United States Patent [19]

Ikeda et al.

[11] **3,797,221**

[45] **Mar. 19, 1974**

[54] **FALSE TWIST-CRIMPED POLYESTER YARNS AND PROCESS FOR THEIR PRODUCTION**

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[30] **Foreign Application Priority Data**

Apr. 6, 1970 Japan 45-29236

[52] **U.S. Cl.** .... **57/140 R,** 57/157 TS

[51] **Int. Cl.** **D02g 1/02,** D02g 3/02

[58] **Field of Search** .... 57/55.5, 140 R, 140 BY, 57/157 R, 157 S, 157 TS; 264/103, 168, 210, 290

[56] **References Cited**

UNITED STATES PATENTS

3,458,986	8/1969	Allison et al.	57/140
2,980,492	4/1961	Jamieson et al.	57/157 S
3,534,541	10/1970	Edison	57/157 TS
3,587,220	6/1971	Eggleston	57/140
3,601,972	8/1971	Rogers et al.	57/157

FOREIGN PATENTS OR APPLICATIONS

746,992	3/1956	Great Britain	57/157 S

Primary Examiner—Werner H. Schroeder
Attorney, Agent, or Firm—Sherman and Shalloway

[57] **ABSTRACT**

A false twist-crimped polyester yarn having a density d of $1.3800 \leqq d \leqq 1.3950$ (g/cm^3) and a total percentage crimp (TC) of TC $\geqq$ 30% is produced by false twisting a polyester multi-filament having a birefringence (Δn) of $0.030 \leqq \Delta n \leqq 0.145$ while heat setting the filament in the twisted state at 160° to 210° at a draft (dr) which satisfies the following equation:

$$-250.\Delta n + 38 \geqq d_r \geqq -150.\Delta n + 17$$

Heat-setting the above false twist-crimped polyester yarn at a higher temperature gives a modified false twist-crimped polyester yarn having a density (d) of $1.3800 \leqq d \leqq 1.3950$ (g/cm^3), a total percentage crimp (TC) of TC $\leqq$ 20%, and a torque (Tq) of Tq $\leqq$ 26 (T/25 cm).

6 Claims, 6 Drawing Figures

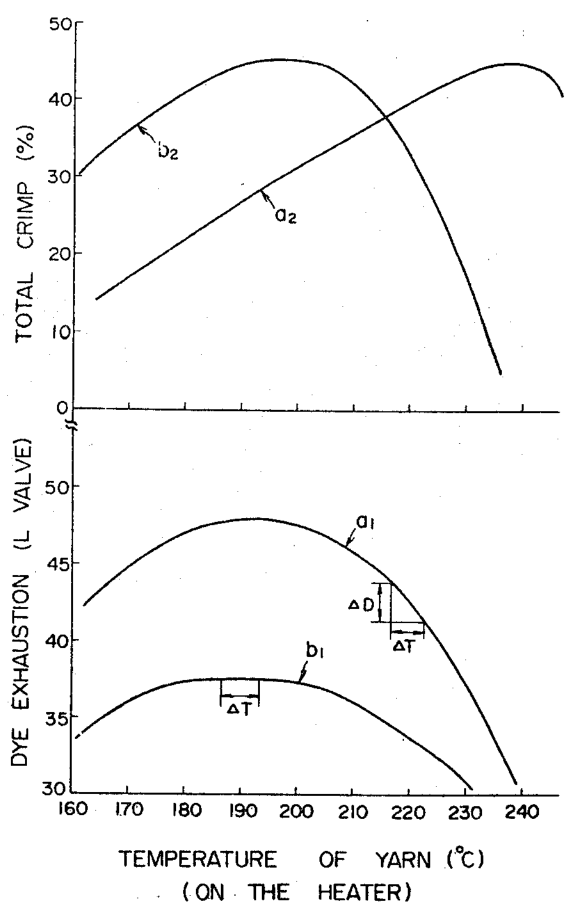


Fig. 1

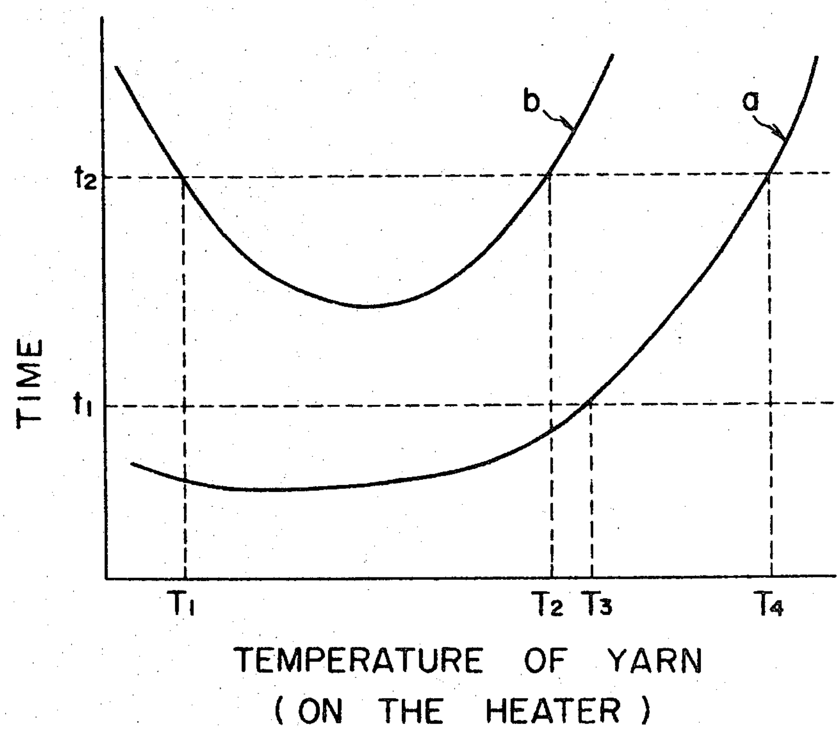
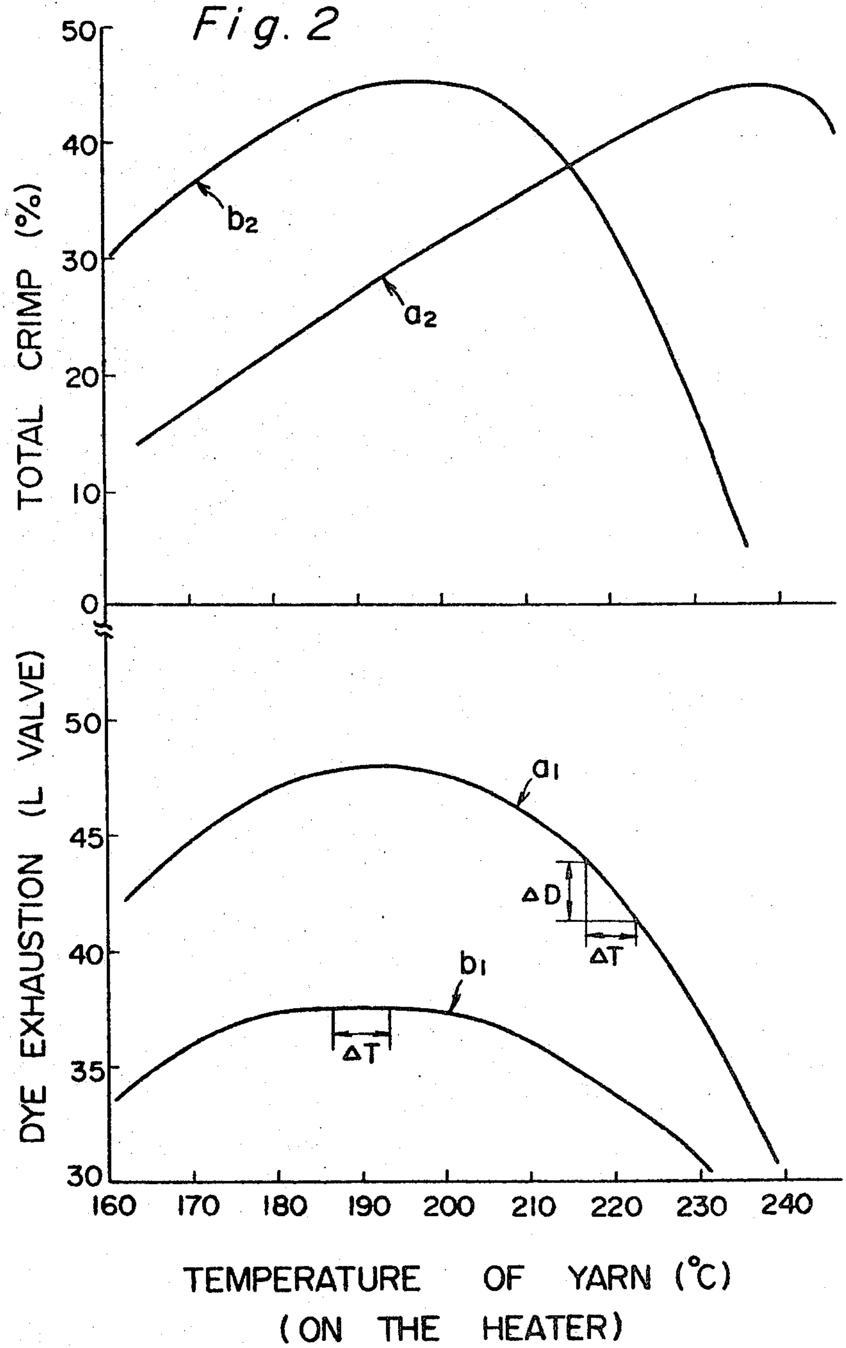


