filed June 5, 1968, the latter being a continuation-in-part application of my application Ser. No. 434,438, filed Feb. 23, 1965.

In the commercial production of staple fiber, it is desirable for economic reasons to combine several hours of production from one or more spinning machines into a large tow containing on the order of thousands of filaments and draw this large bundle of filaments simultaneously. A number of methods have been used to facilitate the drawing of the unoriented filaments by applying heat prior to or during the orientation step, e.g., by passing the yarn over or between hot plates or between hot zones or around hot pins and the like. These procedures have proved satisfactory for drawing textile or industrial denier polyester continuous filament yarns, but are unsatisfactory for the drawing of large tows needed to produce staple fiber. Uniform heating of all the filaments with a large tow is difficult to achieve using hot surfaces or zones and non-uniform drawing normally results. Non-uniform and/or uncontrolled drawing can damage the draw rolls and/or interrupt a continuous process. Further poorly drawn fibers have varying physical properties and since the unoriented and partially oriented fibers dye to much darker shades than the oriented ones, they are particularly undesirable when the staple is intended for dyed goods. These dark-dyed fibers appear in fabrics as flecks or dark color. The use of wet drawing processes has been reported to yield more uniformly drawn fibers than the heated dry processes and is generally preferred in commercial operations.

In the accompanying drawings FIGS. 1 and 2 illustrate schematically front elevations of convenient apparatus for drawing polyester tow in accordance with the present invention.

It is an object of this invention to provide a novel process for drawing tow composed of substantially unoriented polyester filaments.

Another object of this invention is to provide a novel process for drawing large tows of substantially unoriented polyester filaments in which the drawn tow is very uniform and possesses excellent physical properties.

Other objects and advantages of this invention will become readily apparent from the detailed description thereof immediately following.

The objects of this invention are preferably accomplished by exposing a heavy tow of substantially unoriented polyester filaments to a first inert bath maintained at from about 75–100° C., with an exposure time of from about 0.2–5.0 seconds; subjecting the tow to a cooling medium of from about 40–60° C., for a period of from about 5–40 seconds, dwell times and exposure times depending upon temperatures employed and tow thickness; and thereafter drawing the tow at a draw ratio of at least 2× its original length while passing the tow through a second inert bath maintained at about 80–100° C. Preferably, the first inert bath is maintained at about 78° C., the cooling exposure is at about 55° C., and the temperature throughout the tow at the point of entry into the draw bath, distributed as evenly as possible, is about 62° C. Preferably, the tow is drawn at a draw ratio of from about 2–6× its original length while being passed through a second inert bath maintained at about 90° C. When the drawing process is conducted in the manner described above, a uniform draw is imparted to the filaments of the tow, "necking down" is controlled to within the draw zone, and excellent physical properties are obtained.

In the baths utilized to carry out the process of this invention, any fluid harmless to the filaments may be used. Preferably, aqueous baths are used in that they are economical to use and give satisfactory results.

Exposure times are such as to provide, with due regard for the speed of heat permeation of the wet polyester tow, a tow emerging from the first bath with a peripheral temperature higher than that of the optimum pre-draw temperature, and with a temperature at the center of the tow slightly lower than that of the optimum pre-draw temperature, but rising to approach this temperature; and upon emergence from the cooling zone, a uniform temperature throughout the tow close to about 62° C. At this temperature, the tow will not "neck down;" but upon exposure to the higher temperature of the draw bath, the tow, with as much uniformity of temperature as possible, be raised to the ideal stretch temperature of about 90° C., that is, the lowest temperature at which efficient or uniform drawing can be attained.

