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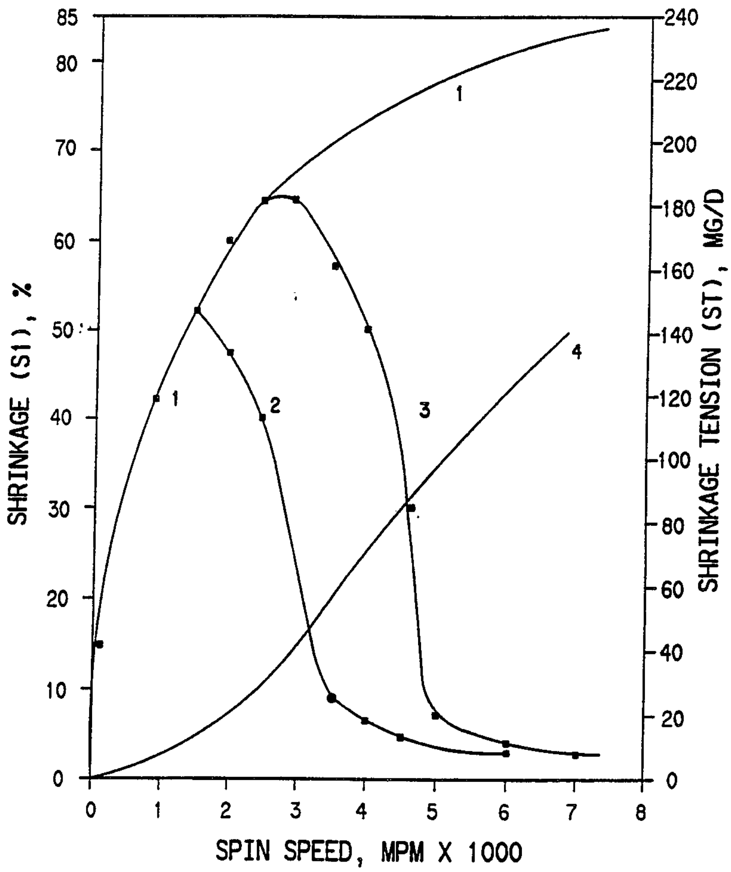
(57) Abstract

Drawing, especially cold-drawing, or hot-drawing or other heat-treatments of spin-oriented crystalline polyester filaments, and particularly polyester feed yarns, that have been prepared by spinning at speeds of, e.g., 4 km/min, and have low shrinkage and no natural draw ratio in the conventional sense, provides useful technique for obtaining uniform drawn filaments of desired denier and of differential shrinkage, and thereby provides improved flexibility to obtain filaments and yarns of mixed shrinkage.



TITLE

IMPROVEMENTS IN POLYESTER FILAMENTS, YARNS AND TOWS

This invention concerns improvements in and relating to polyester (continuous) filaments, especially in the form of filaments of differential shrinkage, and mixed shrinkage yarns thereof, and more especially to a capability to provide from the same feed stock such polyester continuous filament yarns of various differing deniers and shrinkages, as desired, and of other useful properties, including improved processes; and new polyester flat yarns, as well as filaments, generally, resulting from such processes, and downstream products from such filaments and yarns.

According to parent application PCT/US91/XXXXX (DP-4040-B) filed simultaneously herewith, and corresponding to USP 5,066,447, the disclosure of which is hereby incorporated herein by reference, processes are provided for improving the properties of feed yarns of undrawn polyester filaments. Such processes involve drawing with or without heat during the drawing and with or without post heat-treatment, and are most conveniently adapted for operation using a draw-warping machine, some such being sometimes referred to as draw-beaming or warp-drawing operations.

Preferred undrawn polyester feed yarns comprise spin-oriented polyester filaments of low shrinkage, such as have been disclosed in Knox U.S. Pat. No. 4,156,071. Alternatively, spin-oriented feed yarns of low shrinkage may be prepared at speeds higher than are used in the Knox patent, including speeds and conditions such as are disclosed by Frankfort & Knox in U.S. Patent Nos. 4,134,882 and 4,195,051.

From time to time, interest has been shown in making filaments of differential shrinkage, especially from one and the same filament feed stock, and especially for making mixed shrinkage filament yarns.

Over the years many prior suggestions have been made, but the suggestions have had technical disadvantages and have sometimes been costly, so far as commercial manufacture would have been concerned. Also, it is important to maintain uniformity, both along-end and between the various filaments. Lack of uniformity often shows up in the eventual dyed fabrics as dyeing defects, so is undesirable.

The present invention provides a technique by which mixed shrinkage polyester filament yarns may be made efficiently, from the same feed stock if desired, and without some of the cost disadvantages referred to above. This may be achieved by use of the same feed yarns as for the parent application, and adapting the processing of some of the filaments to provide the desired difference in shrinkage. Alternatively, mixed shrinkage may be provided by co-mingling filaments of high shrinkage, such as conventional polyester POY, with spin-oriented low shrinkage polyester filaments, such as are used for feed yarns in the parent application. For convenience herein the former filaments of high shrinkage are referred to as (A_F), whereas the low shrinkage filaments are referred to as (B_F). These filaments may be processed and co-mingled as described herein to provide mixed shrinkage yarns.

According to the present invention, there are provided the following processes:

A process for improving the properties of a mixed shrinkage yarn of spin-oriented polyester filaments of elongation-to-break (E_B) 40 to 120% comprised of polyester filaments (A_F) of high boil-off shrinkage (S_1) greater than 15% and of low shrinkage polyester filaments (B_F), characterized in that the mixed shrinkage yarn is cold-drawn without heat-setting to provide drawn filaments of elongation-to-break (E_B) less than 30% from drawing said filaments (A_F) of high boil-off shrinkage, and wherein said low shrinkage filaments (B_F) are of tenacity at 7% elongation (T_7) at least 0.7 grams/denier, boil-off shrinkage (S_1) less than 10%, thermal stability as shown by an (S_2) value less than +1%, net shrinkage (S_{12}) less than 8%, maximum shrinkage tension (ST) less than 0.3 grams/denier, density (ρ) 1.35 to 1.39 grams/cubic centimeter, and crystal size (CS) 55 to 90 Angstroms and also at least (250ρ - 282.5) Angstroms.

