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3,770,866

DRAWING POLYESTER FILAMENTS USING AS A SNUBING MEANS

A HEATED ROLLER DRIVEN AT THE FEED RATE SPEED

Filed Jan. 4, 1972

2 Sheets-Sheet 1

Fig. 1

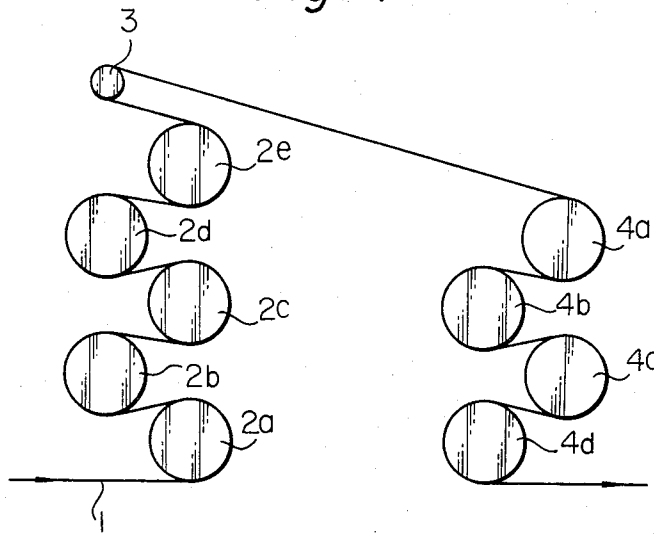
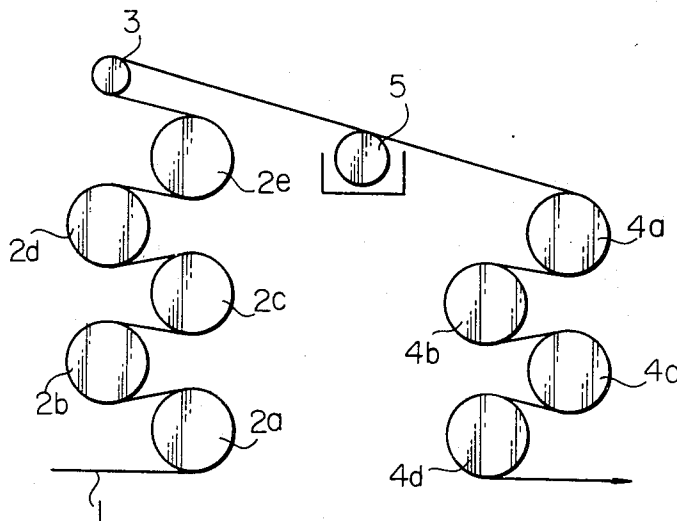


Fig. 2



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2 Sheets-Sheet 2

Fig. 3

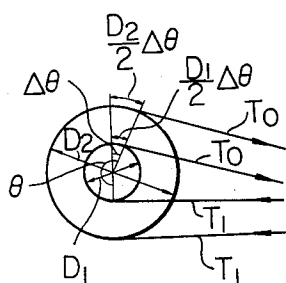
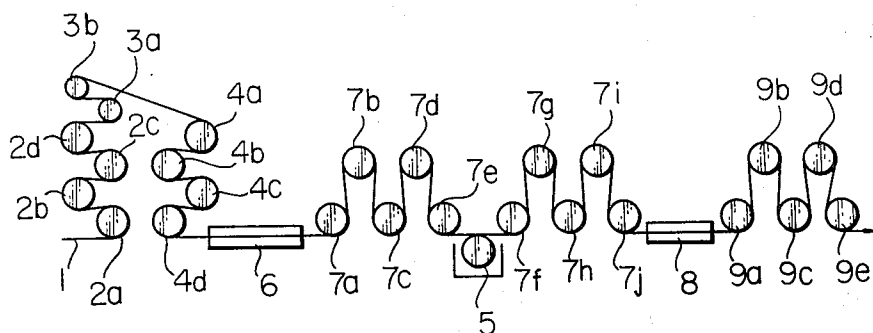


Fig. 4



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DRAWING POLYESTER FILAMENTS USING AS A SNUBING MEANS A HEATED ROLLER DRIVEN AT THE FEED RATE SPEED

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Continuation-in-part of abandoned application Ser. No. 6,733, Jan. 29, 1970. This application Jan. 4, 1972, Ser. No. 215,383

Claims priority, application Japan, Feb. 3, 1969, 44/7,992

Int. Cl. B29c 17/02

U.S. Cl. 264—290 T

12 Claims

ABSTRACT OF THE DISCLOSURE

A process for drawing polyester filaments which comprises drawing undrawn filaments of polyester containing at least 85 mol percent of ethylene terephthalate units between plural, heated feed rollers and at least one drawing roller rotating at a peripheral speed higher than that of the feed rollers, the improvement residing in the features that the peripheral speeds of all feed rollers are substantially the same, at least the last feed roller is given a small diameter of 15 to 50 mm., and the arc of contact of the filaments on said roller is made at least 180°, whereby the drawing point is fixed on said roller.

