Textured polyester yarn is prepared from multifilament yarn by drawing at a draw ratio of 1.3 to 2.0, and false-twist texturing at temperatures above 200°C in a continuous process. Preparation of the starting yarn by melt spinning at 3,000 to 3,500 yards per minute is illustrated.

2 Claims, 1 Drawing Figure
DRAWING AND BULKING POLYESTER YARNS

BACKGROUND OF THE INVENTION

This invention relates to production of false-twist textured yarn from multifilament yarns of synthetic linear ethylene terephthalate polyester; it is more particularly concerned with improvements in the false-twist texturing process and feed yarn supplied for texturing.

Conventional production of synthetic linear ethylene terephthalate yarn for textile use involves melt-spinning the polyester into filaments, cooling the filaments and drawing the filaments to impart desired mechanical properties. To produce bulk and tactility a crimping step is usually added. Crimp is provided in a variety of ways depending on the use of the yarn. A particularly popular method for continuous filament yarns is to twist the yarn, heat-set the twisted configuration in the yarn, and then untwist the yarn, using, for example, a false-twist spindle to twist and untwist the yarn. The strains set in the yarn filaments cause the filaments to curl when relaxed.

In a typical false-twist texturing process, yarn is passed continuously from feed rolls over a hot plate to a rotating false-twist spindle and is forayed by takeoff rolls at a rate which maintains tension between the feed and take-off rolls. The spindle is rotated at high speed to twist the yarn at least 40 turns per inch (1,575 turns/m.) (60 to 100 turns per inch 2,362 to 3,940 turns/m.) are generally used for yarns of 70 to 150 denier. Since a spindle speed of at least 216,000 revolutions per minute is required to produce a twist of 60 tpi. (2,362 turns/m.) when using a feed rate of 100 yards per minute (91.4 meters/min.), relatively low yarn feed rates are necessary because of practical limitation in spindle speeds.

The speed at which filaments can be melt-spun is limited only by the rates at which the molten polymer can be pumped through the spinneret assembly and the extruded filaments wound up. Although windup speeds of up to 4,500 yards per minute (4,115 meters/min.) are feasible, spinning speeds much higher than 1,000 ypm. (914.4 meters/min.) have been considered uneconomical because of the increasing cost of equipment required for greater speeds.

In conventional processes, textile yarn is drawn about 3.5X to 4X between feed and draw rolls driven at different speeds. This can be done at high speed, and drawing can be coupled with melt-spinning to provide drawn yarn in a continuous operation. However, the greatly increased yarn windup speed required in a coupled spin-draw process is a limitation on the spinning speed which can be used.

It is economically desirable to combine the drawing with false-twist texturing in a continuous process. However, previous attempts to do so have not been successful when starting with undrawn polyester yarn. The filaments produced in the melt-spinning operation are substantially amorphous, and previously available undrawn filaments having low molecular orientation are overheated and break during stringup when subjected to conditions used in modern false-twist texturing processes. Attempts to use lower heater temperatures to avoid damaging the filaments have resulted in products having poor crimp development. Separating the draw zone from the texturing zone has not provided a solution to the stringup problem. The products have still been inferior as to crimp development and dyeing uniformity. Furthermore, ageing of the undrawn yarn in storage and shipping has caused further decreases in product quality.

SUMMARY OF THE INVENTION

The present invention provides an improved draw-texture process wherein polyester yarn is drawn and false-twist textured at temperatures high enough for outstandingly good crimp development. The invention also provides feed yarn suitable for use in the process.

The invention provides an improvement in the continuous process for preparing false-twist textured yarn from multifilament yarn composed of synthetic linear ethylene terephthalate polyester by feeding the yarn to a false-twisting device and setting twist backed up in the yarn with a heater having a temperature above 200° C. The improvement in the process comprises continuously drawing immediately prior to the false-twisting device, a feed yarn characterized by (a) having a structural integrity value \( (\varepsilon_{\text{e}}) \), of 0.3 to 1.0, (b) having a boil-off shrinkage of 40 percent to 60 percent, and (c) being composed of synthetic linear ethylene terephthalate polymer which is less than 30 percent crystalline, the feed yarn being drawn during the texturing process at a draw ratio of 1.3X to 2.0X.