Such a mixed shrinkage yarn is preferably prepared by cospinning polyester filaments (A_F) and (B_F) and winding said mixed shrinkage yarn at a speed of at least 3.5 Km/min.

A process for preparing a mixed shrinkage yarn, wherein spin-oriented polyester filaments (A_F) of elongation-to-break (E_B) 40 to 120% and of high boil-off shrinkage (S_1) greater than 15% are cold-drawn without heat-setting to provide drawn filaments of elongation-to-break

(E_B) less than 30%, and spin-oriented low shrinkage polyester filaments (B_F) are cold-drawn without heat setting and the filaments are co-mingled before or after drawing to form a mixed shrinkage yarn.

A process for preparing a mixed shrinkage yarn, wherein spin-oriented polyester filaments (A_F) of high boil-off shrinkage (S_1) greater than 15% are cold drawn without post heat treatment, said drawing being carried out such that the elongation-to-break (E_B) of the resulting drawn filaments is less than 30%, and spin-oriented low shrinkage polyester filaments (B_F) are drawn hot, with or without post heat treatment, and the resulting drawn filaments are co-mingled to provide a mixed shrinkage yarn of uniformly drawn filaments.

A process for preparing a mixed shrinkage yarn, wherein spin-oriented polyester filaments (A_F) of high boil-off shrinkages (S_1) greater than 15% and spin-oriented low shrinkage polyester filaments (B_F) are cold-drawn to form separate drawn filament bundles $(A)_D$ and $(B)_D$, respectively, and such that the elongation-to-break (E_B) of resulting drawn filament bundle (A_D) is less than 30%, and one bundle is heat set and co-mingled with the other bundle to provide a mixed shrinkage yarn of uniformly drawn polyester filaments.

A process for preparing a mixed shrinkage yarn, wherein spin-oriented polyester filaments (A_F) of high boil-off shrinkage (S_1) greater than 15% are drawn hot, with or without post heat treatment, such that the elongation-to-break (E_B) of the resulting drawn filaments is less than 30%, and spin-oriented low shrinkage polyester filaments (B_F) are drawn cold, without post heat treatment, and the resulting drawn filaments are co-mingled to provide a mixed shrinkage yarn of uniformly drawn polyester filaments.

A process for preparing a mixed shrinkage yarn, wherein spin-oriented polyester filaments (A_F) of high boil-off shrinkages (S_1) greater than 15% are cold-drawn with or without heat setting, said drawing being carried out such that the elongation-to-break (E_B) of the resulting drawn filaments is less than 30%, and co-mingled with spin-oriented low shrinkage polyester filaments (B_F) to provide a mixed shrinkage yarn.

A process for preparing a mixed shrinkage yarn, characterized in that spin-oriented polyester filaments (B_F) are cold-drawn, the resulting drawn filaments are separated into at least two filament bundles, only one of which bundles is heat set, and then the filament bundles are co-mingled to provide a mixed shrinkage yarn of uniformly drawn filaments.

A process for preparing a mixed shrinkage yarn from at least two bundles of low shrinkage spin-oriented polyester filaments (B_F), wherein one of said bundles is drawn cold without post heat treatment and another of said bundles is drawn hot or cold with post heat treatment, or drawn hot with post heat treatment, and the resulting drawn filaments are co-mingled to provide a mixed shrinkage yarn of uniformly drawn filaments.

A process for preparing a mixed shrinkage yarn from at least two bundles of low shrinkage spin-oriented polyester filaments (B_F), wherein one of said bundles is drawn hot with or without post heat treatment and the resulting drawn filaments are comingled with another of said bundles of spin-oriented filaments to provide a mixed shrinkage yarn.

Thus, the invention contemplates a process for preparing a mixed shrinkage yarn with filaments of higher shrinkage and filaments of lower shrinkage wherein the filaments of lower shrinkage are undrawn polyester filaments (B_F), as aforesaid, that are processed with or without post heat treatment.

The undrawn polyester filaments preferably have an elongation (E_B) of 60 to 90%.

The drawing may, if desired, be carried out in the form of a weftless warp sheet of yarns and/or filament bundles prior to knitting, weaving or winding onto a beam.

The resulting mixed shrinkage yarns are also provided, according to the present invention, and preferably have a differential filament shrinkage of at least 5% and a maximum shrinkage tension (ST) at least 0.15 gpd, and the filaments and/or yarns may, if desired, be air jet-textured to provide textured yarns

The bulk in the yarn is developed conveniently by appropriate heat treatment, on account of the difference in shrinkage of the component filaments, and such a process is provided according to the invention. Conveniently, such bulky filament bundles may be developed by heat relaxation of the filament bundles in the form of a weftless warp sheet, if desired.

Polyester polymers, used herein, may, if desired, be modified by incorporating ionic dye sites, such as ethylene-5-M-sulfo-isophthalate residues, where M is an alkali metal cation, for example in the range of about 1-3 mole % ethylene-5-sodium-sulfo-isophthalate residues, to provide dyeability with cationic dyes, as disclosed by Griffing and Remington in U. S. Patent No. 3,018,272. A suitable polymer of relative viscosity (LRV) about 13 to about 18 is particularly useful. Representative copolyesters used herein to enhance dyeability with disperse dyes are described in part by Most U. S. Patent No. 4,444,710, Pacofsky U. S. Patent No. 3,748,844, Hancock U. S. Patent No. 4,639,347, and Frankfort and Knox U. S. Patent Nos. 4,134,882 and 4,195,051, and representative chainbranching agents used herein to reduce shrinkage, especially of polyesters modified with ionic dye sites and/or copolyesters, are described in part in Knox U. S. Patent No. 4,156,071, MacLean U. S. Patent No. 4,092,229, and Reese U. S. Patent Nos. 4,883,032; 4,996,740; and 5,034,174. To obtain undrawn feed yarns of low shrinkage from modified polyesters, it is generally advantageous to increase polymer viscosity by about +0.5 to about +1.0 LRV units and/or add minor amounts of chainbranching agents (e.g., about 0.1 mole percent).