This is a continuation-in-part application of Ser. No. 6,733, filed Jan. 29, 1970, now abandoned.

This invention relates to a process for drawing polyester filaments. More particularly, the invention relates to a process for drawing polyester filaments in which the drawing point is fixed, and filament breakage and wrapping of the broken filaments around the drawing rollers are reduced, the resulting drawn filaments exhibiting uniform tensile strength, uniform elongation and little fluffs.

The most conventionally employed means for drawing polyester filaments comprises the provision of a fixed heating means such as a heated snubbing pin or plate, between the feed roller and drawing roller, and drawing the filaments by fixing the drawing point on said pin or plate. This method is quite effective when the denier of the filaments to be drawn is light and the drawing rate is low, but when filaments of heavy deniers are to be drawn, it is difficult to heat uniformly the entire filaments across the cross-section, and consequently filament breakage and wrapping of the broken filaments around the drawing roller during drawing operation increase, which causes uneven distribution of physical properties and fluff formation in the drawn filaments.

Again, when the drawing rate is increased, the friction between the fixed pin or plate and the filaments passing thereon is also increased to cause frequent filament breakage, rendering satisfactory drawing impossible.

For this reason, it has been proposed to not use such fixed heating means, but to employ plural, heated feed rollers, the filaments being passed on the rollers in zig-zag form to be sufficiently heated and drawn at high speed (British Pat. No. 874,652).

According to the above process, the defects in the first-mentioned method are generally removed, but new problems such as shifting in drawing point, containing of undrawn portions in drawn filaments, wrapping of the broken filaments onto the drawing roller during drawing operation, occurrence of filament breakage and fluffs, increase of unevenness in tensile strength, elongation of the drawn filaments, etc. are brought about. Particularly, when undrawn polyester filaments of high polymerization degree are drawn at high draw ratios in order to produce high tenacity filaments, such shifting in drawing point re-

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duces the drawability, and drawn filaments having uniform properties cannot be obtained.

The object of the present invention is to provide a process for effectively drawing polyester filaments without using fixed heating means, in which the drawing point is not mobile but fixed, and such troubles as drawing, monofilament coiling around the drawing roller, occurrence of filament breakage and fluffs, etc. are eliminated.

Another object of the present invention is to provide an economically advantageous process whereby polyester filaments of heavy deniers can be effectively drawn, free of the aforementioned drawbacks.

Still other objects and advantages of the invention will become apparent from the following descriptions.

We discovered that in drawing polyester filaments without using a fixed heating means, filament breakage and wrapping of the broken filaments around the drawing roller during the drawing operation could be remarkably reduced and uneven tensile strength and elongation distribution in the resulting drawn filaments could also be reduced by provision of plural, heated feed rollers rotating at substantially identical peripheral speeds, making the diameter of at least the last feed roller, i.e., the roller located the nearest to the drawing roller, 15 to 50 mm., and contacting filaments on said roller to deflect at least 180° of arc, whereby the drawing point is fixed on the last feed roller.

Due to the identical peripheral speeds, the smaller feed roll or rolls must of course be positively driven rather than rotating freely. According to the present invention, the draw point of undrawn yarn is fixed effectively on the smaller diameter roll, and there is less breaking of the yarn by positively driving the smaller diameter roll and making the peripheral speed of the smaller diameter roll equal to that of the large diameter feed rolls. If the peripheral speeds are not equal, for example if the smaller diameter roll is allowed to rotate freely, the draw point varies and considerable yarn breakage occurs. This is shown later on in a comparative example. Such a defect can be obviated with the present invention.

Thus, the present invention is characterized in that, while drawing thermoplastic, synthetic filaments between plural, heated feed rollers rotating at substantially the same peripheral speed and at least one drawing roller rotating at a higher peripheral speed than the feed rollers, a small diameter, i.e. 15 to 50 mm., is given at least to the last feed roller, and the filaments are contacted on said roller to be deflected at least 180° of arc, to fix the drawing point on said roller.

We furthermore discovered that, in the above drawing process, if the quantity of finishing agent applied to undrawn polyester filaments is adjusted to less than that conventionally employed, such as 0.05 to 0.6% by weight, the drawing point is still more accurately fixed on the last feed roller, and still better drawing can be performed.

Thus, in an embodiment of the present invention, undrawn filaments of polyester containing at least 85 mol percent of ethylene terephthalate units are drawn between plural, heated feed rollers rotating at substantially the same peripheral speed, and at least one drawing roller rotating at a peripheral speed higher than that of the feed rollers, the quantity of finishing agent applied to the undrawn filaments is adjusted to 0.05 to 0.6 wt. percent, at least the last of the heated feed rollers is given a small diameter of 15 to 50 mm., and the filaments are contacted on the small diameter roller to be deflected at least 180° of arc, whereby the drawing point is fixed on said small diameter roller.