The feed yarn preferably has a structural integrity value \( (\varepsilon_{\text{e}}) \) of 0.4 to 0.9. A boil-off shrinkage of 55 percent to 58 percent is also preferred. The feed yarn can be prepared in a substantially amorphous condition by a high speed melt-spinning process, using windup speeds of 3,000 to 4,000 yards per minute with controlled cooling of the filaments between spinneret and windup.

The yarn is preferably twisted at least 7.34 \( \times 10^{5} / \sqrt{D} \) – 10 turns per inch in the improved process, where \( (D) \) is the denier of the yarn before texturing, and this twist can be heat-set with heater temperatures above 200° C. to give a crimp development \( (CD_{\pm}) \) of at least 22–0.05 \( (D'_{\text{c}}) \), wherein \( (D')_{\text{c}} \) is the denier of the textured yarn. The feed yarn is quite stable and can be stored in a warehouse for more than 60 days without significant effect on the products of the process. The yarn draws satisfactorily at ambient temperatures or at elevated temperatures to give highly uniform products. No draw heater is required, even when using a tandem draw-texturing arrangement wherein the drawing operation is completed prior to the texturing machine heater. It is surprising that adequate drawing is accomplished at the low draw ratios of 1.3X to 2.0X. The examples illustrate that yarns having structural integrity values of about 0.5–0.6 can be drawn at draw ratios of about 1.5X to 1.7X, false-twisted and heat-set with heater temperatures above 215° C. to give outstanding products. Lower draw ratios can be used with lower values of structural integrity.

BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE of drawing is a diagrammatic representation of the false-twist process and suitable equipment.

DETAILED DESCRIPTION

In the drawing, polyester yarn 1 is fed continuously from package 2 by feed rolls 3 and 3', passes through texturing heater 4 and false-twisting device 5, is pulled away by rolls 6 and 6', and is wound up on package 7. The false-twisting device rotates at high speed to insert
3,771,307

“S” twist on one side and “Z” twist on the other. The twist backs up to feed rolls 3 and 3’ so that the yarn is highly twisted as it passes through heater 4. The heat plasticizes the polyester yarn and causes crystallization. Uponcooling, the twisted configuration is locked in by the crystallized molecular arrangement. The yarn untwists as it passes from the false-twisting device to rolls 6 and 6’. Rolls 6 and 6’ are driven at a higher peripheral speed than the feed rolls 3 and 3’ to provide a draw ratio between 1.3X and 2.0X. Because the yarn is drawn in the twist zone; i.e., between feed rolls 3 and 3’ and rolls 6 and 6’, the latter set of rolls being preceded by the false-twist device 5, this process is herein termed a “simultaneous” process. This process can be carried out on commercially available false-twist texturing machines by lowering the speed of rolls 3,3’ and/or increasing the speed of rolls 6,6’ to provide the required draw ratio. The machines used in the examples were modified by changing gears to reduce the speed of rolls 3,3’ relative to rolls 6,6’.

The yarn then passes to package 7, which is usually driven at a somewhat slower peripheral speed than rolls 6 and 6’ to provide a package overfeed so that tension of the yarn will not be excessive in the package. Another heating means may be used between the draw rolls and the package to stabilize the textured yarn and decrease its twist-liveliness. Illustrations of such later heating steps are given in U.S. Pats. No. 3,131,528 and No. 3,316,705.

Optional rolls 8 and 8’ are indicated in dotted lines between feed rolls 3,3’ and texturing heater 4. These rolls are used when it is desired to separate a drawing zone from the twisting zone. Rolls 8 and 8’ can be used as draw rolls when lower tensions are desirable in the twist-texturing operation. A process wherein rolls 8,8’ are rotated at a higher peripheral speed than rolls 3,3’ to draw the yarn immediately prior to the twisting zone is herein termed a tandem process. The relative speeds of rolls 3,3’, rolls 8,8’ and rolls 6,6’ can be adjusted to provide a process which combines tandem and simultaneous drawing. If desired, a heater can be inserted in the draw zone between rolls 3,3’ and rolls 8,8’, but no draw heater is required for tandem drawing.