Fig. 2


TOTAL CRIMP (%)
50
40
30
20
10
0
b2
a2
DYE EXHAUSTION (L VALVE)
50
45
40
35
30
a1
ΔD
ΔT
b1
ΔT
160
170
180
190
200
210
220
230
240
TEMPERATURE OF YARN (°C)
(ON THE HEATER)

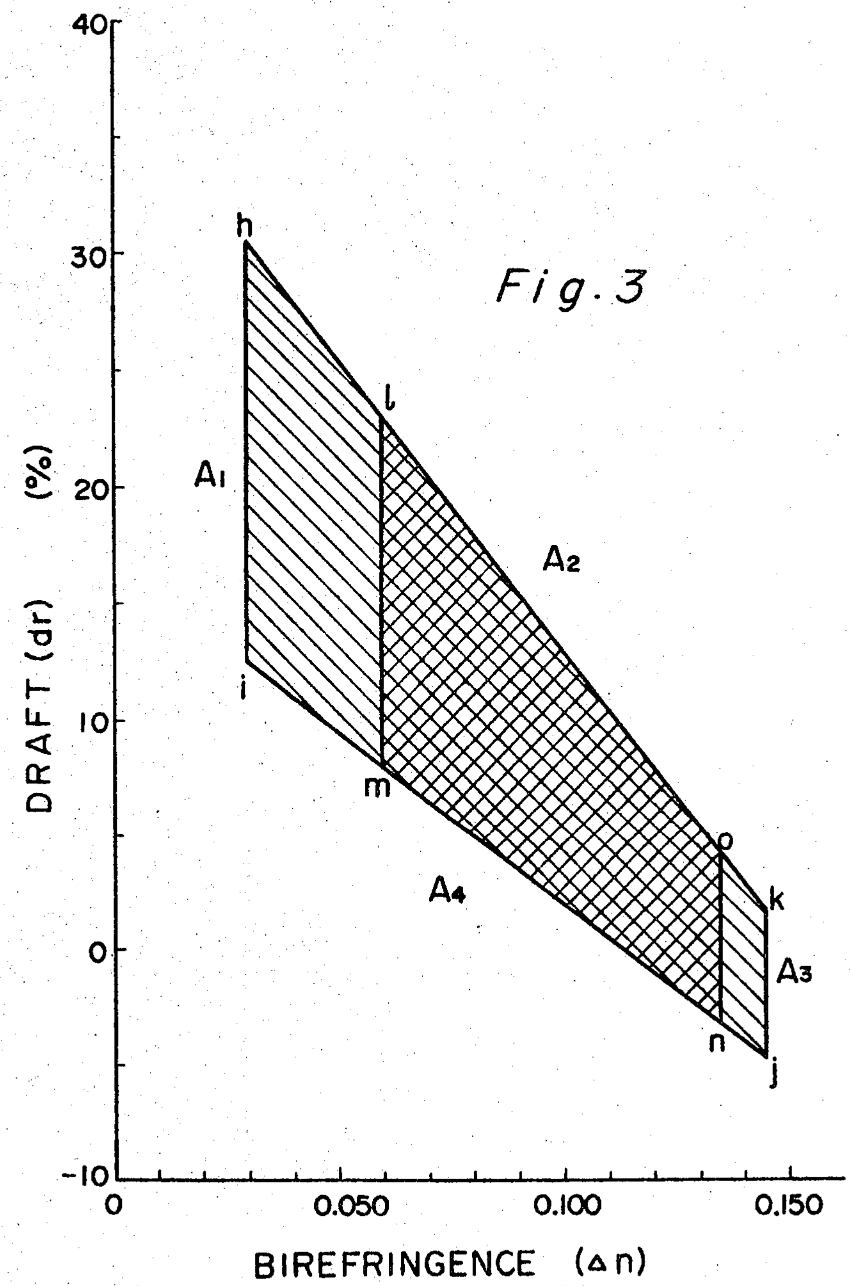
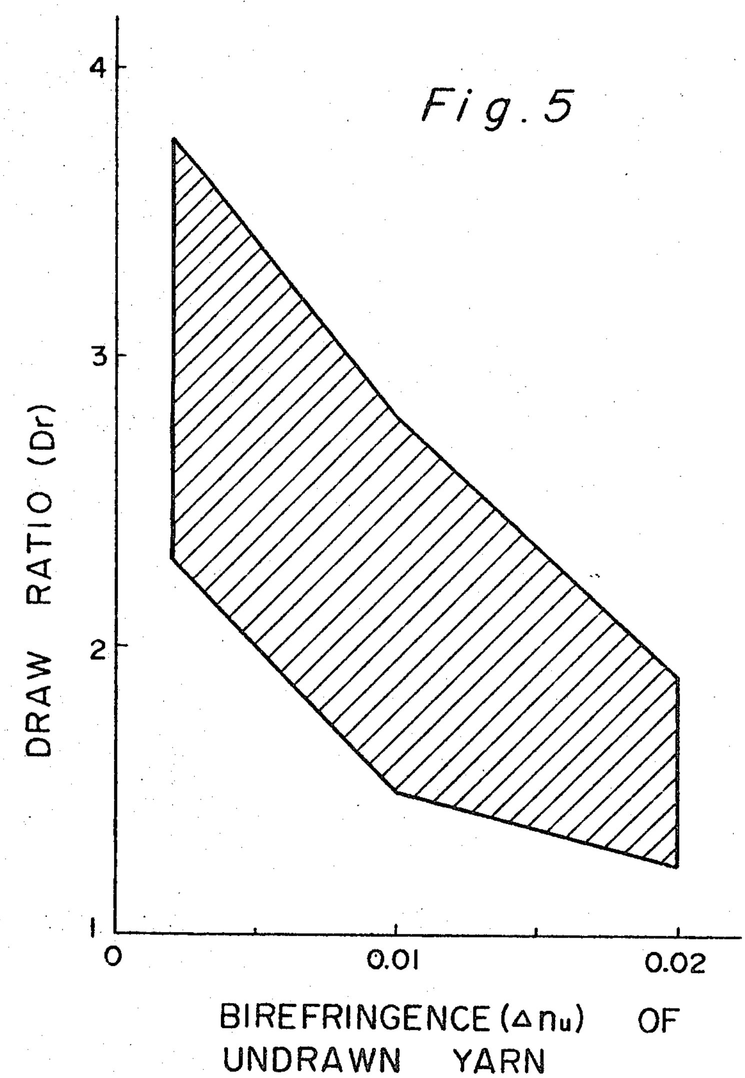

h
l
i
m
o
k
n
j
A1
A2
A3
A4
DRAFT (dr) (%)
40
30
20
10
0
-10
0
0.050
0.100
0.150
BIREFRINGENCE (Δn)