Although not critical within this range, the ratio of the diameter of the large feed rolls to that of the small feed rolls should be within the range 1.6–40:1.

During our research works, it was discovered that, particularly in multi-stage drawing for making polyester filaments of high tenacity, a markedly satisfactory result is obtained when the above-described drawing process is adopted for the first stage drawing, while making the surface temperature of the small diameter roller 60–110° C., and the first stage drawing ratio 2.5–5.5 times.

Thus, still in another embodiment of the present invention, undrawn filaments of polyester containing at least 85 mol percent of ethylene terephthalate units and having an intrinsic viscosity (calculated from the measured value in *o*-chlorophenol at 35° C.) of preferably at least 0.75 are (a) drawn between plural, heated feed rollers rotating at substantially the same peripheral speed and at least one drawing roller rotating at a peripheral speed higher than that of the feed rollers, the finishing agent pick-up of the undrawn filaments is adjusted to 0.05 to 0.6 wt. percent, at least the last of the heated feed rollers is given a diameter of 15 to 50 mm., the surface temperature of the small diameter roller is maintained at 60–110° C., the filaments are contacted on the small diameter roller to be deflected at least 180° of arc, and the draw ratio is adjusted to between 2.5 and 5.5 times, and (b) thus drawn filaments are further drawn by at least 1.1 times between said drawing roller and another drawing roller rotating at a peripheral speed higher than that of the first drawing roller, whereby polyester filaments well suited for industrial use are provided.

Hereinafter the subject process will be explained, referring to the attached drawings in which:

FIG. 1 is a diagrammatic side view for illustrating the arrangement of feed rollers and drawing rollers in an apparatus used for practicing the present invention,

FIG. 2 is similar to FIG. 1, except that a finishing agent-applying means is provided between the feed rollers and drawing rollers.

FIG. 3 is an explanatory drawing of the drawing mechanism of the subject process, and

FIG. 4 is a diagrammatic side view showing the arrangement of various rollers in an apparatus for practicing the multi-stage drawing in accordance with the invention.

FIG. 1 shows an embodiment of drawing filaments with an apparatus comprising plural, heated feed rollers and plural drawing rollers, in which the undrawn filament 1 is passed in zig-zag form on the five heated feed rollers 2a–2e driven at a same peripheral speed and a small diameter feed roller 3 driven at the same peripheral speed as rollers 2a–2e and heated to the same temperature level as of the feed rollers 2a–2e, and the filament is then drawn by the four drawing rollers 4a–4d which are driven at a peripheral speed greater than that of the feed rollers. The draw ratio normally ranges 3 to 7 times. In multi-stage drawing, it is preferred to effect the first stage drawing at a draw ratio of 2.5 to 5.5 times, and to make the total draw ratio 3 to 7 times.

In the above embodiment, an oiling roller 5 for applying finishing agent, etc. may be provided before the drawing roller 4a, as illustrated in FIG. 2.

According to the subject process, it is required that at least the last roller 3 among the plural feed rollers is given a small diameter of 15 to 50 mm. as illustrated in the drawings.

When at least the last feed roller 3 in the heated feed rollers group is thus given a diameter of 15 to 50 mm., variation in drawing point is markedly reduced compared with the case of using a greater diameter feed roller. The reason may be explained with reference to FIG. 3. Generally, the tension in the filaments wound on a roller is expressed by $T_0 = T_1 e^{\mu \theta}$, in which T_0 and T_1 are respectively the tension in the filaments at the exit and entrance from and into the roller, μ is the frictional coefficient between the roller and filaments, and θ is the contact angle formed by the roller and the filaments. Therefore, the tension differences ΔT at a smaller contact angle $\Delta \theta$ is determined without regard to the roller diameter. Considering now

two rollers of the diameter D_1 and D_2 , respectively, the tension gradients in the filaments become $2\Delta T/D_1\Delta\theta$, and $2\Delta T/D_2\Delta\theta$, respectively, from FIG. 3. Thus, the less the diameter of the roller, the greater the tension gradient, and it becomes possible to fix the drawing point at a constant position.

However, in case the last roller 3 of the heating and feeding roller system has a diameter less than 15 mm., the strength of the roller system is lowered and it cannot be used for a long time.

According to the subject process, it is furthermore required that the undrawn filament 1 must be contacted on the small diameter feed roller 3 to be deflected at least 180° of arc.

If the arc of contact of the filaments on the small diameter feed roller 3 is less than 180°, even when the roller's diameter is not over 50 mm. as required, the drawing point cannot be fixed on said roller but is moved to the undrawn filaments-feeding side, to increase the occurrence of filament breakage and wrapping of the broken filaments around the drawing roller, making the smooth drawing operation difficult.