METHODS OF EVALUATION

Relative Viscosity of the terephthalate polyester is a measure of its molecular weight. It is measured by either of the following two methods reported herein; (a) RV is the ratio of the viscosity of a solution of 2.15 gm. of polymer dissolved at 140° C. in 20 ml. of fomal to the viscosity of the fomal itself, both measured at 25° C. in a capillary viscometer and expressed in the same units. Fomal is a mixture of 10 parts by weight of phenol and 7 parts by weight of 2,4,6-trichlorophenol, (b) HRV is the ratio of the viscosity of a solution of 0.8 gm. of polymer dissolved at room temperature in 10 ml. of hexafluoroisopropanol to the viscosity of the hexafluoroisopropanol itself, both measured at 25° C. in a capillary viscometer and expressed in the same units.

Crimp Development (CD) of textured yarns is a measure of their crimp characteristics and is determined in the following manner: A skein of yarn is wound on a denier reel the number of times required to achieve a denier (in the looped skein) of 5,000 using the formula:

\[ n = \frac{2,500}{D} \]

wherein \( n \) is the number of turns and \( D \) is the denier of the yarn. A 500 gm. weight is hung from the skein and the length of the skein measured \( L_0 \). The 500 gm. weight is then replaced by a suitable weight and the weighted skein is placed in a hot-air oven for 5 minutes at 120° C. The suitable weight may be 2.5 gm. which would produce a load of 0.5 mg./denier, or some other desired weight. In the examples which follow, loads of 0.5, 1.5, 2.5 and 5.0 mg./denier are used. The skein is removed and allowed to cool with the weights still suspended therefrom. This length is measured and recorded as \( L_c \). The weight is removed and the skein is again loaded with 500 gm. (0.1 gm./denier) to remove the crimp and the skein length is read after 15 seconds. This length is recorded as \( L_c \). Crimp development is calculated by the following formula:

\[ CD_d(\%) = \frac{L_c - L_0}{L_0} \times 100 \]

wherein \( w \) is the skein loading in mg./denier, during the measurement of \( L_c \). All crimp development values expressed herein are percentage values calculated by the above formula. %”T” sign bein understood.

Skein Shrinkage is the decrease in length of a sample yard under a specified load caused by a specific heat treatment expressed as a percentage of the length of the untreated sample. The same method is used as described for CD. Calculations are as follows:

Skein shrinkage (\%) = \( \frac{L_0 - L_d}{L_0} \times 100 \)

Boil-Off Shrinkage is obtained by suspending a weight from a length of yarn to produce a 0.1 gm./denier load on the yarn and measuring its length \( (L_0) \). The weight is then removed and the yarn is immersed in boiling water for 30 minutes. The yarn is then removed, loaded again with the same weight, and its new length recorded \( (L_d) \). The percent shrinkage is calculated by using the formula:

Shrinkage (\%) = \( \frac{L_0 - L_d}{L_0} \times 100 \)

Structural Integrity Parameter \( (\epsilon_{2}) \) is measured by suspending a weight from a length of yarn to produce a 0.2 gm./denier load on the yarn and measuring its length \( (L_0) \). The yarn, bearing this load, is then immersed into 100° C. water for 2 minutes, then carefully removed and allowed to cool while still under the load. The length is measured again \( (L_d) \). The following formula is used to calculate \( \epsilon_{2} \):

\[ \epsilon_{2} = \frac{L_0 - L_d}{L_0} \times 100 \]

Conventional drawn yarns have a negative \( \epsilon_{2} \). The heating means of a conventional false-twist texturing machine is operated at a temperature of about 227° C. As shown in the examples, it is difficult and frequently impossible to string up, under normal operating conditions, conventional as-spun polyethylene terephthalate yarns having an \( \epsilon_{2} \) greater than 1.0.