Fig. 3

Fig. 5


4
3
2
1
DRAW RATIO (Dr)
0
0.01
0.02
BIREFRINGENCE (Δnu) OF UNDRAWN YARN

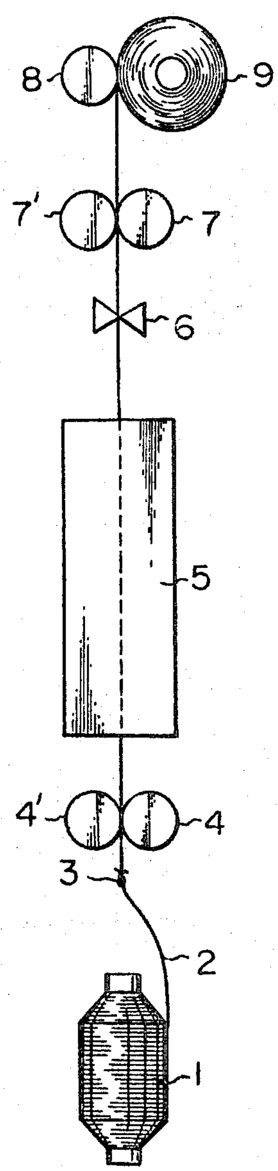


Fig. 4

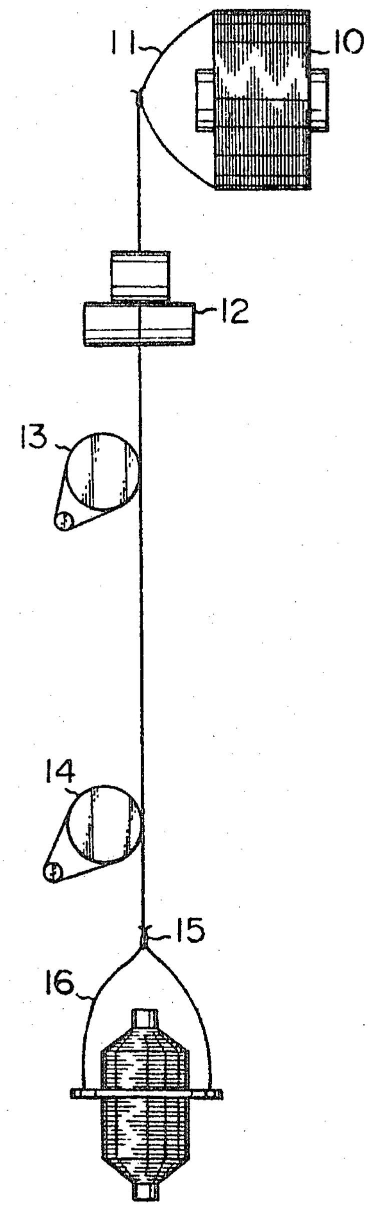


Fig. 6

FALSE TWIST-CRIMPED POLYESTER YARNS AND PROCESS FOR THEIR PRODUCTION

This invention relates to a false twist-crimped polyester yarn or modified false twist-crimped polyester yarn having both highly improved crimp elongation hereinafter refered to as "total percentage crimp" and highly improved dyeability, characteristic which the conventional false twist-crimped polyester yarns cannot possess at the same time, and to a process for producing such yarns.

More particularly, the invention relates to a false twist-crimped polyester yarn having a density d of $1.3800 \leqq d \leqq 1.3950$ (g/cm^3) and a total percentage crimp (TC) of TC $\geqq 30$ (%), and to a modified false twist-crimped polyester yarn having a density d of $1.3800 \leqq d \leqq 1.3950$ (g/cm^3), a total percentage crimp (TC) of TC $\leqq 20$ (%), and a torque (Tq) of Tq $\leqq 26$ (T/25 cm), such modified false twist-crimped polyester yarn being obtained by subjecting the first-mentioned polyester yarn to a second heat set treatment.

The false twist-crimped polyester yarn of the invention has a density d of the above specified range which the conventional flase twist-crimped polyester yarn cannot have for a TC of the above range (the conventional crimped yarn has a density of about $1.398 \leqq d \leqq 1.410$). The modified false twist-crimped polyester yarn of the invention has a density different from that of the conventional polyester yarn for the specified TC, and also a torque which the conventional polyester yarn cannot have for the specified TC (the conventional polyester yarn has a torque of more than about 30).

The invention also provides a process for producing a false twist-crimped polyester yarn which comprises false twisting a polyester multifilament having a birefringence (Δn) of $0.030 \leqq \Delta n \leqq 0.145$, preferably $0.06 \leqq \Delta n \leqq 0.135$ while heat-setting such multifilament in the twisted state at 160° to 210°C., preferably 170° to 200°C. at a draft d_r expressed by the equation $-250 \cdot \Delta n + 38 \geqq d_r \geqq -150 \cdot \Delta n + 17$ . . . . (I); and to a process for producing a modified false twist-crimped polyester yarn which comprises subjecting the false twist-crimped yarn so obtained to a second heat-setting at a temperature in excess of that at which the yarn has been initially heat set, by any means known per se.

The polyester yarns having novel improved properties can be produced by the processes of the invention on the basis of the two important findings that the birefringence (Δn) of the starting polyester multifilament has not previously been employed (previously up to about 0.16 at the lowest) and that the draft is chosen correspondingly to the varying Δn of the starting yarn.

Polyester filament yarns, especially polyethylene terephthalate filament yarns, have high tenacity and Young's modulus, and therefore have found wide applications as apparel, interior decoration and industrial materials. For apparel uses, it is general practice to produce woven or knitted goods by using crimped polyester filament yarns, or blend yarns obtained by mixing slightly crimped filament yarns cut to staple lengths with cotton, wool, or the like. In recent years, the use of crimped filamentary yarns, especially the use of false twist-crimped filamentary yarns, has attracted special attention.

The false twist crimping process is performed continuously by using a false twist by which a filament yarn is heat set in a state of being twisted in one direction, and then untwisted in a direction reverse to the twist direction. The crimp is obtained by heat-setting the filament yarn in the twisted state thereby leaving the torsion permanently in the form of a twist. Therefore, whether the false twist-crimped yarn obtained by such a method has excellent crimp properties is determined by whether the filament yarn has been fully heat set in the twisted state.

Polyester filament yarns now in use for false twist crimping have high Young's modulus and melting point higher than other synthetic filaments such as polyamide filaments, and therefore, it is extremely difficult to leave a molecular torsion in the form of twist in the filament yarn. In order to obtain sufficient crimping effects, the heat setting of the filament yarn should be as high as 210° to 230°C.

Such high temperatures are useful for obtaining good crimps. But the requirement for great quantities of heat energy inevitably results in the deterioration of fiber properties during processing and in the non-uniformity of quality. Furthermore, commercially available false twist crimped yarns of polyesters do not possess entirely satisfactory properties. They have low dyeability (dye exhaustion of less than 80 percent with disperse dyes), and there is a frequent occurrence of the non-uniformity of dyeing within and between spindles during crimping. It must be especially noted that attempts to provide yarns of satisfactory total percentage crimps inevitably result in reduced dyeability, and the extent of reduction changes greatly with slight changes in the heat-setting temperature.

The low dyeability means poor utilization of dyestuffs, Because of the non-uniformity of dyeing, it is now necessary to cut the false twist-crimped yarn obtained in each spindle to certain lengths, measure the dyeability of each yarn, and sort out the yarns according to dyeability prior to use. This is course requires extra labor, and even such treatment cannot obviate a great loss owing to the products of poor quality.

Accordingly, an object of the present invention is to provide a false twist-crimped polyester yarn which has the same or better crimp properties, especially total percentage crimp (TC), as compared with the conventional false twist-crimped polyester yarns, and which has a dyeability (dye exhaustion) and level dyeing property previously incapable of being attained for the TC range specified in the present invention, and also a modified false twist-crimped polyester yarn obtained by subjecting the false twist-crimped polyester yarn to a second heat setting.

Another object of the invention is to provide a process for producing such false twist-crimped polyester yarn having such novel improved properties and the modified false twist-crimped polyester yarn obtained therefrom.

Still another object of the invention is to provide a process for producing a false twist-crimped polyester yarn having dyeability and level dyeing property, which has a total percentage crimp comparable to that of the conventional false twist-crimped polyester yarns even when processed at temperatures lower than the conventional false twisting temperatures.

Many other objects and advantages of the present invention will become apparent from the following description.

As a result of strenuous study for achieving the above objects, the following has been found. Severe high temperature conditions of 210° to 230°C. are necessary. In fact such temperature is employed for obtaining polyester fibers having the percentage crimps required in the market. It has been found that if polyester filaments of lower birefringence (Δn) are used, false twist-crimped yarns having substantially the same percentage crimps as the conventional filaments can be obtained by false twisting the filaments while drafting at a temperature of less than 210°C., especially about 190°C. It has however been found that in spite of the satisfactory percentage crimps of such false twist-crimped yarns, dyeings of woven or knitted goods made of these crimped yarns have a number of striped spots which make the final products still unsatisfactory. In finding out the cause of this, it has been ascertained that the birefringence of polyester filament yarns is closely related to the tension of the yarns at the time of the false twisting treatment, and this has led to the accomplishment of the present invention.