That is, in order to fix the drawing point to perform smooth drawing, it is necessary to use a small size roller of 15 to 50 mm. in diameter as at least the last feed roller, and to contact the filaments on said feed roller at least 180° of arc.

When a small diameter heated feed roller as above is used, that roller alone cannot sufficiently heat the undrawn filaments. Therefore, heated feed rollers must be provided preceding the small diameter roller or rollers to secure the sufficient heating of the filaments. Such can be secured by setting the contact time of the filaments with the surfaces of the heated rollers within the range of 1 to 10 seconds. In the embodiment of FIG. 1, plural feed rollers of relatively large diameters, such as above 100 mm., are provided to effect sufficient heating. The small diameter feed roller is preferably provided close to the larger diameter, heated feed rollers, preferably within the distance of 50 mm., so as to prevent cooling of the filaments.

The surface temperatures to be given to the feed rollers are variable depending on such factors as the type of polyester filaments to be drawn, filament size, travelling speed of the filaments, etc., but generally temperatures around or over the second transition point of the polyester forming the filaments are conveniently employed. Particularly preferred temperatures range from 60 to 110° C., especially 65–100° C. When many feed rollers are used, the feed roller group may contain a few number of unheated rollers, so far as the sufficient heating of undrawn filaments is secured.

The surface of the small diameter feed roller is suitably given a mirror surface finish in order to prevent filaments from slipping thereon as well as to fix a drawing point thereon, but in certain cases it may be given a matte finish.

Only one, or plural drawing rollers may be used. All the heated feed rollers and drawing roller or rollers are suitably driven forcedly.

Furthermore, in the process of this invention, the finishing agent pick-up of the undrawn filaments 1 is preferably controlled to 0.05–0.6 wt. percent to the weight of undrawn filaments. Generally, in drawing synthetic filaments a finishing agent is applied to the filaments to be drawn, during the spinning or immediately before the drawing step, in order to prevent accumulation of static charge and to improve filament bundling property as well as drawability. The finishing agent pick-up on the undrawn filaments is normally controlled to be at least 1.0 wt. percent in case of polyester filaments. However, in the preferred embodiment of the subject process, it is reduced to such minor amount as at most 0.6 wt. percent.

When the diameter of at least the last feed roller 3 is made 15 to 50 mm., the arc of contact of the fila-

ments on the small diameter feed roller at least 180°, and the finishing agent pick-up onto the undrawn filament from 0.05 to 0.5 percent by weight, the drawing point can be fixed on the small diameter feed roller 3 with increased certainty, compared with the case when more than 0.5 percent by weight of the finishing agent is applied. Thus, the filament breakage and wrapping of the broken filaments around the drawing roller can be further decreased to effect still smoother drawing. Accordingly, in this embodiment of the invention, uneven distribution in tensile strength, and elongation of drawn filaments are also further reduced.

The type of the finishing agent to be applied onto the undrawn filaments in the subject process may be any which has been conventionally employed in the spinning or drawing step of polyester filaments. Those finishing agents are applied to the filaments in the optional, conventionally employed form such as the oily state, emulsion, solution, etc., while the finishing agent pick-up referred to in the present specification is the weight percent of the finishing agent itself, per the filaments' weight. In order to control the finishing agent's pick-up to such minor amount as 0.05 to 0.6 wt. percent, either the finishing agent of the specified amount is applied to the undrawn filaments, or the once applied excessive amount of finishing agent may be squeezed out of the filaments preceding the drawing.

Since the finishing agent pick-up on the undrawn filaments is as little as at most 0.6 wt. percent according to the invention, the drawn filaments tend to accumulate static electric charge, exhibit deteriorated bundling property, or form loops. Therefore, it is a preferred practice to apply a suitable amount of finishing agent to the filaments after the drawing (in case of multi-stage drawing, after the first stage drawing) but before winding, to prevent occurrence of such troubles. The finishing agent to be applied onto the filaments after drawing is not necessarily the same as that applied to the undrawn filaments. When polyester filaments for tire cord, belt cord, belt duck, etc., are to be drawn, epoxy compound, isocyanate compound, etc. may be applied to the filaments at the optional point between the drawing and winding, so as to improve their adhesion with rubber.

The subject process is particularly effective for multi-stage drawing of undrawn filaments to make high tenacity filaments for industrial use.

FIG. 4 shows one example of such multi-stage drawing, in which the undrawn filament 1 is subjected to the first stage drawing between the heated feed rollers 2a-2d, small diameter, heated feed rollers 3a, 3b, and the first stage drawing rollers 4a-4d. In that case it is necessary to make the diameter of the small size feed roller 3b 15 to 50 mm., and the arc of contact of the filaments on the roller 3b, at least 180°. Furthermore, it is desirable to control the finishing agent pick-up on the undrawn filaments 1 within the range of 0.05 to 0.6 wt. percent. It is also necessary that the surface temperature of the heated feed rollers 2a-2d and that of the small diameter, heated feed rollers 3a, 3b, should range from 60° to 110° C., and the first stage draw ratio should range from 2.5 to 5.5 times (preferably 3.5-5.0 times). When the temperature and draw ratio are out of the specified ranges, the fixing of the drawing point becomes imperfect and the filaments tend to break and form fluffs during drawing at the second and subsequent stages, failing to provide drawn filaments of uniform properties.