The examples illustrate preparation of the feed yarns of the present invention by melt-spinning at high spinning speeds, with windup speeds of about 3,000 to 3,500 yards per minute (2,743 to 3,200 meters per minute). Higher windup speeds can be used. Somewhat lower speeds can be used when the filaments in the draw-textured product are to be less than about 4 dpf.

Conventional spinning conditions are suitable up to the point where the molten polyester leaves the spinneret in the form of filaments. The filaments are cooled as they are pulled away from the spinneret at a speed which causes them to become greatly attenuated be-
before reaching the pulling means. The cooled filaments may be forwarded to the windup by high speed pulling rolls or the like at substantially the same speed as the filaments are wound up, i.e., the process does not require a conventional drawing step. The cooled filaments may be interlaced as described in Bunting et al. U.S. Pat. No. 2,985,995 before the windup or at any time prior to texturing. The cooling conditions are preferably controlled to provide an $e_{21}$ value of 0.4 to 0.9. In the examples, the cooling medium is room temperature air, free circulation of the air takes place with the motion of the filaments, and the filaments travel a distance of about 20 feet (6.1 meters) in the cooling medium. The filaments can be cooled more quickly with a forced flow of gas, e.g., 70°F. air. Effective temperature and flow conditions for the cooling medium selected, distance of travel in the cooling medium, and filament speed (within the indicated range of windup speeds), for producing suitable feed yarn, can readily be determined by simply varying controllable conditions and measuring the $e_{21}$ values obtained.

The feed yarns of the present invention are molecularly oriented and are not fully crystalline. Orientation and crystallinity can be measured by conventional techniques.

It is highly surprising to find that as-spun yarn can be prepared which is suitable for draw-texturing, under conventional conditions with standard machines modified for drawing the yarn, to produce textured yarn with improved crimp development and other properties as compared with commercial textured yarn. The yarn has a low degree of crystallinity which facilitates formation of the desired crystalline structure when it is heat set. The yarn differs from commercial undrawn yarn in having an $e_{21}$ value of less than 1.0.

The unusual feed yarns of this invention not only are easy to texture in conventional high-speed operations but the final textured yarns are found, unexpectedly, to possess higher crimp development than conventional false-twist textured yarns processed under similar conditions. Surprisingly, the lower the $e_{21}$ values of the starting yarn within reasonable limits, the higher the crimp development of the final yarns textured under similar conditions by either the tandem or the simultaneous process. Higher throughput in the texturing operation and improved dye uniformity are other advantages of yarns produced according to this invention.

A further advantage of the new feed yarn is its stability in storage compared to similar amorphous yarn having an $e_{21}$ of greater than 1. It has now been found that polyester feed yarn of the present invention can be stored prior to texturing for more than 60 days with no significant deterioration of draw-texturing performance taking place whereas similar amorphous yarn having an $e_{21}$ of greater than 1 develops significant deterioration of draw-texturing performance during the same period making it unsuitable for drawing and texturing.

In the draw-texturing operation the minimum twist that should be given to the yarn increases with decreasing yarn denier. The draw-texturing machine is adjusted to produce a twist in the yarn, in turns per inch, which is numerically equal to or greater than $7.34 \times 10^5 / D - 10$ wherein $D$ is the denier of the yarn before texturing.

The textured yarns produced by the new process have a crimp development under a load of 2.5 mg. per denier which is numerically equal to or greater than 22.0.5 (D') wherein D' is the denier of the textured yarn. Thus a 70-denier yarn would have a crimp development (CD) greater than 18.5 and a 400-denier yarn would have a crimp development (CD) greater than 2.

As in conventional false-twist texturing, a lubricating finish should be applied to the feed yarn to facilitate the draw-texturing operation. The yarn polymer may contain minor amounts of the usual delustrants, particulate matter, antistats, optical brighteners, antioxidants and copolymer components, provided that the modified yarn satisfies the requirements specified for the process invention. In the examples which follow, the yarns contain one or more of these agents.

The invention is further illustrated by the following examples, which are not intended to be limiting.