Advantageously, if desired, mixed shrinkage yarns may be prepared according to the invention from undrawn feed yarns that have been treated with caustic in the spin finish (as taught by Grindstaff and Reese in copending allowed Patent Application Serial No. 07/420,459, filed October 12, 1989) to enhance their hydrophilicity and provide improved moisture-wicking and comfort. Incorporating filaments of different deniers and/or cross-sections may also be used to reduce filament-to-filament packing and thereby improve tactile aesthetics and comfort. Unique dyeability effects may be obtained by co-mingling drawn filaments of differing polymer modifications, such as homopolymer dyeable with disperse dyes and ionic copolymers dyeable with cationic dyes.

Figure 1 is a plot of boil-off shrinkage (S_1) and shrinkage tension (ST) v. spin speed. It will be understood that other Figures are incorporated herein from the parent application, refereed to above.

Similarly, Tables I-XV are incorporated herein by reference from the parent application, with the accompanying disclosure of drawing of feed yarns/filaments (B_F), so the Tables herein are numbered consecutively XVI to XVIII, following Tables I-XV in the parent application.

Mixed shrinkage yarns have generally been formed previously by combining filaments of different shrinkage potential, wherein the differing shrinkage potentials have, in part, been developed by differential drawing and/or by differential post heat treatment, and in part, by selecting different polymer compositions (e.g., relative viscosity and copolymers) with different propensities for crystallization during said drawing and\or heat treatments (such as disclosed in Reese, U.S. Patent 3,444,681 and 3,998,042). Prior techniques disclosed for obtaining mixed shrinkage from a single polymer have been achieved by combining filaments of different shrinkage potential, developed typically by differential treatment of two filament bundles by heat (Maerov and McCord, U.S.Patent 3,199,281), by asymmetric quenching (J. J. Kilian, U.S. Patent 3,118,012), by applying spin finishes of different heat transfer characteristics (Reese, U.S.Patent 4,153,660), by application of crystallizing solvents to one bundle, or by combining filament bundles of different filament deniers and/or cross-sectional shapes to provide differential surface-to-volume ratio (Jamieson and Reese, U.S.Patent 2,980,492), and such filaments of differential shrinkage potential have been combined before or after drawing and heat treatment to provide fully drawn mixed shrinkage yarns with high shrinkage tensions (ST). Partial drawing of such conventional filaments (i.e., to residual elongations greater than about 30%) would have provided along-end "thick-thin" denier variability characteristic of intermittent neck-draw.

To provide uniform mixed shrinkage yarns, according to the present invention, however, filament bundles of differing shrinkage potential may be formed by high speed spinning, for example, of mixed-dpf filament yarns at 4 Km/min, wherein the high denier filaments have greater shrinkage than the low denier filaments. This is graphically represented in Figure 1, wherein lines 1, 2 and 3 are plots of boil-off shrinkage (S_1) against spin speed (V_S) in Km/min, whereas line 4 is a plot of shrinkage tension (ST) against spin speed. Considering first line 1, this represents the fact that shrinkage (S_1) increases with spin speed in the absence of any crystallization that is generally (in practice) induced by stresses during attenuation and quenching of the solidifying filaments. Line 3 represents a plot of boil-off shrinkage (S_1) versus spin speed (in Km/min) for filaments (A_F), such as POY, characterized by high shrinkage (e.g., as represented by feeder yarns of Piazza and Reese). Line 2 is a plot for filaments (B_F), characterized by lower shrinkage (e.g., as disclosed by Knox). The fact, that the shrinkage (S_1) of the (B_F) filaments is lower is attributed to the greater amount of stress-induced crystallization. This difference enables one to combine spin-oriented filament bundles (A_F) and (B_F) and thereby provide mixed shrinkage (undrawn) yarns $(AB)_F$ from a single polymer source. These are referred to herein as Type C yarns (see Table XVII Differential shrinkage may also be obtained by, but limited to, use of different polymer melt viscosities (e.g., via differential capillary shear and temperature of polymer feed streams), differential cooling (e.g., via differential convergence guide length, delay length, quench air rates/temperature, filament arrays), and are further illustrated in Table XVI.

Type C mixed shrinkage yarns (of undrawn filaments) are found to be unsuitable for tightly constructed knits and for most woven fabrics, because internal fabric yarn-to-yarn restraining frictional forces are not generally overcome by the low shrinkage tension of the yarns on heating. This limits the bulk developed, in practice in the fabrics, in contrast to what might be expected from the differential shrinkage potential of yarn that is free from such restraints. Typically, such undrawn Type C yarns are characterized by (maximum) shrinkage tensions (ST) of about 0.1 g/d (herein also expressed as mg/d, = 1000 x g/d). This may be seen from line 4 in Fig 1, where the value of ST increases (with spin speed) through a value of 100 mg/d at a spin speed of about 5 Km/min, so is less than 100 mg/d at preferred spin speeds of about 4 Km/min. However, post-bulking in fabrics typically requires shrinkage tensions (ST) significantly greater than even (0.15g/d). So such Type C yarns may be "pre-bulked" under relaxed conditions, prior to knitting and weaving; however, for a long time, it has been a more desirable objective to provide mixed shrinkage yarns from a single polymer source that may also be usable in a large range of fabric constructions without pre-bulking. The improved drawing process of the invention, described herein, provides uniform mixed shrinkage yarns with differential shrinkage of at least about 5% and (maximum) shrinkage tensions (ST) at least about 0.15 g/d (i.e., at least about 150 mg/d). The present invention also provides a process for preparing uniform mixed shrinkage yarns of different deniers from the same feed (herein after illustrated by yarn Types I-IV).