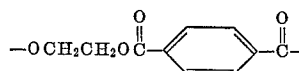
Then the first-stage drawn filaments are further drawn at least 1.1 times, preferably 1.2-1.7 times, by second stage drawing between the first stage drawing rollers 4a-4d and second stage drawing rollers 7a-7j. In that case, the filaments are preferably heated to approximately 120-300° C. during the second stage drawing. As the heating means 6 in FIG. 4, a slit heater is suitable for eliminating its friction with the running filaments to enable high speed drawing. In order to raise the atmospheric temper-

ature in the slit to 120-300° C. as aforesaid, it is necessary to heat the heater itself to 200-400° C. Between the second stage drawing rollers 7e and 7f, an oiling roller 5 for applying a finishing agent to the filaments is suitably provided.

Thus second-stage drawn filaments are then heat-treated between the second stage drawing rollers 7a-7j and driven rollers 9a-9e, in a stretched, constant length, or shrunk state ranging from 1.2 to 0.8 times the length before the heat treatment. The heating means 8 in that case may be a slit heater similar to that employed in the second stage drawing. The atmospheric temperature in the slit ranges 120-300° C.

As already mentioned, it is desirable to use undrawn filaments of polyester having an intrinsic viscosity of at least 0.75, for producing high tenacity filaments by such multi-stage drawing.

The polyester undrawn filaments employed in the invention are composed of high molecular polyester containing at least 85 mol percent, preferably 95 mol percent, of a recurring structural unit of the formula,



The undrawn filaments may be those which are spun by optional spinning means conventionally employed.

Thus the term "polyester" is used in the specification and claims, in the sense including modified polyethylene terephthalate by the addition of no more than approximately 15 mol percent of other ester-forming units. As such other ester-forming units, the following may be named by way of examples; diethylene glycol, other polymethylene glycol of 1-10 carbons, hexahydro-p-xylylene glycol; aromatic dicarboxylic acids such as isophthalic, dibenzoic, p-terphenyl-4,4'-dicarboxylic, and hexahydro-terephthalic acids; aliphatic acid such as adipic acid; hydroxy acid such as hydroxyacetic acid; and the like.

The properties of the undrawn filaments are not critical, but the filaments having an intrinsic viscosity of at least 0.3, preferably at least 0.75 and a birefringence ranging 0.0005-0.0120 are preferred. The undrawn filaments having a birefringence outside the specified range tend to produce drawing failure or increase filament breakage during drawing operation. The density of the undrawn filaments is preferably no higher than 1.35 g./cm.³. Otherwise the filament breakage during drawing tends to be increased.

Also the filaments to be drawn may have optional cross-sectional configuration, such as a circle and other modified forms. Again the subject drawing process is applicable to any of multifilaments and tows for staple fibers, while it is particularly effective for drawing undrawn filaments of heavy deniers such as above 2,000 deniers, at high draw ratios.

According to the present drawing process, even with such heavy denier filaments, the drawing point can be fixed. Consequently the resulting drawn filaments have uniform tensile strength and elongation and little fluffs, providing high quality products. Furthermore, filaments breakage as well as wrapping of the broken filaments around the drawing roller are reduced to improve production efficiency.

It is also possible in the subject process to parallel many strands of filaments and draw them simultaneously.

The values denoting the properties of polymer and filaments given in the specification are measured as follows.

Intrinsic viscosity of a polymer is given as a norm of degree of polymerization of that polymer, which is defined below:

$$\lim_{c \rightarrow 0} \frac{\ln \eta_r}{c}$$

In the formula, η_r is normally referred to as relative viscosity, obtained by dividing the viscosity of a dilute solution of a polymer by the viscosity of solvent em-

ployed which is measured at the same temperature. Also c is the polymer concentration in the solution expressed by g./100 cc. The intrinsic viscosities given in the present specification are calculated from the values measured at 35° C., using ortho-chlorophenol as the solvent.

It is well known that the load-elongation curve and breaking strength and breaking elongation calculated from the curve are variable in shape and value according to the length of test specimen and extension rate. In the present specification, the tensile test is performed with 20-cm. long samples at an extension rate of 50 percent/min. under standard conditions (20° C., relative humidity of 65%), using an Instron tensile tester.

EXAMPLE 1

Tows of polyethylene terephthalate undrawn filaments having an intrinsic viscosity of 0.62, birefringence of 526×10^{-3} , monofilament denier of 5 de. and total denier of 1,600,000 de. were drawn with the apparatus illustrated in FIG. 1.