**EXAMPLE I**

Polyethylene terephthalate of 27 RV is spun at 294°C. using a spinneret containing 34 round orifices of 15-mil (0.38-mm.) diameter. The freshly spun filaments travel in air approximately 20 feet (6.1 meters) before they are wound up at 2,000 yards per minute (1,829 meters/minute) as 395-denier yarn. This first yarn has an $e_{21}$ of 1.53, a shrinkage (%) of 61, is moderately oriented and substantially amorphous.

A second yarn is produced in similar fashion with the exception that the second yarn is wound-up at 3,500 yards per minute (3,200 meters/minute) as 255-denier yarn. The second yarn is undrawn, highly oriented, substantially amorphous, has an $e_{21}$ of 0.5, and a shrinkage (%) of 54.

The second yarn is textured by the simultaneous process on a commercial texturing machine of the type described previously. The heater plate is at the conventional temperature of 227°C. Spindle speed of the false-twist means is 210,000 rpm to produce in the yarn 60 turns per inch (2,362 turns/meter) in the twist zone. Draw ratio and crimp development values for this yarn are shown in Table 1. The first yarn could not be textured at the machine settings shown because it melted on contact with the heater.

A commercially available, semi-dull, drawn polyethylene terephthalate yarn having a denier of 150 and containing 34 filaments is textured in the manner shown for the second yarn. The draw ratio (in texturing) and crimp development values for this commercial yarn are shown in Table 1.

<table>
<thead>
<tr>
<th>Yarn</th>
<th>Draw Ratio</th>
<th>Second Yarn Commercial</th>
<th>0.98</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$D_1$</td>
<td>$D_2$</td>
</tr>
<tr>
<td></td>
<td>1.67</td>
<td>55</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>69</td>
<td>46</td>
<td>25</td>
</tr>
</tbody>
</table>

**EXAMPLE II**

Polyethylene terephthalate of 26 RV is spun at 290°C. using a spinneret containing 34, 15-mil (0.38-mm.) diameter, round orifices. The freshly spun filaments travel in air approximately 20 feet (6.1 meters) before they are wound up at 3,430 yards per minute (3,136 meters/minute). The $e_{21}$ of this test yarn is approximately 0.56 and the denier is 255. The yarn is undrawn, highly oriented, and substantially amorphous.

As a control, the same type polymer is spun at 803 yards per minute (734 meters/minute) as a 34-filament yarn, forwarded to feed rolls, then to an aqueous draw bath at 95°C. and then to enclosed heated draw rolls.
maintained at 128° C. and rotating at 3,000 yards per minute (2,743 meters/min.) to produce a draw ratio of 3.73. The filaments are then forwarded directly to a windup and the total denier of the yarn is 150.

Both yarns are textured by the simultaneous process on the same type machine as used in Example I using a spindle speed of 210,000 rpm, to produce 60 turns per inch (2362 turns/meter) twist in the twist zone, 227° C. hot-plate temperature, and 12 percent top overfeed. Top overfeed is the relationship between the draw roll peripheral speed and the speed of the yarn as it is wound on the final package. By regulating top overfeed, the “tightness” of the yarn on the package is regulated in conventional fashion. Draw ratio (in the texturing process) and crimp development values of these yarns are shown in Table 2.

<table>
<thead>
<tr>
<th>Yarn</th>
<th>Draw Ratio in Texturing</th>
<th>CD3,4</th>
<th>CD4,5</th>
<th>CD5,6</th>
<th>CD6,7</th>
<th>CD1,2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>1.64</td>
<td>71.0</td>
<td>50.0</td>
<td>36.0</td>
<td>11.0</td>
<td>3.8</td>
</tr>
<tr>
<td>Control drawn</td>
<td>72.0</td>
<td>50.0</td>
<td>30.0</td>
<td>8.0</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>previously</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From these results, it can be seen that the yarn drawn and textured simultaneously compares favorably to conventional textured yarn and even shows superior crimp properties under relatively high restraints such as would be encountered in fabric structures.

**EXAMPLE III**

This example shows the criticality of the $\varepsilon_{0.2}$ parameter.