Example I-4 shows that cold drawing of low shrinkage undrawn textile yarns (B_F), as described hereinbefore, increased the boil-off shrinkage (S_1) from about 2-4% to about 8-10%, and increased shrinkage tension (ST) to values greater than about 0.15 g/d, while maintaining thermal stability, as measured by an S_2-value less than about +1% and net shrinkage (S_{12}) less than about

8%. Combining cold drawn filaments (B_D) of the invention with the low shrinkage, undrawn filaments of same said feed yarn (B_F) can provide uniform mixed shrinkage filament yarns [herein denoted as Type I] with differential shrinkage of about 5% and maximum shrinkage tension (ST) greater than about 0.15 g/d. The undrawn filaments of the invention (B_F) may be partially cold-drawn to provide for a broader range of denier and tactile aesthetics (such as fabric drape), which is not possible with conventional drawing processes.

Alternatively, the undrawn low shrinkage feed yarns of the invention (B_F) may be cold drawn, as in preparing Type I yarns, but then said cold drawn filaments (B_D) may be split into two drawn filament bundles, wherein one bundle is heat treated to reduce shrinkage (S_1) and the second is not heat treated, and these filament bundles are combined to provide a drawn mixed shrinkage filament yarn [herein denoted as type II], wherein the differential is about 5% and the shrinkage tension (ST) is greater than about 0.15 g/d. Both components of Type II yarn may be uniformly partially drawn to differing deniers without "thick-thin" sections to provide a broad range of aesthetics. A variation of Type II is to hot draw, with or without post heat treatment, one of the undrawn filament yarns (B_F) to reduce said shrinkage, and combine with the high shrinkage cold drawn filament yarns (B_D) to provide for mixed-shrinkage filament yarns [herein denoted as Types III and IV, respectively] with greater differential shrinkage and lower shrinkage surface filaments than Types I and II mixed shrinkage yarns.

The drawing process of the invention may be used to improve the properties of the mixed shrinkage undrawn filament yarns $(AB)_F$, described herein before, denoted as Type C yarns and illustrated in Table XVI, by providing said mixed shrinkage yarns with shrinkage tensions (ST) of at least about 0.15 g/d, wherein the low shrinkage drawn filaments (B_D) are those previously described hereinbefore, and the high shrinkage drawn filaments (A_D) are representative of drawn filaments of conventional POY (such as those described by Piazza and Reese). A mixed shrinkage yarn $(AB)_F$ comprised of undrawn filaments (A_F) and (B_F) is typically characterized by shrinkage tensions (ST) less than about 0.15 g/d. Cold drawing said mixed shrinkage undrawn yarn $(AB)_F$ without any post heat treatment provides for a mixed shrinkage drawn filament yarn [herein denoted as Type V] with a shrinkage tension (ST) greater than about 0.15 g/d, making said mixed shrinkage yarns suitable for post-bulk development in most fabric constructions (e.g., wovens).

Alternatively, the same undrawn filaments (A_F) and (B_F) of the mixed shrinkage undrawn yarn $(AB)_F$ may be supplied as separate undrawn feed yarns (A_F) and (B_F), wherein said feed yarns may be cold drawn and combined without any post heat treatment [Type VI], or the undrawn filament yarn (B_F) may be cold-drawn followed by heat treatment [Type VII] or may be hot-drawn with post heat treatment [Type VIII] or without post heat treatment [Type IX] to further reduce shrinkage and increase overall differential filament shrinkage. In mixed-shrinkage yarns Type VI-IX the draw ratio of the A-filament yarns is generally selected to provide uniform drawn A-filaments with elongation-to-break (E_B) less than about 30%. The draw-ratio of the B-filaments, however, may be varied over a wide range, to provide for different denier drawn filaments without "thick-thin" along-end denier variability which is characteristic of partially drawing, for example, the above high shrinkage filament feed yarns (A_F).

Mixed shrinkage yarn Types V-IX, XIII, and XIV are characterized in that the shrinkages of drawn filaments (A_D) are greater than that of drawn filaments (B_D) (that is, $S_A > S_B$). Mixed shrinkage yarns may be provided, wherein the shrinkage S_A is less than that of shrinkage S_B, by the cold drawing of the undrawn filaments B_F without any post heat treatment to provide uniform high shrinkage filaments which are then combined with drawn filaments (A_D), wherein undrawn filaments A_F are drawn cold with post heat treatment, or drawn hot with or without post heat treatment to provide for mixed shrinkage drawn filament yarns (Types X-XII, respectively), wherein $S_A < S_B$. Mixed shrinkage yarns may also be provided by co-mingling the undrawn filaments of the invention (B_F) with or without post heat treatment, with cold drawn filaments (A) (Types XIII and XIV, respectively).

In the above examples, the drawing and heat treatment may be carried out on single-ends to provide mixed shrinkage yarns on packages for circular knitting or for fill yarns for weaving, for example; or the drawing and heat treatment may be carried out on weftless warp sheets prior to warp knitting, weaving or winding onto beams. The bulk may be developed in fabric with conventional heat setting under relaxed conditions, or prior to knitting or weaving on single-end or on weftless warp sheets; and air-jet texturing of said pre-bulked or post-bulked yarns may be incorporated to provide unique textured bulky yarns and fabrics therefrom. To further enhance tactile aesthetics mixed dpf/cross-section filament yarns are preferred. The relative viscosity (LRV) of the polyester polymer is defined according to Broaddus U. S. Patent 4,712,998.