The feed rollers 2a-2e each had a diameter of 300 mm. and surface temperature of 75° C., and the small diameter feed roller 3 was given a surface temperature of also 75° C., while its diameter and the arc of contact of the filaments on it were varied in each run. The draw ratio employed in the experiments was 3.9 times, and the drawing speed was 100 m./min. hTe finishing agent pick-up on the undrawn filaments was 0.5% by weight of the filaments.

The results were as given in Table 1 below.

TABLE 1

	Diameter of roller 3 (mm.)	The arc of contact (°)	Amount of broken filament wrapped around drawing roller ¹ (g./hr.)	Drawing point variation range ² (mm.)	Filament breakage ³ (times/day)	Strength distribution (g./de.)	Elongation distribution (percent)	Remarks
Conventional process...	300	180	0.24	±22	3.8	6.10±0.6	29.8±4.8	Control.
Run No.:								
A.....	35	120	0.19	(4)	3.5	5.90±0.8	31.0±4.4	Do.
B.....	35	180	0.01	±2	0	6.02±0.2	30.4±1.8	Subject process.
C.....	35	540	0.00	±1	0	5.95±0.2	31.6±1.5	Do.
D.....	45	120	0.12	(4)	3.0	5.90±0.7	30.8±4.5	Control.
E.....	45	180	0.01	±5	0	6.08±0.3	29.5±2.0	Subject process.
F.....	45	540	0.01	±4	0	6.01±0.2	30.0±2.3	Do.
G.....	55	120	0.17	±18	1.2	6.00±0.5	29.9±3.8	Control.
H.....	55	180	0.12	±15	2.0	6.05±0.4	30.6±4.0	Do.
I.....	55	540	0.13	±12	1.8	5.98±0.4	30.8±3.5	Do.

¹ "Amount of broken filaments wrapped around drawing roller" means the measured amount of the filaments broken and wrapped around the drawing roller during drawing operation expressed by the unit of gram per hour.

² The "drawing point variation range" was determined by naked eye observation.

³ "Filament breakage" denotes the frequency of entire filament breakage during drawing operation per day.

⁴ Drawing point shifted out of the small diameter roller.

From the above table, it can be clearly understood that in the runs B, C, E and F within the scope of the subject process, drawing point variation ranges were little and drawability was remarkably improved, particularly when compared with the conventional practice using large diameter feed rollers only, and that, as the result, drawn filaments of uniform strength and elongation were obtained.

EXAMPLE 2

Polyethylene terephthalate-adipate undrawn filaments (3.0 mol percent of ethylene adipate was copolymerized) having an intrinsic viscosity of 0.80, birefringence of 200×10^{-5} , monofilament denier of 25 de., and total denier of 6250 de. were applied with 0.45% of a finishing agent, drawn by 4.2 times with the apparatus illustrated in FIG. 1, and further drawn by 1.4 times in a slit heater at 200° C., followed by a shrinkage of 5% in a slit heater at 210° C. The diameter of each feed roller

in FIG. 1 2a-2d was 250 mm., that of the feed rollers 2e and 3 was 20 mm., and surface temperature of all the feed rollers was 70° C. The arc of contact of the filaments on the feed roller 3 was 190°. In this run, variation in drawing point was substantially nil as indicated in Table 2, and excellent drawability was demonstrated. Furthermore, the resulting drawn filaments showed uniform tensile strength and elongation distribution. However, when the diameter of the feed rollers 2e and 3 was increased to 250 mm., the same size as the rest of feed rollers 2a-2d, in the manner of conventional practice, the variation in drawing point was notable, and uniformly drawn filaments could not be obtained.

TABLE 2

	Drawing point variation range (mm.)	Amount of broken filaments wrapped around second stage drawing roller (g./hr.)	Filament breakage (times/day)	Strength distribution (g./de.)	Elongation distribution (percent)
Subject process.....	0	0	0.3	9.0±0.2	12.0±0.5
Conventional process.....	20	0.10	4.8	8.3±0.5	11.0±0.7

EXAMPLE 3

Tows of polyethylene terephthalate undrawn filaments having an intrinsic viscosity of 0.65, birefringence of 632×10^{-5} , monofilament denier of 6.5 de., and total denier of 1,600,000 de. were drawn with the apparatus shown in FIG. 1.

The feed rollers 2a-2e were each given a diameter of 300 mm. and surface temperature of 73° C., and the small diameter feed roller 3, a diameter of 45 mm. and surface temperature of 73° C. The arc of contact of the filaments on the small diameter feed roller 3 was 190°. The finishing agent pick-up on the undrawn filaments applied at the spinning step was varied in each run. The draw ratio was

3.6 times, and drawing rate was 100 m./min.

The results were as given in Table 3 below.