Example I is repeated with the following exceptions: 3 yarns are made, each yarn consisting of 34 filaments. Yarn 1 is wound-up at 2,800 yards per minute (2,560 meters/minute) and has an $\varepsilon_{0.2}$ of about 1.05; yarn 2 is wound-up at 3,000 yards per minute (2,743 meters/minute) and has an $\varepsilon_{0.2}$ of about 0.85; yarn 3 is wound up at 3,500 yards per minute (3,200 meters/minute) and has an $\varepsilon_{0.2}$ of about 0.6.

The texturing machine for each yarn is a Leesona No. 555, similar to the machine of the preceding examples and the simultaneous process is used. The spindle speed is 210,000 revolutions per minute to produce 58 turns-per-inch (2,283 turns/meter) twist in the yarn in the twist zone, the temperature of the heater plate is set at 227° C., and the top overfeed is 12 percent. Table 3 shows the as-spun denier, draw ratio in the texturing process, and crimp development values of the yarns.

<table>
<thead>
<tr>
<th>Yarn</th>
<th>Denier (As spun)</th>
<th>Dr w ratio</th>
<th>CD3,4</th>
<th>CD4,5</th>
<th>CD5,6</th>
<th>CD6,7</th>
<th>CD1,2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>288</td>
<td>1.61</td>
<td>68</td>
<td>47</td>
<td>16</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>265</td>
<td>1.86</td>
<td>94</td>
<td>55</td>
<td>28</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>260</td>
<td>1.61</td>
<td>68</td>
<td>47</td>
<td>16</td>
<td>10</td>
<td>11</td>
</tr>
</tbody>
</table>

*CD measured after yard packages were placed in an autoclave for 30 minutes at 17 p.s.i. (1.195 kg. per sq. cm.) steam.

Yarn 1 ($\varepsilon_{0.2}$ about 1.05) could not be strung up in spite of intense effort on the part of two experienced operators because it melted.

**EXAMPLE IV**

(a) Polyethylene terephthalate is melt-spun at 290° C. using a spinneret containing 34 round orifices of 15-mil (0.38 mm.) diameter. The freshly spun filaments travel in air approximately 20 feet (6.1 meters) before they are wound up at 3,430 yards/min. (3,136 meters/min.) as 248-denier yarn of 20.3 HRV. The yarn has an $\varepsilon_{0.2}$ of about 0.55, a shrinkage of 57 percent and is undrawn, highly oriented and substantially amorphous.

The yarn is textured by the tandem process on a Leesona 553 to which a draw zone was attached immediately before the bottom feed roll. The heater plate is at the conventional temperature of 227° C.

Spindle speed is 210,000 rpm to produce in the yarn 60 turns per inch (2,362 turns per meter) in the twist zone. The speed of the feed rollers (similar to rolls 8 and 9 of the drawing) is set to provide an overfeed of about 1 percent and the yarn is overfed to the take-up package approximately 12 percent. In the draw zone the yarn is drawn 1.64X while passing in the vicinity of a heater set at 100° C.

Item “a” in Table 4 shows spindle tensions during texturing and final properties of this textured yarn.

(b) The process for producing Item “a” is repeated with the exception that the spinning temperature is 285° C. instead of 290° C., feed yarn is 110 denier instead of 248 denier, the spindle speed is 240,000 rpm to produce in the yarn 72 turns per inch (2,834 turns/meter) in the twist zone and the yarn is overfed to the take-up package at 8 percent instead of 12 percent. In the draw zone the yarn is drawn 1.53X. Item “b” in Table 4 shows process conditions and final properties of this textured yarn.

(c) The process for producing Item “b” is repeated with the exception that no heater is used in the draw zone. Item “c” in Table 4 describes this yarn. Surprisingly, the properties of the final textured yarn compare very favorably to Item “b” above which employed a heater in the drawing step; whereas yarns having an $\varepsilon_{0.2}$ of more than 1.0, if at all operable, are nonuniform when drawn in the tandem process with no heater in the draw zone.