Mixed shrinkage yarns Types X-XII provide low shrinkage surface filaments that are predominantly A-filaments, and high shrinkage core filaments that are predominantly B-filaments, whereas for yarns Types V-IX, XIII and XIV, the opposite is the case. Thus the process of the invention provides flexibility, in that, from the same source feed yarns (herein A and B), the surface and core filaments may be interchanged to provide for a wider range of visual and tactile aesthetics in the resulting yarns. For convenience, the yarn types C, and I-XIV are summarized in Table XVIII, wherein (B1/B2) denote 2 different yarn bundles of low shrinkage type B.

The shrinkage and shrinkage tension of the undrawn textile filament yarns used herein as filaments (B_F), may be increased by rapid heating/cooling on the order of 100 degrees centigrade in less than one hundredth of a second while keeping said yarn under low tensions (i.e., about normal winding tensions). The heat may be provided by hot tubes, raising yarns to preferably about 100°C-135°C, or by passing through a steam jet at 245°C and 100 lb/in^2 pressure. The resultant yarns can be provided with (S_1) and ST values greater than about 10% and 0.15 g/d and peak ST temperatures T(ST) less than about 100°C.

High power filament yarns characterized by ST-values > 0.5 g/d and T(ST) > 100°C are provided by increasing yarn temperatures to greater than about 150°C.

TABLE XVI

EX. XVI-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SPIN SPEED, YPM	4500	4500	4000	4000	5000	5000	4500	4500	4500	4500	4500	4500	4500	5500	5500
SPIN SPEED, MPM	4115	4115	3658	3658	4572	4572	4115	4115	4115	4115	4115	4115	4115	5029	5029
[n]	0.65	0.65	0.73	0.73	0.59	0.59	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Tp, °C	302	302	302	302	302	302	302	302	302	296	296	302	302	305	297
CAP. (DxL), MILS	10X40	15X60	10X40	15X60	10X40	10X40	9X50	15X72	15X72	9X50	15X72	10X40	15X60	9X50	9X36
NO. FILAMENTS	34	34	34	34	34	34	34	34	34	68	34	40	34	34	34
DPF	2.88	2.90	2.86	2.89	2.89	2.90	2.89	2.92	4.34	2.22	3.06	2.45	2.90	5.20	4.90
SHAPE	RND	RND	RND	RND	RND	RND	RND	TRI	TRI	RND	OCTA	RND	RND	RND	RND
QUENCH	XF	XF	XF	XF	XF	XF	XF	XF	XF	4RAD	2RAD	XF	XF	4XF	XF
MODULUS, G/D	44.7	48.2	40.6	45.1	53.3	51.6	42.0	46.4	43.4	36.9	51.1	43.8	48.2	53.3	45.6
ELNG. (Eb), %	76.3	78.8	88.4	84.2	68.4	68.5	80.6	73.0	73.8	87.0	71.4	78.8	78.8	60.8	65.8
TENACITY, G/D	3.12	3.23	3.04	3.07	3.34	3.32	3.15	2.88	2.82	3.04	2.98	3.18	3.23	3.96	3.56
S1, %	13.8	5.4	9.2	4.8	13.1	5.5	30.0	4.7	15.3	20.1	3.4	7.6	5.4	9.1	3.4
DHS, %	9.0	4.4	7.1	4.3	9.4	4.5	24.6	4.0	10.1	13.6	3.3	6.9	4.4	8.0	3.7
(DHS-S1),%	-4.8	-1.0	-2.1	-0.5	-3.7	-1.0	-5.5	-0.7	-5.2	-6.5	-0.1	-0.7	-1.0	-1.1	0.3
STmax, MG/D	91	85	52	65	87	92	73	72	62	78	75	76	85	65	76
Ms, G/D	0.60	1.57	0.57	1.35	0.66	1.67	0.53	1.53	0.41	0.39	2.21	1.00	1.57	0.71	2.24
Ps, G/D	1.26	0.46	0.48	0.31	1.14	0.51	1.01	0.34	0.95	1.57	0.26	0.58	0.46	0.59	0.26
DENSITY, G/CC	1.353	1.359	1.353	1.356	1.351	1.356	1.348	1.359	1.352	1.352	1.371	1.356	1.359	1.354	1.371
RDDR, x1000	120	98	145	139	109	99	119	147	115	139	202	101	98	N/A	100

TABLE XVII

EX. XVII-	1	2	3	4	5	6	7	8	9
YARN TYPE	1-HIGH	1-LOW	1-MIX	2-HIGH	2-LOW	2-MIX	3-HIGH	3-LOW	3-MIX
SPIN SPEED, YPM	4500	4500	4500	4500	4500	4500	4000	4000	4000
SPIN SPEED, MPM	4115	4115	4115	4115	4115	4115	3658	3658	3658
[n]	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Tp, °C	302	302	302	302	302	302	288	288	288
CAP. (DxL), MILS	9X50	15X72	N/A	9X50	15X72	N/A	9X12	15X60	N/A
NO. FILAMENTS	34+34	40+40	34+40	34+34	34+34	34+34	17+17	34+34	17+34
DPF	2.2	1.9	N/A	2.2	2.2	N/A	3.9	2.0	N/A
SHAPE	RND	OCTA	N/A	RND	TRI	N/A	RND	RND	RND
QUENCH	XF	XF	XF	XF	XF	XF	XF	XF	XF
MODULUS, G/D	43.3	53.8	50.5	43.4	49.7	49.7	30.9	38.6	28.8
ELNG. (Eb), %	82.0	80.9	76.6	82.0	71.7	72.7	98.0	90.0	102.0
TENACITY, G/D	3.15	3.39	3.07	3.15	2.96	2.92	2.80	2.90	2.80
S1, %	12.5	3.9	11.0	12.5	3.9	10.6	16.7	5.9	16.5
DHS, %	9.4	3.7	8.8	9.4	4.2	7.4	16.3	5.3	16.0
(DHS-S1),%	-3.1	-0.2	-2.2	-3.1	0.3	-3.2	-0.4	-0.6	-0.5
STmax, MG/D	75	86	81	75	77	76	77	97	73
Ms, G/D	0.60	2.21	0.74	0.60	1.97	0.72	0.46	1.64	0.44
Ps, G/D	0.94	0.34	0.89	0.94	0.30	0.81	1.29	0.57	1.20
DENSITY, G/CC	1.3514	1.3627	1.3570	1.3514	1.3620	1.3573	1.3484	1.3600	1.3561
RDDR, x1000	119	126	123	119	139	129	---	---	195
DFL (DHS), %	0.0	0.0	5.1	0.0	0.0	5.2	0.0	0.0	11.0
REL. BULK, %	3.1	0.2	8.8	3.1	0.3	8.3	0.4	0.6	11.4