Excessive dwell time in the first bath should, as as practical matter, be avoided. It is not the function of the first bath to remove pre-orientation or double refraction. Such removal, although not in itself objectionable, involves higher temperature or longer dwell-time which would not, as explained below, be suitable to the practice of this invention. The function of the first bath is rather to precondition the fiber for its orientation stretch, by wetting the fiber, and, in conjunction with the cooling step, to provide for the most uniform optimum pre-draw temperature, thereby providing a uniform draw and controlling the point at which "necking down" occurs. As temperature and/or dwell time is increased, for example, there is a tendency of the fiber to stretch on the cooling rolls rather than in the stretch bath. As temperature and/or dwell time is decreased within prescribed limits "necking down" will ordinarily be delayed. The temperature must also be within a range which, in conjunction with the cooling step, will permit an orientation stretch resulting in good fiber qualities of tenacity and elongation. As adapted to a commercial continuous tow process, excessive dwell-time presents no problem, for the rapid passage of the

tow through the bath is desirable. It has been found that The preferred dwell-time at 78° is about 0.5 second. e.g., about 75° C., should not exceed about 5 seconds for optimum results; and when the temperature of the first bath is increased, the maximum dwell-time at the upper temperature range should not exceed about 0.5 second. The preferred dwell-time at 78° is about 0.5 seconds.

If desired, finishing agents may be incorporated in either of these baths or they may be applied to the filaments at some later point. These finishing agents may include antistatic agents, wetting agents, plasticizers, stabilizers and the like.

The accompanying drawings illustrate convenient methods for practicing the present invention. In FIG. 1, the tow which is to be oriented is passed over rolls **1** through **8**, and **11** through **18**, respectively, rolls **1** to **8** being maintained at a given uniform peripheral speed while rolls **11** through **18** have a uniform peripheral speed at least 2× greater. Between rolls **2** and **3** the tow passes through a vessel **9**, which contains the first inert liquid bath maintained at a temperature at a range of about 75 to 100° C. Rolls **1**, **2**, and **3** are neither heated nor cooled. Rolls **4**, **5**, **6**, **7**, and **8** are maintained at a temperature of from about 40 to 60° C. Between rolls **7** and **11** the tow passes through a second vessel **10**, which contains a second inert liquid bath maintained at a temperature in the range of about 80 to 100° C. The second inert liquid bath may be in the form of a liquid spray if desired.

Using the FIG. 2 version of the apparatus, the tow is passed over rolls **1** through **16** and **19** through **26**, respectively, rolls **1** to **16** being maintained at a given peripheral speed while rolls **19** through **26** have a uniform peripheral speed at least 2× greater. Between rolls **6** and **7** the tow passes through a vessel **17**, which contains the first inert liquid bath maintained at a temperature at a range of about 75 to 100° C. Rolls **1** to **7** are neither heated nor cooled. Rolls **8** to **16** are maintained at a temperature of from about 40 to 60° C. Between rolls **16** and **19** the tow passes through a second vessel **18**, which contains a second inert liquid bath maintained at a temperature in the range of about 80 to 100° C. The second inert liquid bath may be in the form of a liquid spray if desired.

The apparatus described is convenient to carry out the process of this invention. However, it should be pointed out that other apparatus may be used equally as well. The number and arrangement of the rolls in the apparatus used may be varied, although it is desirable to employ a plurality of feed rolls and a plurality of draw rolls.

The tow cooling step between the two aqueous baths is required to prevent filaments from breaking at draw ratios required to develop desirable high fiber tenacity and low fiber elongation. The combination of high preheat bath temperature, medium temperature between the two baths and high temperature in the draw bath gives the optimum fiber properties.

The process of the present invention is used to its greatest advantage in drawing large tows comprised of substantially unoriented polyester filaments. By "large tows" is meant tows of a thickness (dry) in excess of about 1/32 inch. Wetted tow is about twice the thickness of the dry tow. The width of the tow is not critical because the rise in temperature at the interior of the tow is determined by the thickness and not by the width. Using normal spinning conditions, the filaments will usually have a small degree of orientation introduced during the spinning operation. The draw ratio applied to the tow will vary depending upon the character of the product desired and upon the degree of orientation introduced into the filaments during spinning. Generally, a draw ratio of at least 2× the original length of the filaments may be used for the purposes of this invention. Preferably, the draw ratio used will be from about 2 to about 6× the original length of the filaments. Drawing speeds of up to about 500 yards/minute may be used.