Specifically, when polyester filaments having a birefringence of 0.030 to 0.145 are false twist-crimped at a draft specified by the Equation I above, satisfactory crimping becomes possible at lower temperatures in the range of 210°C. to 160°C., and various difficulties which reduce the value of the final products, such as the occurrence of striped spots, non-levelling, or poor dyeability, can be overcome.

The birefringence (Δn), total percentage crimp (TC) and dye exhaustion (L-value) are defined as follows:

A. Birefringence (Δn)

Sodium D rays (wavelength 589 millimicrons) are used as a light source, and the specimen filaments are disposed in a diagonal position. The birefringence (Δn) of the specimen is computed from the following equation:

$$n = n\lambda + r/\alpha$$

where n is the interference fringe due to the degree of orientation of the polymer molecular chain: r is the retardation obtained by measuring the orientation not developing into the interference fringe by means of a Berek's compensator; α is the diameter of the filament; and λ is the wavelength of the sodium D rays.

B. Total Percentage Crimp (TC)

A yarn processed on a false twist crimper is placed under an initial load of 2 mg/de and a heavier load of 0.2 g/de. After a lapse of 1 minute, the length (l_o) is read. Immediately the heavier load is removed, and the yarn under the initial load is placed in boiling water. It is taken out of the water 20 minutes later. The initial load is removed, and the yarn is naturally dried for 24 hours. The initial load and the heavier load are again exerted on the dried yarn, and its length (l_2) is read after a lapse of 1 minute. Immediately, the heavier load is removed, and after a lapse of 1 minute, its length (l_3) is read. The total percentage crimp (TC), which is the crimp properties of the false twisted filaments, is expressed by the following equation:

$$TC = (l_2 - l_3)/l_o \times 100\ \%$$

C. Dye exhaustion (L value)

A yarn processed by a false twist crimper is circular knitted. The knitted article is dyed for 30 minutes in boiling water using a dye bath containing 3 - 4% of Eastmann Polyester Blue BLF and 0.5 g/liter of Monogen at a goods-to-liquor ratio of 1:100. The lightness (L-value) of the dyeing is measured by a CM-20 type color differential meter, Nippon Color Machine Company. This L-values is employed as the dye exhaustion. LargerL-value mean lighter colors, and smaller L-values mean darker colors.

To facilitate the understanding of the invention, reference may be made to the accompanying drawings in which:

FIG. 1 is a schematic representation of the reaction between the heat treating temperature and the time required to attain the secondary crystallization:

FIG. 2 is a graphic representation showing one example of the relation among the false twist crimping temperature of the polyester filament (temperature of the filament), the dye exhaustion (L-value) and the total percentage crimp of the filament;

FIG. 3 is a graphic representation showing the relation between the birefringence of the starting polyester filaments of the invention and the draft employed in the false twist crimping treatment;

FIG. 4 is a schematic arrangement of one example of a false twisting apparatus suitable for the production of the false twist-crimped polyester yarns of the present invention;

FIG. 5 is a graphic representation showing the relation between the birefringence of an undrawn polyester filament and the draw ratio; and

FIG. 6 is a view showing one example of a drawing apparatus suitable for drawing by a dry heat drawing method in order to obtain a polyester filament having a birefringence $0.030 \leqq \Delta n \leqq 0.145$.

Referring to FIG. 1, the axis of abscissas represents the temperature of the filament on the heater, and the axis of ordinates, the time required until the secondary crystallization is attained. The curve a shows the conventional polyester filament, and the curve b, the starting polyester filament of the present invention. The denier size (de/fil), birefringence (Δn), and draft of the filament used are as follows:

	a	b
Denier size (de/fil)	75/24	75/24
Birefringence (Δn)	0.168	0.085
Draft (%)		
4	8	

By the term "time required until the secondary crystallization is attained," used herein, is meant the time of the initial stage where a substantially straight line relation is established between the logarithm of the time required to treat the specimen at a certain temperature and the density of the specimen. The $t_1 - t_2$ in the ordinate shows the time required for obtaining good crimps. When the time is shorter than t_1, the desired heat treating time cannot be attained, and the treating time longer than t_2 means that on the lower temperature side, heat setting is insufficient, and on the higher temperature side, the melt-adhesion of the filaments occur. Thus, in order to obtain good crimp setting effects, the time required until the secondary crystallization is attained should be within the range of t_1 to t_2, that is to say, the secondary crystallization should not precede the setting of the yarn form. Now referring to the drawing from this point of view, it is found that with the conventional polyester filament, at a temperature below T_3, the secondary crystallization is reached before arriving at the heat-treating time $t_1 - t_2$, and therefore, good crimp setting effects cannot be obtained. For instance, at about 180°C., the secondary crystallization stage is reached almost instantaneously, and the time is less than 10^{-1} seconds. At higher temperatures, the time required to attain the secondary crystallization stage becomes longer. Therefore, in order to obtain the treating time t_1 - t_2 within the range where the secondary crystallization does not precede, the processing is compelled to be performed at a temperature in the range of T_3 to T_4. As $T_3 - T_4$, the temperatures of 210° to 230°C. are generally used.

With the polyester filament of the present invention, the temperature corresponding to the minimum time required to attain the secondary crystallization exists within the range of T_1 to T_2, and this time becomes gradually longer both on the lower temperature side and the higher temperature side. It is assumed that the filaments showing such behavior of crystallization may have a different crystalline structure from that of the conventional polyester filaments. Such behavior of crystallization leads to ease of processing. Within the time range of t_1 to t_2 for obtaining good crimp setting effects, the temperatures in the range of T_1 to T_2 can be employed for the false twist crimping treatment. Such lower temperatures could not be used previously for false twist crimping of polyester filaments.

The dye exhaustion of the processed yarn of the invention is shown in FIG. 2 by the curve b_1. It is seen from the curve b_1 that at temperatures below 210°C., the dyeing difference (ΔD) in relation to the temperature difference (ΔT) is very small, and the dye exhaustion is markedly improved over the conventional false twist-crimped polyester yarns.

On the other hand, with the conventional false twist-crimped polyester yarns, the dyeing difference (ΔD) with the temperature difference (ΔT) is very large as shown by the curve a_1 of FIG. 2. If a number of such yarns having the temperature non-uniformity are used to produce woven or knitted articles, the resulting articles present clear dyeing non-uniformity, and are not suitable for sale on the market.

The curves a_2 and b_2 of FIG. 2 represent the total percentage crimps of the crimped yarns corresponding to a_1 and b_1. The total percentage crimp of the crimped polyester yarn of the invention becomes maximum at a temperature in the range of 160° to 210°C. within which excellent level dyeing properties and dyeability can be obtained. In contrast, with the conventional false twist-crimped polyester yarns, the total percentage crimps become maximum at 210° to 230°C. and above. It is seen from FIG. 2 that the conventional crimped polyester yarns have the desired total percentage crimps only when heat set at a temperature above 210°C., and suffer from considerably large fluctuations in dyeing difference (ΔD) with the temperature difference (ΔT) and also reduced dye exhaustion; whereas the present invention provides crimped yarns having comparable total percentage crimps and good dyeability and level dyeing properties by processing at lower temperatures of 160° to 210°C. It is appreciated that the processing temperatures in the range of 170° to 200°C. are especially preferred for obtaining good dyeability and level dyeing properties.

FIG. 3 shows that when the birefringence of the filament is set, the draft should be confined within a certain range. When polyester filament yarns having the birefringence specified in the invention are processed at a draft shown by the area A_4 in the drawing, the twisting tension becomes very small, and there is frequent occurrence of non-untwisted yarns or melt-adhered yarns. This makes it impossible to obtain crimped yarns which serve for practical purposes. When the yarns are processed at a draft shown by the area A_2 in the drawing, the twisting tension becomes very great, and the non-untwisted yarns or melt-adhered yarns do not occur to such an extent, but the crimp characteristics of the yarns become poor. Therefore, crimped yarns of practical value cannot be obtained. Accordingly, the draft specified in the invention is necessary for maintaining the yarn tension during twisting within the range of 0.05 to 0.15 g/de which has been required in the conventional false twisting in order to obtain stable twisting effects.