TABLE XVIII
MIXED-SHRINKAGE YARN TYPES

YARN TYPE	DRAWING MODE A	DRAWING MODE B(B1/B2)	HEAT TREATMENT A	HEAT TREATMENT B	RELATIVE SHRINKAGE
Control	ND	ND	NO	NO	A > B
I	N/A	COLD/ND	N/A	NO/NO	B1 > B2
II	N/A	COLD/COLD	N/A	NO/YES	B1 > B2
III	N/A	COLD/HOT	N/A	NO/YES	B1 > B2
IV	N/A	COLD/HOT	N/A	NO/NO	B1 > B2
V	COLD	COLD	NO	NO	A > B
VI	COLD	COLD	NO	NO	A > B
VII	COLD	COLD	NO	YES	A > B
VIII	COLD	HOT	NO	YES	A > B
IX	COLD	HOT	NO	NO	A > B
X	COLD	COLD	YES	NO	B > A
XI	HOT	COLD	YES	NO	B > A
XII	HOT	COLD	NO	NO	B > A
XIII	COLD	ND	NO	YES	A > B
XIV	COLD	NC	NO	NO	A > B

What is claimed is:

1. A process for improving the properties of a mixed shrinkage yarn of spin-oriented polyester filaments of elongation-to-break (E_B) 40 to 120% comprised of polyester filaments (A_F) of high boil-off shrinkage (S_1) greater than 15% and of low shrinkage polyester filaments (B_F), characterized in that the mixed shrinkage yarn is cold-drawn without heat-setting to provide drawn filaments of elongation-to-break (E_B) less than 30% from drawing said filaments (A_F) of high boil-off shrinkage, and wherein said low shrinkage filaments (B_F) are of tenacity at 7% elongation (T_7) at least 0.7 grams/denier, boil-off shrinkage (S_1) less than 10%, thermal stability as shown by an (S_2) value less than +1%, net shrinkage (S_{12}) less than 8%, maximum shrinkage tension (ST) less than 0.3 grams/denier, density (ρ) 1.35 to 1.39 grams/cubic centimeter, and crystal size (CS) 55 to 90 Angstroms and also at least (250ρ - 282.5) Angstroms.

2. A process according to Claim 1, wherein said mixed shrinkage yarn is prepared by cospinning polyester filaments (A_F) and (B_F) and winding said mixed shrinkage yarn at a speed of at least 3.5 Km/min.

3. A process for preparing a mixed shrinkage yarn, wherein spin-oriented polyester filaments (A_F) of elongation-to-break (E_B) 40 to 120% and of high boil-off shrinkage (S_1) greater than 15% are cold-drawn without heat-setting to provide drawn filaments of elongation-to-break (E_B) less than 30%, and spin-oriented low shrinkage polyester filaments (B_F) are cold-drawn without heat setting and the

filaments are co-mingled before or after drawing to form a mixed shrinkage yarn, and wherein said filaments (B_F) are of elongation-to-break 40 to 120% tenacity at 7% elongation (T_7) at least 0.7 grams/denier, boil-off shrinkage (S_1) less than 10%, thermal stability as shown by an S_2 value less than +1%, net shrinkage (S_{12}) less than 8%, maximum shrinkage tension (ST) less than 0.3 grams/denier, density (ρ) 1.35 to 1.39 grams/cubic centimeter, and crystal size (CS) 55 to 90 Angstroms and also at least ($250\rho - 282.5$) Angstroms.

4. A process for preparing a mixed shrinkage yarn, wherein spin-oriented polyester filaments (A_F) of high boil-off shrinkage (S_1) greater than 15% are cold drawn without post heat treatment, said drawing being carried out such that the elongation-to-break (E_B) of the resulting drawn filaments is less than 30%, and spin-oriented low shrinkage polyester filaments (B_F) are drawn hot, with or without post heat treatment, and the resulting drawn filaments are co-mingled to provide a mixed shrinkage yarn of uniformly drawn filaments, wherein said low shrinkage filaments (B_F) are of elongation-to-break (E_B) 40 to 120%, tenacity at 7% elongation (T_7) at least 0.7 grams/denier, boil-off shrinkage (S_1) less than 10%, thermal stability as shown by an S_2 value less than +1%, net shrinkage (S_{12}) less than 8%, maximum shrinkage tension (ST) less than 0.3 grams/denier, density (ρ) 1.35 to 1.39 grams/cubic centimeter, and crystal size (CS) 55 to 90 Angstrom and also at least ($250\rho - 282.5$) Angstroms.

5. A process for preparing a mixed shrinkage yarn, wherein spin-oriented polyester

filaments (A_F) of high boil-off shrinkages (S_1) greater than 15% and spin-oriented low shrinkage polyester filaments (B_F) are cold-drawn to form separate drawn filament bundles $(A)_D$ and $(B)_D$, respectively, and such that the elongation-to-break (E_B) of resulting drawn filament bundle (A_D) is less than 30%, and one bundle is heat set and co-mingled with the other bundle to provide a mixed shrinkage yarn of uniformly drawn polyester filaments, and wherein said low shrinkage filaments (B_F) are of elongation-to-break (E_B) 40 to 120%, tenacity at 7% elongation (T_7) at least 0.7 grams/denier, boil-off shrinkage (S_1) less than 10%, thermal stability as shown by an (S_2) value less than +1%, net shrinkage (S_{12}) less than 8%, maximum shrinkage tension (ST) less than 0.3 grams/denier, density (ρ) 1.35 to 1.39 grams/cubic centimeter, and crystal size (CS) 55 to 90 Angstroms and also at least (250ρ - 282.5) Angstroms.