The polyester filaments suitable for drawing according to the process of this invention are those formed from dicarboxylic acids and glycols, and copolyesters or modifications of these polyesters and copolyesters. The polyesters and copolyesters specifically useful in the instant invention are those resulting from heating one or more of the glycols of the series, $HO(CH_2)_nOH$, in which n is an integer from 2 to 10, with one or more dicarboxylic acids or ester-forming derivatives thereof. The process of this invention is particularly useful in the drawing of polyethylene terephthalate filaments which are the polycondensation product of ethylene glycol and terephthalic acid or an ester-forming derivative thereof.

The drawing of polyester filaments using the process of this invention produces highly uniform oriented filaments. Attempts to draw polyester tows under process conditions outside the scope of this invention result in a less desirable product. An important factor in determining the quality of the drawn tow is the frequency of segments of undrawn filaments in the drawn tow. Undrawn filament segments accept dye much more readily than drawn filaments and therefore show up in the dyed fabrics as undesirable deeply dyed flecks. Drawing filament according to the process of this invention produces drawn filament exhibiting very few of these deeply dyed flecks.

To further illustrate the present invention and the advantages thereof, the following specific examples are given, it being understood that these are merely intended to be illustrative and not limitative. The values reported in the examples for dyeing defects were determined by cutting the tow to staple fiber, carding and blending the staple fibers, and dyeing samples of the blended fibers with Latyl Blue FLW dye (C.I. Disperse Blue 27). The dyeing defects are reported as the number of dark-dyed fibers per 100 grains of card sliver. Dyeing defect values in excess of about 20 are usually regarded as being too high for commercial acceptability; and average values lower than 10 are desired in order that occasional samples will not exceed the value 20.

EXAMPLE I

Polyester yarn was prepared by extruded molten polyethylene terephthalate through a 280 hole spinnerette in a conventional manner. The yarn was collected at a speed of 1,100 yards/minute and wound on bobbins. Yarn denier was 1430. Fiber birefringence averaged 0.0047. Ninety-six ends of this yarn were plied to form a tow of approximately 28,880 filaments and 137,000 undrawn denier. This tow was drawn on the apparatus shown in FIG. 1. The first aqueous bath was maintained at 55° C., rolls **4–8** at 55° C. and the second aqueous bath, in the form of a spray, at 90° C. The tow was fed in the form of a flat sheet 2½ inches wide and 0.012 inch thick over feed rolls **1–8** at 27.8 yards/minute and taken up on draw rolls **11–18** at 125 yards/minute. Dwell time in the first aqueous bath was 0.9 second. Exposure time on rolls **4–8** was 8.4 seconds. The draw ratio was 4.5. From the draw rolls the tow passed into a conventional stuffing box crimper and then into a hot air oven where it was dried at 145° C. for 9 minutes in a free-to-relax condition. The filaments in the dried tow averaged 1.49 denier, 4.1 grams per denier tenacity and 43 percent elongation. The tow was found to have a dyeing defect count of 22 per 100 grain card sliver.

The experiment was repeated using the same yarn bobbins but raising the first aqueous bath temperature to 80° C. and changing the temperature of rolls **4–8** to 40–45° C. Tow drawing performance was equally good. Filament denier was slightly lower at 1.45, tenacity significantly higher at 5.0 grams/denier, and elongation lower at 34 percent. The tow was uniformly drawn as proved by a dyeing defect count of 10 per 100 grains card sliver.

EXAMPLE 2

Polyester yarn was prepared by extruding molten polyethylene terephthalate through a 280 hole spinnerette in

a conventionl manner. The yarn was collected at a speed of 1100 yards/minute and wound on bobbins. Yarn denier was 1270. Fiber birefringence was in a 0.006 to 0.010 range. One hundred and forty ends of this yarn were plied to form a tow of approximately 39,200 filaments and 177,000 undrawn denier. This tow was drawn on the apparatus shown in FIG. 1. The first aqueous bath was maintained at 78° C., rolls **4** through **8** at 55° C. and the second aqueous bath at 90° C. The tow was fed in the form of a flat sheet 2½ inches wide and 0.012 inch thick over feed rolls **1–8** at 52.7 yards/minute and taken up on draw rolls **11–18** at 215 yards/minute. Dwell time in the first aqueous bath was 0.47 second. Exposure time on rolls **4–8** was 4.8 seconds. The draw ratio was 4.08. From the draw rolls the tow passed into a conventional stuffing box crimper and then into a hot air oven where it was dried at 145° C. for 9 minutes in a free to relax condition. The filaments in the dried tow average 1.56 denier, 50 percent elongation, and 5.4 grams/denier tenacity. The tow was uniformly drawn as shown by a dyeing defect count of 3.