If the draft is in the area shown by A_1 in the drawing, the yarn exhibits the same properties as an undrawn yarn, and it is impossible to obtain crimped yarns of practical value. In the area A_3, the crimp characteristics, dye exhaustion, and level dyeing property are hardly improved. It is appreciated therefore that when polyester filaments having a birefringence of $0.06 \leq \Delta n \leq 0.135$, preferably $0.06 \leq \Delta n \leq 0.120$ are used, crimped yarns can be obtained which are most satisfactory in crimp characteristics, dye exhaustion and level dyeing property. The area formed by connecting h, i, j and k with one another in FIG. 3 satisfies the requirements for obtaining the crimped yarns of the invention, and the area formed by connecting l, m, n and o with one another is the preferred range. It is absolutely necessary therefore that the draft at the time of false twisting should be prescribed in relation to the birefringence of the polyester filaments used.

Referring to FIG. 4, polyester filament yarn **2** wound on pirn **1** passes snail guide **3** and is delivered by a pair of feed rollers **4** and **4'**. It then passes heater **5** and false twist spindle **6**, and is then taken up by a pair of delivery rollers **7** and **7'**. It is then wound up on bobbin **9** which rotates frictionally by roller **8**. In this instance, the birefringence of the polyester filament yarn wound up on the pirn **1** is 0.030 to 0.145. It is necessary that such a filament yarn should be processed between the feed rollers **4** and **4'** and the delivery rollers **7** and **7'** under the draft which satisfy the foregoing Equation I. Generally draft (dr) is determined by the following equation.

$$\text{draft (dr)} = (V_2 - V_1)/V_1 \times 100\ (\%)$$

wherein V_1 stands for the peripheral speed of the feed roller **4**, **4'** and V_2 for the peripheral speed of delivery roller **7**, **7'**.

The type of the false twist crimping is not particularly restricted, but the spindle method is especially preferred. If desired, a secondary heater may be provided between the spindle **6** and the delivery rollers **7** and **7'** in order to heat-treat the crimped yarn and reduce the torque of the yarn.

In FIG. 6, the numeral **10** shows a cheese, **11** an undrawn polyester yarn, **12** a roller for exerting a preliminary tension, **13** a hot feed roller, **14** a draw roller, **15** a guide and **16** a drawn yarn. In the drawing of an undrawn polyester yarn using this apparatus, it is preferable to impart a preliminary tension to the yarn to an extent such that the undrawn yarn will not substantially be drawn between the roller **12** and the hot roller **13.** This can desirably be done by controlling the peripheral speed ratio between the roller **12** and the hot roller **13.** The proper ratio of peripheral speed between the roller **12** and the hot roller **13** is about 1:1.001–1.030. A heat-treating device such as a slit heater or hot plate may be provided between the hot roller and the draw roller in order to heat set the drawn yarn.

The starting polyester filament yarn to be false twist-crimped by the process of the invention can be obtained by drawing an ordinary undrawn polyester yarn at a low draw ratio in dry heat using a heated feed roller, heated drawing pin or plate or wet heat (including warm water bath). For obtaining polyester yarns having a birefringence of 0.030 to 0.145, it is necessary to employ a suitable draw ratio (Dr) according to the birefringence (Δn_u) of the undrawn yarn. The following relation has been found to exist between Dr and Δn_u:

i. when $0.002 \leqq \Delta n \leqq 0.010 -100 \cdot \Delta n + 2.50 \leqq Dr \leqq -120 \cdot \Delta n + 4.00$ (II)

ii. when $0.010 < \Delta n \leqq 0.020 -25 \cdot \Delta n + 1.75 \leqq Dr \leqq -90 \cdot \Delta n + 3.7$ (III)

In FIG. **5**, the range which satisfies the above relations is shown by the hatched area. If the draw ratios which satisfy the above Equations II and III are used according to the birefringence of the undrawn yarn, the drawn polyester filaments can have a birefringence of 0.030 to 0.145.

As regards the wet heat drawing, the desired polyester filaments can be obtained by maintaining the drawing tension at 0.01 to 1.00 g/de in a water bath at 80° to 100°C. The drawing under these specified conditions leads to the formation of filament yarns which are molecularly oriented uniformly and free from necking. It is therefore necessary to adjust the drawing tension to a range of 0.01 to 1.00 g/de. If the drawing tension is less than 0.01 g/de, substantial molecular orientation does not occur, and the drawn yarn has much the same physical properties as an undrawn yarn. On the other hand, when the drawing tension exceeds 1.00 g/de, a high degree of molecular orientation occurs in the filament, and the properties become the same as those of the conventional polyester filaments. The drawing tension varies depending upon such factors as the type of the undrawn yarn, the temperature of the draw bath, the draw ratio, or the draw speed. In the case of a 155 denier/24 filaments undrawn polyester yarn having a birefringence of 0.0105 and an intrinsic viscosity of 0.59, the drawing tension will become 0.01 – 1.00 g/de when the yarn is drawn at a draw ratio of 1.40 to 2.80 at a draw bath temperature of about 90°C. and at a feed rate of 300 meters per minute.

Other methods of drawing are also available. For instance, an undrawn filament yarn extruded from a spinning nozzle is drawn between two pairs of rollers without prior wind-up, or an undrawn filament extruded from a spinning nozzle is first wound up on a bobbin rotating at peripheral speed of 3,000 meters per minute, and molecular orientation is induced in the meantime to form filaments having the desired birefringence.

The differences between the present invention and the prior art (British Pat. No. 777,625, British Pat. No. 746,992) will be discussed below at some length.

British Pat. No. 777,625 discloses that an undrawn yarn is drawn to more than several times the original length and simultaneously false twist-crimped. In this process, a tension as high as at least 0.2 g/de is exerted on the yarn, although it depends on the physical properties of the yarn, and under such a high tension, the twisting effect on the yarn is hardly obtainable. Therefore, this process can give a drawn yarn, but not a crimped yarn of practical value. Furthermore, in the process wherein drawing and false twist crimping are simultaneously performed, there will be a greater non-uniformity of dyeing if the processing is done under such conditions as to give good crimped yarns; thus, it is impossible to obtain serviceable crimped yarns by the process disclosed in this British Patent.

British Pat. No. 746,992 discloses the imparting of a draft of 0.5 to 20 percent at the time of false twisting. The starting raw yarn to be processed is a completely oriented or highly oriented drawn yarn (birefringence of greater than 0.160) of Terylene or Dacron. The drafting performed in the British Patent is intended to obtain twist yarns having uniform twist effect and to prevent duplicating twists, etc., when the yarn is false twist crimped in an overfeed state in a conventional manner.

The undrawn polyester yarns used in the present invention are a substantially non-oriented polyester filament consisting of a polyester containing at least 80 percent of ethylene terephthalate units. The preferred polyester is polyethylene terephthalate, but copolyesters containing less than 20 percent of other copolymerizable components may also be used. Examples of other acid components to be copolymerized with ethylene terephthalate include dibasic acids such as phthalic acid, isophthalic acid, adipic acid, oxalic acid, sebacis acid, suberic acid, glutaric acid, pimelic acid, fumaric acid, or succinic acid. Examples of other alcohol components that can be copolymerized with ethylene terephthalate are dihydric alcohols such as polymethylene glycols having two to 10 carbon atoms (trimethylene glycol and butylene glycol, for example), cyclohexane dimethanol, etc.

The polyester may contain a minor amount of a modifier such as 5-oxydimethyl isophthalate, 5-oxydimethyl hexahydroisophthalate, benzene-1,3,5-tricarboxylic acids, para-carbomethoxyphenyl diethyl phosphonate, 3,5-dicarboxy phenyl diethyl phosphate, pentaerythritol, glycol, phosphoric acid, triphenyl phosphate, tri-1-carbomethoxyphenyl phosphate, triphenyl arsenite, tricapryl boric acid, sorbitan, trimesic acid, or diethylene glycol. Furthermore, the polyester may contain a small amount of another polymer such as a polyamide, polycarbonate, or polyolefin.

The undrawn polyester yarns used in the present invention may be those obtained by melt-spinning the aforementioned-polyesters. Especially preferred are those having a denier size of not more than 150 denier per monofilament, a birefringence of 0.002 to 0.020, and an intrinsic viscosity of 0.3 – 1.2, as computed from the value measured in o-chlorophenol at 35°C. The drawing of an undrawn yarn composed of a polyester having an intrinsic viscosity of less than 0.5 presents difficulties in operation such as the occurrence of fuzzes in an ordinary hot pin drawing procedure. In such a case, the undrawn yarn of a polyester of low degree of polymerization can be satisfactorily drawn by using the hot roller drawing procedure.