6. A process for preparing a mixed shrinkage yarn, wherein spin-oriented polyester filaments (A_F) of high boil-off shrinkage (S_1) greater than 15% are drawn hot, with or without post heat treatment, such that the elongation-to-break (E_B) of the resulting drawn filaments is less than 30%, and spin-oriented low shrinkage polyester filaments (B_F) are drawn cold, without post heat treatment, and the resulting drawn filaments are co-mingled to provide a mixed shrinkage yarn of uniformly drawn polyester filaments, wherein said low shrinkage filaments (B_F) are of elongation-to-break (E_B) 40 to 120%, tenacity at 7% elongation (T_7) at least 0.7 grams/denier, boil-off shrinkage (S_1) less than 10%, thermal stability as shown by an (S_2) value

less than +1%, net shrinkage (S_{12}) less than 8%, maximum shrinkage tension (ST) less than 0.3 grams/denier, density (ρ) 1.35 to 1.39 grams/cubic centimeter, and crystal size (CS) 55 to 90 Angstroms and also at least ($250\rho - 282.5$) Angstroms.

7. A process for preparing a mixed shrinkage yarn, wherein spin-oriented polyester filaments (A_F) of high boil-off shrinkages (S_1) greater than 15% are cold-drawn with or without heat setting, said drawing being carried out such that the elongation-to-break (E_B) of the resulting drawn filaments is less than 30%, and co-mingled with spin-oriented low shrinkage polyester filaments (B_F) to provide a mixed shrinkage yarn, and wherein said low shrinkage filaments (B_F) are of elongation-to-break (E_B) 40 to 120%, tenacity at 7% elongation (T_7) at least 0.7 grams/denier, boil-off shrinkage (S_1) less than 10%, thermal stability as shown by an (S_2) value less than +1%, net shrinkage (S_{12}) less than 8%, maximum shrinkage tension (ST) less than 0.3 grams/denier, density (ρ) 1.35 to 1.39 grams/cubic centimeter, and crystal size (CS) 55 to 90 Angstroms and also at least ($250\rho - 282.5$) Angstroms.

8. A process for preparing a mixed shrinkage yarn, characterized in that spin-oriented polyester filaments are cold-drawn, the resulting drawn filaments are separated into at least two filament bundles, only one of which bundles is heat set, and then the filament bundles are co-mingled to provide a mixed shrinkage yarn of uniformly drawn filaments, wherein said spin-oriented filaments are of elongation-to-break (E_B) 40 to 120%, tenacity at 7% elongation (T_7) at least 0.7 grams/denier, boil-

off shrinkage (S_1) less than 10%, thermal stability as shown by an (S_2) value less than +1%, net shrinkage (S_{12}) less than 8%, maximum shrinkage tension (ST) less than 0.3 grams/denier, density (ρ) 1.35 to 1.39 grams/cubic centimeter, and crystal size (CS) 55 to 90 Angstroms and also at least (250ρ - 282.5) Angstroms.

9. A process for preparing a mixed shrinkage yarn from at least two bundles of low shrinkage spin-oriented polyester filaments, wherein one of said bundles is drawn cold without post heat treatment and another of said bundles is drawn hot or cold with post heat treatment, or drawn hot with post heat treatment, and the resulting drawn filaments are co-mingled to provide a mixed shrinkage yarn of uniformly drawn filaments, and wherein said spin-oriented filaments are of elongation-to-break (E_B) 40 to 120%, tenacity at 7% elongation (T_7) at least 0.7 grams/denier, boil-off shrinkage (S_1) less than 10%, thermal stability as shown by an (S_2) value less than +1%, net shrinkage (S_{12}) less than 8%, maximum shrinkage tension (ST) less than 0.3 grams/denier, density (ρ) 1.35 to 1.39 grams/cubic centimeter, and crystal size (CS) 55 to 90 Angstroms and also at least (250ρ - 282.5) Angstroms.

10. A process for preparing a mixed shrinkage yarn from at least two bundles of low shrinkage spin-oriented polyester filaments, wherein one of said bundles is drawn hot with or without post heat treatment and the resulting drawn filaments are comingled with another of said bundles of spin-oriented filaments to provide a mixed shrinkage yarn, and wherein said spin-oriented filaments are of

elongation-to-break (E_B) 40 to 120%, tenacity at 7% elongation (T_7) at least 0.7 grams/denier, boil-off shrinkage (S_1) less than 10%, thermal stability as shown by an (S_2) value less than +1%, net shrinkage (S_{12}) less than 8%, maximum shrinkage tension (ST) less than 0.3 grams/denier, density (ρ) 1.35 to 1.39 grams/cubic centimeter, and crystal size (CS) 55 to 90 Angstroms and also at least ($250\rho - 282.5$) Angstroms.

11. A process according to Claim 7 or 10, wherein said spin-oriented filaments are filaments that have been processed with post heat treatment.

12. A process according to any one of Claims 1 to 11, wherein the resulting mixed shrinkage yarn has a differential filament shrinkage of at least 5% and a maximum shrinkage tension (ST) at least 0.15 gpd.

13. A process according to any one of Claims 1 to 12, wherein the drawing is carried out with the filaments in the form of a weftless warp sheet of filament bundles and/or yarns prior to knitting, weaving or winding onto a beam.

14. A process according to any one of Claims 1 to 13, wherein the filaments and/or mixed shrinkage yarns are air jet-textured.