TABLE 3

Run No.	Finishing agent pick-up on undrawn filaments (wt. percent)	Amount of broken filaments wrapped around drawing roller (g./hr.)	Drawing point variation range (mm.)	Filament breakage (times/day)
A.....	0.5	0.00	±2	0
B.....	0.7	0.04	±5	0.8
C.....	1.0	0.08	±7	1.2

The above results clearly demonstrate that, by reducing the finishing agent pick-up on the undrawn filaments to not more than 0.6%, variation range in drawing point is reduced and the filaments' drawability can be markedly improved.

9 EXAMPLE 4

Polyethylene terephthalate-adipate undrawn filaments (3.0 mol percent of ethylene adipate was copolymerized) having an intrinsic viscosity of 0.78, birefringence of 183×10^{-5} , monofilament denier of 25 de., total denier of 5840 de., and finishing agent pick-up of 0.45 wt. percent were drawn with the apparatus illustrated in FIG. 4. The feed rollers 2a-2d were each given a diameter of 250 mm., surface temperature of 70° C., and the small diameter feed rollers 3a and 3b, the diameter of 20 mm. and surface temperature of 70° C. The arc of contact of the filaments on the small diameter feed roller 3b was 540°. The draw ratio in the first stage drawing was 4.3 times, that in the

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the resulting drawn filaments showed little non-uniformity in tensile strength and elongation.

However, when the draw ratio in the first stage was selected outside the specified range of 2.5-5.5 times, the drawing point could not be fixed on the small diameter feed roller 3b. Also when the surface temperature of the feed rollers 2a-2d, 3a and 3b was selected outside the specified range of 60°-110° C., the drawing point could not be fixed on the small diameter roller 3b, and objectionable wrapping around the drawing roller, fluff formation and filament breakage tended to occur more frequently.

The results were as shown in Table 5 below.

TABLE 5

Run No.	First stage draw ratio (times)	Second stage draw ratio (times)	Total draw ratio (times)	Feed rollers surface temp. (° C.)	Drawing point variation range (mm.)	Amount of broken filaments wrapped around second stage drawing roller (g./hr.)	Filament breakage (times/day)	Strength distribution (g./de.)	Elongation distribution (percent)
A.-----	4.0	1.5	5.6	80	±1	0.0	0	9.5±0.2	11.3±0.4
B.-----	2.0	2.8	5.6	80	(1)	1.5	15	9.0±0.4	10.7±0.9
C.-----	5.6	1.0	5.6	80	(1)	2.4	28	8.8±0.7	9.8±0.9
D.-----	4.0	1.5	5.6	40	(1)	1.3	18	9.3±0.4	10.7±0.8
E.-----	4.0	1.4	5.6	130	(1)	0.7	12	8.9±0.6	11.1±1.0

¹ Drawing point shifted out of the small diameter roller.

second stage drawing was 1.4 times, and the temperature in the slit of slit heater 6 was 200° C. Thus drawn filaments were then heat-treated under stretching to 1.05 times in a slit heater 8 heated to such a level as will maintain the atmosphere in the slit at 200° C. during the third stage treatment. In this experiment the variation in drawing point was substantially nil as demonstrated in Table 4, and the filaments exhibited excellent drawability. Furthermore, the resulting drawn filaments showed little unevenness in tensile strength and elongation.

In contrast, when the diameter of feed roller 3b was increased over 50 mm., or when the arc of contact of the filaments on the feed roller 3b was reduced to less than 180°, drawing point variation became remarkable, and uniform drawn filaments could not be obtained.

To show the necessity for positively driving the smaller diameter feed roll at substantially the same peripheral speed as the preceding feed rolls, the following experiment was conducted.

COMPARATIVE EXPERIMENT

Polyethylene terephthalate undrawn filaments having an intrinsic viscosity of 0.92, a birefringence of 200×10^{-5} , a monofilament denier of 21.8 and a finishing agent pick-up of 0.40% by weight were drawn with the apparatus illustrated in FIG. 1. The large feed rollers 2a-2e each had a diameter of 250 mm. and a surface temperature of 80° C., and the smaller feed roller a diameter of 20 mm. and a surface temperature of 80° C. The arc of contact of the filaments on the small roller 3 was 190°. The draw

TABLE 4

Run No.	Diameter of feed roller 3b (mm.)	The arc of contact of filaments on the feed roller 3b (°)	Drawing point variation range (mm.)	Amount of broken filament wrapped around second stage drawing roller (g./de.)	Filament breakage (times/day)	Strength distribution (g./de.)	Elongation distribution percent	Remarks
A.-----	20	540	0	0	0.1	9.1±0.2	11.9±0.4	Subject process.
B.-----	20	150	5	0.09	3.0	8.9±0.4	11.9±0.6	Control.
C.-----	55	540	16	0.12	3.6	8.7±0.5	11.5±0.8	Do.

EXAMPLE 5

Polyethylene terephthalate undrawn filaments having an intrinsic viscosity of 0.92, birefringence of 200×10^{-5} , monofilament denier of 21.8 de., total denier of 5,430 de., and finishing agent pick-up of 0.40 wt. percent drawn with the same apparatus as employed in Example 4.