The undrawn yarn may not only have a circular section, but also a non-circular section such as triangle, quadangle, pentagonal, flat, or cruciform section and a hollow section such as doughnut or non-circular hollow section.

Thus according to the present invention, a low torque false twist-crimped polyester yarn of highly improved dyeability can be obtained by dexterously combining the birefringence of the polyester filaments, the conditions for drawing the filaments, the draft at the time of false twist crimping procedure which is dependent on the birefringence, and the processing temperatures. The crimping operation can be performed at lower temperatures than in the conventional methods, and the resulting crimped yarns have comparable percentage crimp, and good dye exhaustion which hardly fluctuates even with the false twisting temperatures. The advantage of the present invention resides in the fact that good false twist-crimped yarns can be obtained even when the false twisting temperature is below 200°C. The invention also has the advantage that at this temperature, there is hardly any change in the difference of dye exhaustion, and no inspection is necessary to sort out the yarns according to the difference of dye exhaustion. That the false twisting temperature can be maintained at a low level helps to increase the speed of twisting to a marked extent, and this has a great industrial significance. The length of the heater of the false twister and the size (especially height) of the machine are naturally restricted, and with increasing processing temperatures, the speed of processing must be reduced in order to obtain the desired heat-treatment effects. However, when the false twisting can be performed at lower temperatures as in the present invention, the desired heat-treating effects can be obtained within shorter periods of time, and therefore higher speeds of processing.

The false twist-crimped polyester yarns of the invention have a density of $1.3800 \leq d \leq 1.3950$ (g/cm^3) which the conventional yarns having a total percentage crimp of not less than 30 percent cannot possess, and this contributes to the marked improvement of dyeing properties.

The modified false twist-crimped polyester yarns obtained by subjecting the aforementioned false twist-crimped polyester yarns to a second heat setting have a torque of not more than 26 (T/25 cm).

The torque and the density used in the invention are determined as follows:

D. Torque

The specimen false twist-crimped yarn is set at both ends spaced from each other at a distance of about 1 m, and a load of about 1 mg/de is applied to the central part of the yarn. The yarn is bent at the point of the load. The yarn is fixed at a point at which the intertwining (twist) generated as a result of the bending is maximum. The torque is expressed by the number of twists (T/24 cm) present per 25 cm of the yarn before untwisting. A crimped yarn having a larger number of twists has a larger torque. The torque values described in the present application are the averages of the measured values of 20 points.

E. Density:

The specimen is put into a density gradient tube of n-heptane-carbon tetrachloride (25°) using a float (precision $\pm 2 \times 10^{-4}$ g/cm^3) (made by Shibayama Scientific Instruments Works, Ltd.). The density is measured after a lapse of 48 hours.

The invention will further be described by the following Examples.

EXAMPLE 1

Polyethylene terephthalate chips having an intrinsic viscosity of 0.65 were melted at 288°C., and extruded through a spinneret having 24 orifices, each having a diameter of 0.25 mm, followed by windingup as undrawn filaments. The intrinsic viscosity of the undrawn filaments was 0.63, and they had a birefringence of 1050×10^{-5}. The drawing conditions of the undrawn filaments, the properties of the drawn filaments, and the conditions under which the drawn filaments were false twist-crimped by using a false twisting crimping machine of the type shown in FIG. 4 are shown in Table 1.

Table 1

Sample		A	B	C	D
Drawing conditions	heating means	warm water	hot roller	hot roller	warm water
	temperature (°C)	95	85	85	95
	draw ratio (x)	1.80	2.73	2.73	1.80
	draw speed (m/min)	600	1000	1000	600
Physical properties of the drawn yarn	denier size (de/fil.)	944/24	78.8/24	76.4/24	88.9/24
	birefringence (Δn)	0.045	0.138	0.138	0.045
	tenacity at break (g/de)	3.2	3.8	3.8	3.2
	elongation at break (%)	135	45	45	135
	density (g/cm^3)	1.350	1.365	1.365	1.350
Flase twist crimping conditions	number of false twists (T/M)	3380	3380	3380	3380
	draft (%)	21	1	−2	14
	processing speed (m/min)	100	100	100	100
	twist tension at 190°C. (gr/de)	0.108	0.110	0.089	0.072

Ten spindles were used for the crimping of the drawn filaments. The temperatures were varied from spindle to spindle by a maximum of ± 4°C. based on the standard spindle. Thus, ten false twist-crimped yarns were obtained. The total percentage crimps (TC) of these crimped yarns and their dyeing characteristics are shown in Table 2. It is seen from the Tables that according to the present invention, even if the temperature non-uniformity among the spindles exists, the crimp non-uniformity of the yarns does not occur, and the dye exhaustion difference (D = maximum dye exhaustion — minimum dye exhaustion) is negligibly small at temperatures at which the total percentage crimps of the yarns are large.

Table 2

Processing temperature (°C.)	Sample	Total percentage crimp: Standard spindle (TCs)	Total percentage crimp: Crimp difference (ΔTC)	Dyeing properties: Standard spindle (Ds)	Dyeing properties: Dyeing difference (ΔD)	Density of standard spindle (g/cm³)
	A	38:3	≤ 5:0	35:2	≤ 0.4	1.3875
170	B	32.6	≤ 5.0	37.8	≤ 0.4	1.3874
	C	33.4	≤ 5.0	37.5	≤ 0.4	1.3876
	D	38.5	≤ 5.0	35.7	≤ 0.4	1.3875
	A	43.1	≤ 4.0	35.3	≤ 0.2	1.3899
180	B	38.4	≤ 4.0	37.9	≤ 0.2	1.3897
	C	39.0	≤ 4.0	37.5	≤ 0.2	1.3896
	D	43.6	≤ 4.0	35.8	≤ 0.2	1.3898
	A	45.8	≤ 2.0	35.3	≤ 0.2	1.3920
190	B	40.7	≤ 4.0	37.9	≤ 0.2	1.3919
	C	41.5	≤ 4.0	37.6	≤ 0.2	1.3921
	D	45.9	≤ 2.0	35.8	≤ 0.2	1.3921
	A	45.1	≤ 2.0	35.2	≤ 0.8	1.3945
200	B	44.8	≤ 2.0	37.6	≤ 0.8	1.3943
	C	45.0	≤ 2.0	37.5	≤ 0.8	1.3944
	D	45.7	≤ 2.0	35.6	≤ 0.8	1.3942
	A	42.6	≤ 3.0	34.6	≤ 1.5	1.3965
210	B	44.3	≤ 2.0	37.0	≤ 1.5	1.3963
	C	44.6	≤ 2.0	36.9	≤ 1.5	1.3964
	D	43.0	≤ 3.0	34.9	≤ 1.5	1.3965

EXAMPLE 2

The conditions for the drawing of undrawn filaments obtained in Example 1, the properties of the resulting drawn filaments, and the conditions for false twist crimping of the drawn filaments using a false twisting crimping apparatus of the type shown in FIG. 4 are given in Table 3.

Ten spindles were used for crimping of drawn yarns, and the temperatures were varied from spindle to spindle by a maximum of ± 4°C. based on the standard spindle. Ten false twist-crimped yarns were obtained. The total percentage crimp and dyeing characteristics are given in Table 4. It is seen from the results shown in the above table that according to the present invention, even if the temperature non-uniformity exists among the spindles, the crimp non-uniformity of the yarns does not occur, and the dye exhaustion difference is still small at temperatures at which the total percentage crimps of the yarns are large.