15. A process according to any one of Claims 1 to 14, wherein the polyester of at least some of said filaments is modified with 1 to 3% by weight of ethylene-5-sodium-sulfo isophthalate.

16. A process according to Claim 15, wherein such polyester contains a chainbranching

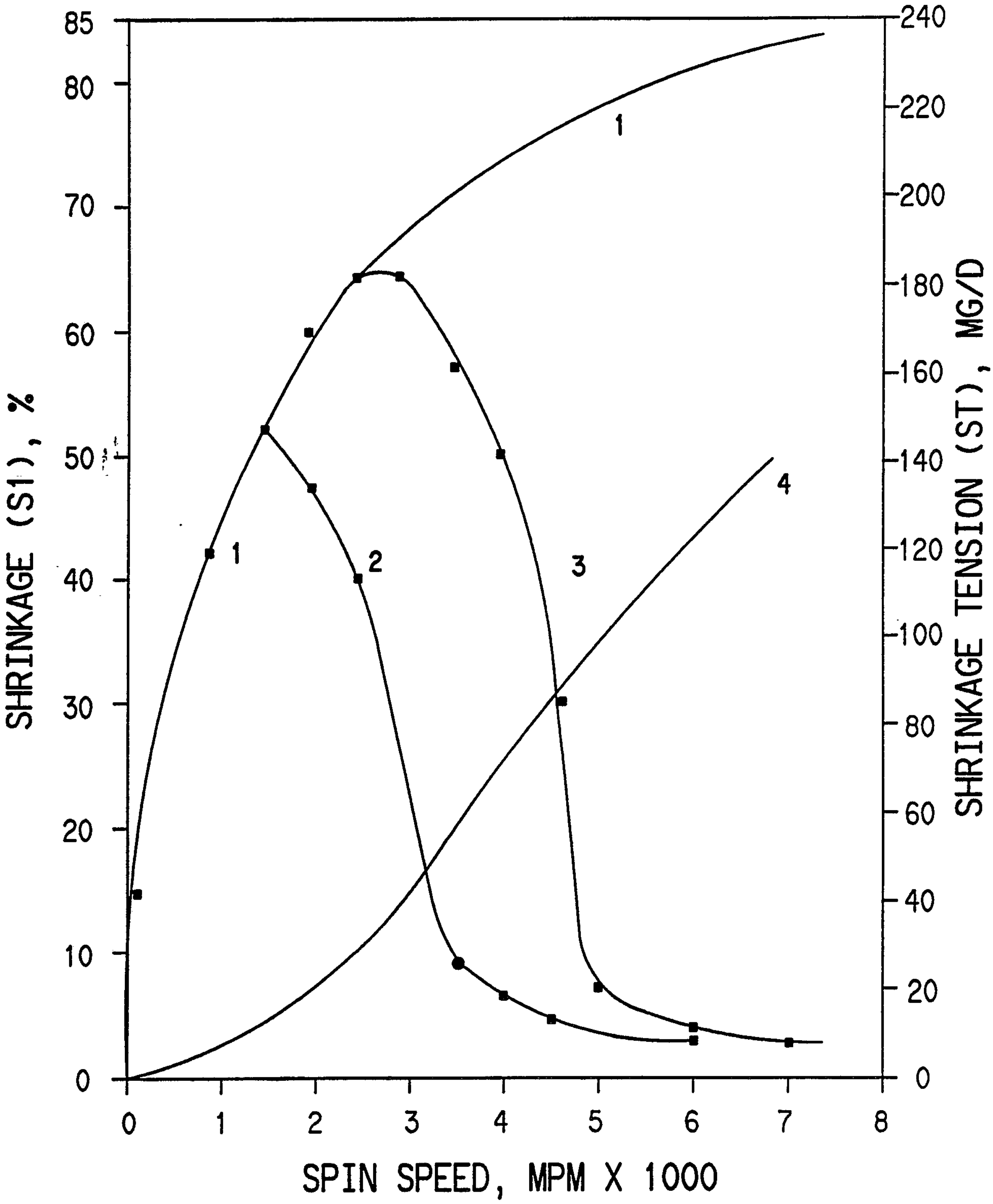
agent in minor amount sufficient to provide boil-off shrinkage (S_1) of less than 10%.

17. A process according to any one of Claims 1 to 16, wherein the resulting filaments of low shrinkage are of denier less than one.

18. A process according to any one of Claims 1 to 17, wherein the resulting mixed shrinkage yarn is relaxed by heat treatment to develop bulk on account of the difference in shrinkages and to form a bulky yarn.

19. A process according to Claim 18, wherein a plurality of bundles of filaments having different shrinkages are relaxed to develop bulk and are in the form of a weftless warp sheet of filament bundles and/or yarns.

FIG.1


85
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2
3
4
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1
2
3
4
5
6
7
8
SHRINKAGE (S1), %
SHRINKAGE TENSION (ST), MG/D
SPIN SPEED, MPM X 1000

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 91/08382

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 D02G1/18; D02J1/22; D01F6/62

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	D02G ; D02J ; D01F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category [°]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
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A	US,A,4 156 071 (KNOX) 22 May 1979 cited in the application see column 4, line 24 - column 20, line 12	1,3,4,7, 14
A	WORLD PATENTS INDEX Week 7743, 17 September 1977 Derwent Publications Ltd., London, GB; AN 77-76945Y & JP,A,52 110 963 (TEIJIN KK) 17 September 1977 see abstract	1,3,4
A	US,A,5 034 174 (REESE) 23 July 1991 cited in the application see column 4, line 37 - column 7, line 40	16

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° Special categories of cited documents : [10]

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"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
06 JULY 1992	16.07.92
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	HOPKINS S.C.

2

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A	GB,A,2 078 605 (TORAY INDUSTRIES INC.) 13 January 1982 * whole document * ---	1,2

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The members are as contained in the European Patent Office EDP file on 06/07/92
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