The experiment was repeated raising rolls **4–8** to 80° C. Tow drawing performance was very poor. Due to a premature "necking down," the tow broke and wrapped on the draw rolls three times in a 60 minute run. Filament properties were 1.57 denier, 51 percent elongation, and 4.6 grams/denier tenacity, a considerable drop in strength from the previous run; nevertheless, the tow had a low dyeing defect count.

EXAMPLE 3

Polyester yarn was prepared by extruding molten polyethylene terephthalate through a 280 hole spinnerette in a conventional manner. The yarn was collected at a speed of 1,120 yards/minute and wound on bobbins. Yarn denier was 1310. Fiber birefringence was in a 0.004 to 0.010 range. One hundred and forty-four ends of this yarn were plied to form a tow of approximately 40,300 filaments and 187,000 undrawn denier. This tow was drawn on the apparatus shown in FIG. 2. The first aqueous bath was maintained at 55° C. rolls **8–16** at 55° C. and the second aqueous bath, in the form of a spray, at 90° C. The tow was fed in the form of a flat sheet 2½ inches wide and 0.012 inch thick over feed rolls **1–16** at 55.3 yards/minute and taken up on draw rolls **19–26** at 215 yards/minute. Dwell time in the first aqueous bath was 0.45 second. Exposure time on rolls **8–16** was 8.0 seconds. The draw ratio was 3.93. From the draw rolls, the tow passed into a conventional stuffing box crimper and then into a hot air oven where the tow was dried at 145° C. for 12 minutes in a free-to-relax condition. The filaments in the dried tow averaged 1.54 deniers, 5.16 grams per denier tenacity, 30 percent elongation, and 35 modulus.

The experiment was repeated using the same yarn bobbins but raising the first aqueous bath temperature to 80° C. The drawing performance was equally good. Filament denier was the same at 1.54, tenacity slightly higher at 5.19 grams/denier, elongation 30 percent and modulus higher at 43. Both samples were uniformly drawn as shown by comparable dyeing defect counts.

EXAMPLE 4

A polyester tow of approximately 300,000 filaments having a d.p.f. of 13.3, and a total denier of 4,000,000, the tow being about 15 inches wide and about 0.05 inch thick, was passed through a first bath at a temperature of 76° F., with an exposure time of 4½ seconds. The tow was then passed over a series of rolls maintained at a temperature of 60° C. Exposure time to this temperature was about 35 seconds. Thereafter, the tow passed through a draw bath maintained at 100° C., and was drawn at a ratio of 5.40. Drawing performance was good. The tow was then crimped, dryed, and annealed at 132° C. for about 15 minutes. The fiber product, 3 deniers/filament with a tenacity of 5.2 grams/denier and an elongation of 43%, was uniformly drawn as shown by a low dyeing defect count.

I claim:

1. A process for orienting filaments composed of at least 85% by weight of an ester of a dihydric alcohol and terephthalic acid, in the form of tows of a thickness in excess of about 1/32 inch, at speeds prior to drawing of at least about 50 yards/minute, comprising passing the tow containing a plurality of substantially unoriented filaments through an inert bath at a temperature of from about 75° C.–100° C., with a dwell-time of from about 0.2–5.0 seconds; immediately thereafter exposing the tow to a temperature from about 40–60° C. with exposure time of from about 5–40 seconds, thereby effecting a uniform optimum pre-draw temperature of about 62° C. throughout the tow; and immediately thereafter drawing said tow to at least two times its original length while passing it through a second inert fluid bath maintained at a temperature of from about 80° C.–100° C.

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