The surface temperature of feed rollers 2a-2d, 3a and 3b was 80° C., the arc of contact of the filaments on the small diameter feed roller 3b was 190°, the draw ratio in the first stage drawing was 4.0 times, that in the second stage drawing was 1.4 times, and intra-slit temperature of the slit heater 6 was 200° C. Thus drawn filaments were heat-treated in a slit heater 8 which was heated to maintain the intra-slit temperature at the third stage treatment

ratio employed was 4.0 and the drawing speed was 172 m./min. The large and smaller feed rollers 2a-2e, 3 were positively driven at a peripheral speed of 43 m./min. The drawn filaments were further drawn by 1.4 times in a slit heater at 200° C., followed by shrinking by 9% in a slit heater at 210° C. On the other hand, when a freely rotatable roller was employed instead of the smaller positively driven feed roller, with the freely rotatable roller having the same diameter and temperature as the smaller feed roller, the draw point variation became remarkable, and objectionable wrapping around the drawing rollers, fuzz formation, and filament breakage tended to occur much more frequently. The results are shown below.

TABLE

Run No.	Means for fixing the draw point	Draw point variation range (mm.)	Amount of broken filament wrapped around the draw rollers (g./hr.)	Filament breakage (times/day)	Strength distribution (g./de.)	Elongation distribution (percent)	Remarks
A.-----	Positively driven smaller feed roller.....	0	0.0	0	9.0±0.2	12.0±0.5	Subject process.
B.-----	Freely rotatable smaller feed roller.....	*-80	0.5	4.5	8.5±0.5	11.0±0.7	Control.

*The draw point was shifted toward the large feed rollers.

at 210° C., under a shrinkage of 3%. In the experiment, variation in drawing point was substantially nil, and the filaments exhibited excellent drawability. Furthermore,

What is claimed is:

1. A process for drawing an undrawn polyester filament containing at least 85 mol percent ethylene tereph-

thalate units which comprises feeding the filament between plural feed rollers of substantially equal diameter with a surface temperature of 60–110° C. and positively driven at substantially the same peripheral speed, contacting the filament with at least one smaller feed roller, positively driven by means other than the filament at substantially the same peripheral speed as the plural feed rollers and having a diameter of 15–50 mm. and temperature of 60–110° C., at an arc of at least 180°, the ratio of the diameter of the plural feed rollers to the diameter of the smaller feed roller being between 1.6:1 and 40:1, and passing the filament onto at least one drawing roller rotating at a peripheral speed higher than that of the feed rollers to draw the filament at a draw ratio between 2.5:1 and 5.5:1, whereby the draw point is fixed on the last smaller feed roller.

2. The process according to claim 1, wherein 0.05–0.6% by weight of a finishing agent is applied to the filament between the last smaller diameter feed roller and the first drawing roller.

3. The process according to claim 1, wherein the undrawn filament has a denier value above 2,000.

4. The process according to claim 1, wherein the polyester is polyethylene terephthalate.

5. The process according to claim 1, wherein the polyester has an intrinsic viscosity as measured in orthochlorophenol at 35° C. of at least 0.75.

6. The process according to claim 1, wherein the undrawn filament is fed between the plural feed rollers in zig-zag form.

7. The process according to claim 1, wherein 0.05–0.6% by weight of finishing agent is applied to the filament prior to contacting the filament with the first feed roller.

8. A process for drawing an undrawn polyester filament containing at least 85 mol percent ethylene terephthalate units which comprises feeding the filament between plural feed rollers of substantially equal diameter with a surface temperature of 60–110° C. and positively driven at substantially the same peripheral speed, the filament having a finishing agent thereon in an amount of 0.05–0.6% by weight of the filament, contacting the filament with at least one smaller feed roller, positively driven by means other than the filament at substantially the same peripheral

speed as the plural feed rollers and having a diameter of 15–50 mm. and temperature of 60–110° C., at an arc of at least 180°, the ratio of the diameter of the plural feed rollers to the diameter of the small feed roller being between 1.6:1 and 40:1, passing the filament onto at least one drawing roller rotating at a peripheral speed higher than that of the feed rollers to draw the filament at a draw ratio between 2.5:1 and 5.5:1, whereby the draw point is fixed on the last smaller feed roller, and further drawing the drawn filaments at least 1.1 times between the drawing roller and another drawing roller rotating at a peripheral speed higher than that of the first drawing roller.

9. The process according to claim 8, wherein the undrawn filament has a denier value above 2,000.

10. The process according to claim 8, wherein the polyester is polyethylene terephthalate.

11. The process according to claim 8, wherein the polyester has an intrinsic viscosity as measured in orthochlorophenol at 35° C. of at least 0.75.

12. The process according to claim 8, wherein the undrawn filament is fed between the plural feed rollers in zig-zag form.

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