(d) A commercially available, semi-dull, drawn polyethylene terephthalate yarn having a denier of 70 and containing 34 filaments is textured in the same manner as for Item (b) with the exception that the yarn is not drawn as illustrated but it is processed according to customary conditions. Item “d” of Table 4 shows process conditions and final properties of this yarn. It is easily seen that this yarn is inferior in crimp development to the yarns of the present invention. Crimp development measured at loads of 2.5 mg./denier or higher is especially indicative of the performance of a yarn in a fabric.

**EXAMPLE V**

This example shows the surprising effect of $\varepsilon_{0.2}$ on the crimp development of yarns processed according to this invention.

Example IV is repeated for Item “b” with the exception that the spinning temperature is 280° C. Instead of 285° C., the HRV of the undrawn feed yarn is about 22 (except for Item (d), the HRV of which is 20), the spinning speeds and $\varepsilon_{0.2}$ values are as listed in Table 4, and the draw ratios, adjusted for best physical properties, are 2.5X, 1.9X, 1.67X and 1.53X for items “a” to “d”, respectively. Spindle speed is 240,000 rpm and twist in the twist zone is 72 turns/inch (2,834 turns/m.). In order to draw-texture the feed yarns which are spun at 1,700 and 2,500 yards/minute (1,554 to 2,286 meters/min.) it is necessary to hold them away from the textur-
The higher crim development at the middle load of 2.5 grams per denier which is an important number in predicting performance of the yarn in a fabric, is readily apparent in the yarns which are processed according to this invention as compared to yarns processed otherwise.

This example is repeated with the same feed yarns. However, this time the tandem process is not used but the yarn is drawn at the twisting stage (simultaneous process) as in Example I. Again, it is necessary to hold the feed yarns which are spun at 1,700 and 2,500 yards/minute (1,554 to 2,286 meters/minute) away from the texturing-machine heater during stringup and initial operation. Draw ratios for these items (e-h) of Table 4 are as follows: 2.5X, 1.9X, 1.67X, 1.53X, respectively. Process conditions and final yarn properties are shown in Table 4. Overfeed to the take-up package is approximately 8 percent for items e-h. Again, a rise in crim development at middle loads is seen for the yarns of the present invention.

<table>
<thead>
<tr>
<th>Example</th>
<th>Item</th>
<th>Spinning speed of feed yarn, yard/min.</th>
<th>Break elongation (percent)</th>
<th>Final denier</th>
<th>Crimp development at load indicated</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV</td>
<td>Yarn</td>
<td>3,400 (3.360)</td>
<td>0.55</td>
<td>11-15</td>
<td>60-65</td>
</tr>
<tr>
<td></td>
<td>Yarn</td>
<td>3,400 (3.280)</td>
<td>0.55</td>
<td>11-15</td>
<td>60-65</td>
</tr>
<tr>
<td>IV</td>
<td>Yarn</td>
<td>3,400 (3.360)</td>
<td>0.55</td>
<td>11-15</td>
<td>60-65</td>
</tr>
<tr>
<td>IV</td>
<td>Yarn</td>
<td>3,400 (3.360)</td>
<td>0.55</td>
<td>11-15</td>
<td>60-65</td>
</tr>
<tr>
<td>IV</td>
<td>Yarn</td>
<td>3,400 (3.360)</td>
<td>0.55</td>
<td>11-15</td>
<td>60-65</td>
</tr>
<tr>
<td>V</td>
<td>Yarn</td>
<td>3,400 (3.280)</td>
<td>0.55</td>
<td>11-15</td>
<td>60-65</td>
</tr>
<tr>
<td>V</td>
<td>Yarn</td>
<td>3,400 (3.360)</td>
<td>0.55</td>
<td>11-15</td>
<td>60-65</td>
</tr>
<tr>
<td>V</td>
<td>Yarn</td>
<td>3,400 (3.360)</td>
<td>0.55</td>
<td>11-15</td>
<td>60-65</td>
</tr>
<tr>
<td>V</td>
<td>Yarn</td>
<td>3,400 (3.360)</td>
<td>0.55</td>
<td>11-15</td>
<td>60-65</td>
</tr>
</tbody>
</table>

Spindle tension* of feed yarn (gm. per yard) = 0.6

Crimps per inch (2,165 turns/m.) in Yarn A instead of 60 turns per inch (2,362 turns/m.). The third and fourth entries of Table 5 describe these yarns.