Table 3

	Sample	E	F	G	H
Drawing conditions	heating means	warm water	hot roller	hot roller	warm water
	temperature (°C.)	95	85	85	95
	draw ratio (*x*)	210	2.54	2.54	2.10
	draw speed (m/min)	600	1000	1000	600
Physical properties of the drawn yarn	denier size (de/fil.)	90.5/24	82.7/24	79.6/24	85.8/24
	birefringence (Δ*n*)	0.078	0.115	0.115	0.078
	tenacity at break (g/de)	3.4	3.7	3.7	3.4
	elongation at break (%)	92	60	60	92
	density (g/cm³)	1.354	1.362	1.362	1.354
False twist crimping conditions	number of false twists (T/M)	3380	3380	3380	3380
	draft (%)	16	6	2	10
	processing speed (m/min)	100	100	100	100
	twist tension at 190°C. (gr/de)	0.110	0.102	0.087	0.093

Table 4

Processing temperature (°C.)	Sample	Total percentage crimp: Standard spindle (TCs)	Total percentage crimp: Crimp difference (ΔTC)	Dyeing properties: Standard spindle (Ds)	Dyeing properties: Dyeing difference (ΔD)	Density of standard spindle (g/cm³)
	E	37.4	≤ 5.0	36.5	≤ 0.4	1.3873
170	F	35.6	≤ 5.0	36.9	≤ 0.4	1.3875
	G	36.8	≤ 5.0	36.8	≤ 0.4	1.3875
	H	38.1	≤ 5.0	35.7	≤ 0.4	1.3874
	E	44.8	≤ 4.0	36.8	≤ 0.2	1.3900
180	F	43.7	≤ 4.0	37.2	≤ 0.2	1.3898
	G	44.2	≤ 4.0	36.9	≤ 0.2	1.3897
	H	44.6	≤ 4.0	36.1	≤ 0.2	1.3899
	E	45.1	≤ 2.0	36.8	≤ 0.2	1.3917
190	F	44.5	≤ 4.0	37.1	≤ 0.2	1.3820

Table 4 – Continued

Processing temperature (°C.)	Sample	Total percentage crimp: Standard spindle (TCs)	Total percentage crimp: Crimp difference (ΔTC)	Dyeing properties: Standard spindle (Ds)	Dyeing properties: Dyeing difference (ΔD)	Density of standard spindle (g/cm³)
	G	45.4	≤4.0	36.8	≤ 2.0	1.3822
	H	46.0	≤2.0	36.0	≤ 0.2	1.3819
200	E	45.2	≤2.0	36.7	≤0.8	1.3942
	F	44.8	≤2.0	37.1	≤0.8	1.3945
	G	45.2	≤2.0	36.7	≤0.8	1.3944
	H	46.3	≤2.0	35.8	≤0.8	1.3943
210	E	42.8	≤3.0	36.1	≤ 1.5	1.3964
	F	44.4	≤2.0	36.2	≤ 1.5	1.3962
	G	44.7	≤2.0	35.9	≤ 1.5	1.3968
	H	43.5	≤3.0	34.0	≤1.5	1.3965

COMPARATIVE EXAMPLE 1

The conditions for drawing the undrawn yarn obtained in Example 1, the properties of the drawn yarns, and the conditions for false twist crimping of the drawn yarns using a false twist-crimping apparatus shown in FIG. 4 are given in Table 5.

Table 5

	Sample	I	K	M	O
Drawing conditions	heating means	warm water	hot roller	hot roller	warm water
	temperature (°C)	95	85	85	95
	draw ratio (x)	1.80	2.73	2.73	1.80
	draw speed (m/min)	600	1000	1000	600
Physical properties of the drawn yarn	denier size (de/fil.)	105/24	85.8/24	73.6/24	81.9/24
	birefringence (Δn)	0.045	0.138	0.138	0.045
	tenacity at break (g/de)	3.2	3.8	3.8	3.2
	elongation at break (%)	135	45	45	135
	density (g/cm³)	1.350	1.365	1.365	1.350
False twist crimping conditions	number of false twists (T/M)	3380	3380	3380	3380
	draft (%)	35	10	−6	5
	processing speed (m/min)	100	100	100	100
	twist tension at 190°C. (gr/de)	0.25	0.35	0.04	0.03

Ten spindles were used for the crimping of the drawn yarns. The temperatures were varied from spindle to spindle by maximum of ± 4°C. based on the standard spindle. Thus, ten false twist-crimped yarns were obtained. The total percentage crimps and dyeing properties of these crimped yarns are shown in Table 6. It is seen from Table 6 that in Samples M and O, non-untwisted yarns and melt-adhered yarns occurred and it was impossible to obtain crimped yarns of practical values, and that in Samples I and K in which a twisting tension was large, the crimp properties of the yarns are poor, on the other hand considerably large difference (ΔD) of the dye exhaustion at processing temperatures at which the total percentage crimp is relatively large, which in turn produces the tendency of the dyeing non-uniformity among the spindles.

Table 6

Processing temperature)°C.)	Sample	Total percentage crimp: Standard spindle (TCs)	Total percentage crimp: Crimp difference (ΔTC)	Dyeing properties: Standard spindle (Ds)	Dyeing properties: Dyeing difference (ΔD)	Density of standard spindle (g/cm³)
170	I	23.5	≤ 5.0	43.6	≤ 0.5	1.3872
	K	14.3	≤5.0	45.7	≤ 0.5	1.3874
	M	(occurence of non-untwisted yarns)				
	O	(occurrence of non-untwisted yarns and melt-adhered yarns)				
190	I	28.7	≤ 3.0	45.1	≤ 0.3	1.3920
	K	20.2	≤ 3.0	46.8	≤ 0.3	1.3918
	M	(occurence of non-untwisted yarns)				
	O	(occurence of non-untwisted yarns and melt-adhered yarns)				
210	I	33.4	≤ 2.0	44.2	≤ 1.5	1.3963
	K	28.5	≤ 2.0	45.6	≤ 1.5	1.3964
	M	(occurrence of non-untwisted yarns and melt-adhered yarns)				
	C	(occurrence of non-untwisted yarns and melt-adhered yarns)				
220	I	31.6	≤2.0	41.6	≤ 2.5	1.3993
	K	34.6	≤ 2.0	42.1	≤2.5	1.3990
	M	(occurrence of non-untwisted yarns and melt-adhered yarns)				
	O	(occurrence of non-untwisted yarns and melt-adhered yarns)				
230	I	27.5	≤ 5.0	37.8	≤ 5.0	1.4009
	K	29.6	≤ 5.0	38.2	≤ 5.0	1.4007
	M	(occurrence of non-untwisted yarns and melt-adhered yarns)				
	O	(occurrence of non-untwisted yarns and melt-adhered yarns)				

COMPARATIVE EXAMPLE 2

The conditions for drawing the undrawn yarns obtained in Example 1, the properties of the resulting drawn yarns, and the conditions for twist crimping of the drawn yarns using a false twist crimping machine of the type shown in FIG. 4 are shown in Table 7.

In Samples L and N in which the birefringence of the drawn yarn is large as in the conventional drawn yarns that are commercially available, the yarns have good total percentage crimps at the processing temperatures above 210°C. But in this temperature range, the dye exhaustion difference becomes maximum, and the dyeing non-uniformity tends to occur among the spindles.

Table 7

Sample		J	L	N	P
Drawing conditions	heating means	warm water	hot roller	hot roller	warm water
	temperature (°C)	95	82	82	95
	draw ratio (x)	1.40	3.04	3.04	1.40
	drawspeed (m/min	200	1000	1000	200
Physical properties	denier size (de/fil)	101.24	81.1/24	75.0/24	89.7/24
of the	birefringence (Δn)	0.021	0.168	0.168	0.021
tenacity at break (g/de)	3.0	5.1	5.1	3.0	
drawn yarn	elongation at break (%)	160	28	28	160
	density (g/cm³)	1.348	1.380	1.380	1.348
False twist crimping conditions	number of false twists (T/M)	3380	3380	3380	3380
	draft (%)	30	4	−4	15
	processing speed (m/min)	100	100	100	100
	twist tension at 190°C. (gr/de)	0.084	0.385	0.100	0.036

Ten spindles were used for crimping the drawn yarns, and the processing temperatures were varied from spindle to spindle by maximum of ± 4°C. based on the standard spindle. Thus, ten false twist-crimped yarns were obtained. The total percentage crimps and dyeing properties are given in Table 8. It is seen from the table that in Samples J and P in which the birefringence of the drawn yarn was low, non-untwisted yarns and melt-adhered yarns occur, and the dyeing non-uniformity occurred, making it impossible to obtain crimped yarns of practical values.