The fifth entry (Yarn C) is a commercial Dacron Type 56 yarn of the same type but which had been fully drawn before being textured according to standard commercial practice.

In each process Yarn B has to be held off the heater of the Leesona machine during stringup. In the simultaneous process Yarn B has frequent broken filaments. Surprisingly, Yarn A does not require heat in the draw zone in the tandem process.

**EXAMPLE VI**

Polyethylene terephthalate is melt spun at 290° C. using a spinneret containing 34 round orifices of 20-mil (0.50 mm.) diameter. The freshly spun filaments travel in air approximately 20 feet (6.1 meters) before they are wound up at 3,400 yards per minute (3,109 meters per minute) as 258-denier yarn. This undrawn, highly oriented, substantially amorphous yarn (Yarn A) contains about 0.3 percent TiO₂, has an HRV of about 21, and an εₐ₂₀ of about 0.53.

A second yarn (Yarn B) is produced in the same manner with the exception that it is wound up at 2,000 yards per minute (1,829 meters/min.) instead of at 3,400 yards per minute (3,109 meters/min.). The denier of the second yarn is 362 and its εₐ₂₀ is 1.43. It is substantially amorphous.

Each yarn is separately textured by the simultaneous process on a commercially available false-twisting texturing machine (Leesona 555/570). For Yarn A the draw ratio is 1.65, the spindle speed is 270,000 rpm to produce in the yarn 60 turns per inch (2,362 turns/m.), the bottom heater is at 216°C., and the top heater is at 213°C., the package overfeed is -4 percent and the second-heater overfeed is 14.5 percent. As in the conventional process, the second heater (top heater) is used to set the yarn. For Yarn B, the same texturing conditions are used with the exception that the draw ratio is 2.45. The first two entries in Table 5 show the bulk characteristics of these yarns.

The example is repeated with the exception that each yarn is separately textured by the tandem process instead of by the simultaneous process, the draw ratio for Yarn A is 1.75, the draw ratio for Yarn B is 2.4, a heater at a temperature of 150°C. is used in the draw zone for Yarn B, the spindle speed is 240,000 rpm instead of 270,000 rpm and the spindle produces a twist of 55 turns per inch (2,165 turns/m.) in Yarn A instead of 60 turns per inch (2,362 turns/m.).

**TABLE 5**

<table>
<thead>
<tr>
<th>Spinning Speed of Feed Yarn</th>
<th>Crimp development at load indicated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yarn εₐ₂₀</td>
<td>Process</td>
</tr>
<tr>
<td>A</td>
<td>3400</td>
</tr>
<tr>
<td>B</td>
<td>2000</td>
</tr>
<tr>
<td>C</td>
<td>3400</td>
</tr>
<tr>
<td>D</td>
<td>2000</td>
</tr>
<tr>
<td>Commercial</td>
<td></td>
</tr>
</tbody>
</table>

* Spindle tension is measured with a Woehlert Textenometer connected to a Helioscoper Recorder, commercially available from the Woehlert Company, Zurich, Switzerland.

I claim:

1. In a draw-texturing process for producing textured yarn from feed yarn composed of synthetic linear ethylene terephthalate polyester filaments, wherein the feed yarn is drawn as it passes continuously to a false-twisting device and a heater is used for setting twist backed up in the yarn by the false-twisting device; the improvement for providing higher crim development without damage to filaments when using heater temperatures above 200°C., wherein in the improvement comprises draw-texturing at 1.3X to 2.0X draw ratio a feed yarn prepared by melt-spinning the polyester at a windup speed of about 3,000 to 4,000 yards per minute to have a structural integrity value (εₐ₂₀) of 0.3 to 1.0, a boil-off shrinkage of 40 percent to 60 percent and less than 30 percent crystallinity.

2. The process defined in claim 1 wherein feed yarn having a structural integrity value of about 0.5 to 0.6 is draw-textured at a draw ratio of about 1.5X to 1.7X and a heater temperature above 215°C.