EXAMPLE 3

Polyethylene terephthalate chips having an intrinsic viscosity of 0.65 were melted at 288°C., extruded through a spinneret having 30 orifices, each having a diameter of 0.25 mm, and woundup as undrawn yarns. The undrawn yarns had an intrinsic viscosity of 0.62 and a birefringence of 560 × 10⁻⁵. The conditions for drawing these undrawn yarns, the properties of the re-

Table 8

Processing temperature (°C.)	Sample	Total percentage crimp: Standard spindle (TCs)	Crimp difference (Δ TC)	Dyeing properties: Standard spindle (Ds)	Dyeing difference (Δ D)	Density of standard spindle (g/cm³)
170	J	(occurrence of non-untwisted yarns and melt-adhered yarns)				
	L	14.7	≦ 8	45.2	≦ 0.5	1.3873
	N	21.3	≦ 8	43.6	≦ 0.5	1.3872
	P	(occurrence of non-untwisted yarns and melt-adhered yarns)				
190	J	(occurrence of non-untwisted yarns and melt-adhered yarns)				
	L	21.4	≦ 8	46.4	≦ 0.3	1.3919
	N	28.6	≦ 5	44.0	≦ 0.3	1.3921
	P	(occurrence of non-untwisted yarns and melt-adhered yarns)				
210	J	(occurrence of non-untwisted yarns and melt-adhered yarns)				
	L	32.6	≦ 3	44.3	≦ 1.5	1.3963
	N	36.4	≦ 5	42.2	≦ 1.5	1.3964
	P	(occurrence of non-untwisted yarns and melt-adhered yarns)				
220	J	(occurrence of non-untwisted yarns and melt-adhered yarns)				
	L	34.1	≦ 3	41.5	≦ 2.5	1.3994
	N	42.7	≦ 3	39.5	≦ 2.5	1.3991
	P	(occurrence of non-untwisted yarns and melt-adhered yarns)				
230	J	(occurrence of non-untwisted yarns and melt-adhered yarns)				
	L	31.8	≦ 5	37.5	≦ 5.0	1.4006
	N	44.9	≦ 5	35.9	≦ 5.0	1.4005
	P	(occurrence of non-untwisted yarns and melt-adhered yarns)				

sulting drawn yarns, and the conditions for false twist crimping of the drawn yarns using a false twist crimping machine of the type shown in FIG. 4 in which second heat-treating devices are arranged at 7, 7′ and 8 are shown in Table 9.

Ten spindles were used for crimping of the drawn yarns, and the processing temperatures were varied from spindle to spindle by a maximum of ± 4°C. based on the standard spindle. The total percentage crimps, dyeing properties, and torques of the crimped yarns are shown in Table 10. It is seen from this table that according to the present invention, even if the temperature non-uniformity occurs among the spindles, the crimped yarns have little crimp non-uniformity, and small dyeing differences and torque at the temperatures at which the total percentage crimps are large.

COMPARATIVE EXAMPLE 3

The conditions for drawing the undrawn yarns obtained in Example 3, the properties of the resulting drawn yarns, and the conditions for false twist-crimping of the drawn yarns using a false twist crimping machine of the type shown in Table 4 in which second heat-treating devices are arranged at 7, 7′ and 8 are given in Table 11.

Table 9

		Sample	Q	R	S	T
Drawing conditions		heating means	warm water	hot roller	hot roller	hot roller
		temperature (°C)	98	87	85	85
		draw ratio (x)	2.40	2.60	2.85	3.4
		draw speed (m/min)	600	800	800	800
Physical properties of the drawn yarn		denier size (de/fil)	168.0/30	1620/30	157.5/30	154.5/30
		birefringence (Δ n)	0.068	0.085	0.106	0.124
		tenacity at break (g/de)	3.4	3.7	3.8	4.1
		elongation at break (%)	96	80	65	58
		density (g/cm³)	1.354	1.358	1.360	1.362
False twist crimping conditions	False twist part	number of false twists (T/M	2750	2750	2750	2750
		draft (%)	12	8	5	3
		twist tension at 190°C.(gr/de)	0.104	0.098	0.099	0.102
	heat treating part	draft (%)	−17	−17	−17	−17
		treating temperature (°C)	230	230	230	230
		processing speed (m/min)	124	124	124	124

Table 10

Processing temperature (°C.)	Sample	Total percentage crimp: Standard spindle (TCs)	Crimp difference (Δ TC)	Dyeing properties: Standard spindle (Ds)	Dyeing difference (Δ D)	Torque of standard spindle (T/25 cm)	Density of standard spindle (g/cm³
170	Q	13.5	≤ 1	37.3	≤ 0.2	11	1.3859
	R	12.7	≤ 1	38.5	≤ 0.2	14	1.3860
	S	12.3	≤ 1	39.1	≤ 0.2	15	1.3858
	T	11.0	≤ 1	39.5	≤ 0.2	17	1.3862
190	Q	14.4	≤ 1	37.5	≤ 0.2	14	1.3912
	R	14.9	≤ 1	38.6	≤ 0.2	16	1.3914
	S	14.5	≤ 1	39.0	≤ 0.2	16	1.3910
	T	12.7	≤ 1	39.7	≤ 0.2	20	1.3911
210	Q	13.0	≤ 2	36.6	≤ 0.7	13	1.3954
	R	13.6	≤ 2	37.5	≤ 0.7	15	1.3960
	S	13.4	≤ 2	38.2	≤ 0.7	17	1.3957
	T	14.3	≤ 2	38.5	≤ 0.7	22	1.3962
220	Q	9.6	≤ 4	35.1	≤ 1.5	10	1.3988
	R	10.5	≤ 4	35.9	≤ 1.5	12	1.3991
	S	11.0	≤ 4	36.4	≤ 1.5	15	1.3989
	T	12.1	≤ 4	36.7	≤ 1.5	20	1.3988

Table 11

		Sample	U	V
Drawing conditions		heating means	hot roller	hot roller
		temperature (°C.)	81	81
		draw ratio (x)	3.70	3.70
		draw speed (m/min)	800	800
Physical properties of the drawn yarn		denier size (de/fil)	156.0/30	144.2/30
		birefringence (Δn)	0.162	0.162
		tenacity at break (g/de)	5.4	5.4
		elongation at break (%)	28	28
		density (g/cm³)	1.378	1.378
False twist crimping conditions	False twist part	number of false twists (T/M)	2750	2750
		draft (%)	4	−4
		twist tension at 190°C. (gr/de)	0.368	0.101
	heat treating	draft (%)	−17	−17

Table 11—Continued

	Sample	U	V
part	treating temperature (°C.)	230	230
	processing speed (m/min.)	124	124

Ten spindles were used for the heat crimping of the drawn yarns, and the processing temperatures were varied from spindle to spindle by a maximum of ± 4°C. based on the standard spindle. Thus, ten false twist crimped yarns were obtained. The total percentage crimp, dyeing properties and torques of the crimped yarns are shown in Table 12. It is seen from the table that in Samples U and V in which the birefringences of the drawn yarns are large as in the commercially available conventional drawn yarns of polyester, the torque becomes large at the temperatures (above 210°C.) at which the yarns have good total percentage crimp. Snarl occurs frequently when the crimped yarns are knitted. Furthermore, the dye exhaustion difference becomes large, and the non-uniformity of dyeing tends to occur among the spindles.

Table 12

Processing temperature (°C.)	Sample	Total percentage crimp: Standard spindle (TCs)	Total percentage crimp: Crimp difference (Δ TC)	Dyeing properties: Standard spindle (Ds)	Dyeing properties: Dyeing difference (ΔD)	Torque of standard spindle (T/25 cm)	Density of standard spindle (g/cm³)
210	U	11.5	≤ 2	43.5	≤ 0.7	23	1.3972
	V	14.4	≤ 2	42.6	≤ 0.7	27	1.3968
220	U	12.9	≤ 4	41.9	≤ 1.5	27	1.3996
	V	15.9	≤ 4	41.5	≤ 1.5	30	1.4401

What we claim is:

1. A false twist-crimped polyester yarn having a density (d) of $1.3800 \leq d \leqq 1.3950$ (g/cm³) and a total percentage crimp (TC) of TC ≧ 30 (%).

2. A modified false twist-crimped polyester yarn having a density (d) of $1.3800 \leqq d \leqq 1.3950$ (g/cm³), a total percentage crimp (TC) of TC ≦ 20(%), and a torque (Tq) of Tq ≦ 26 (T/25 cm).

3. A process for producing a false twist-crimped polyester yarn which comprises false twisting a polyester multifilament having a birefringence (Δn) of $0.030 \leqq \Delta n \leqq 0.145$ while heat setting the filaments in the twisted state at 160° to 210°C. at a draft (d_r) which satisfies the following equation:

$$-250 \cdot \Delta n + 38 \geqq d_r \geqq -150 \cdot \Delta n + 17.$$

4. The process of claim **3** wherein the polyester multifilament has a birefringence (Δn) of $0.06 \leqq \Delta n \leqq 0.135$.

5. The process of claim **3** wherein the heat setting temperature is 170° to 200°C.

6. A process for producing a modified false twist-crimped polyester yarn which comprises subjecting the false twist-crimped polyester yarn obtained in claim **3** to a second heat setting at a temperature exceeding the temperature at which the yarn has been initially heat set.

* * * * *