May 12, 1970 H. G. MARTIN 3,511,905

PROCESS FOR THE PREPARATION OF SYNTHETIC POLYMER FILAMENTS

Filed Aug. 22, 1967

FIG. 1

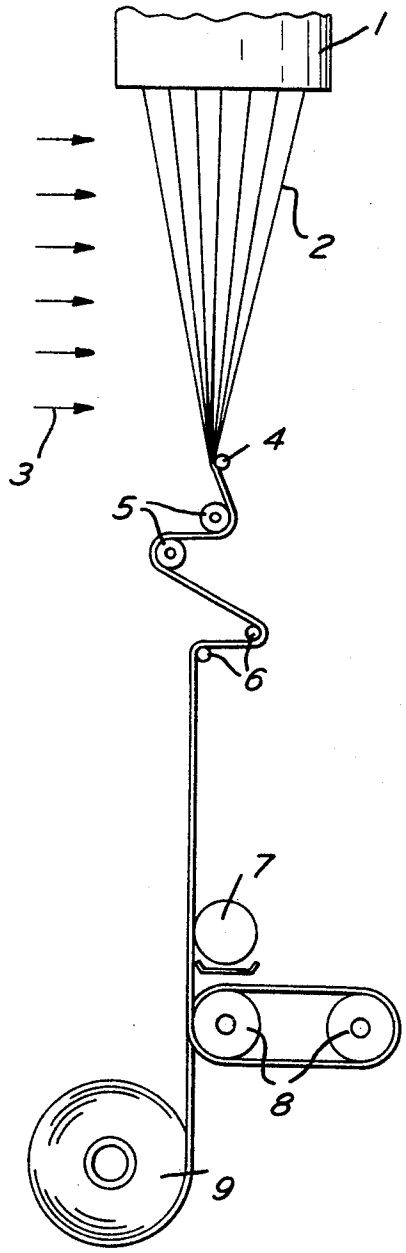
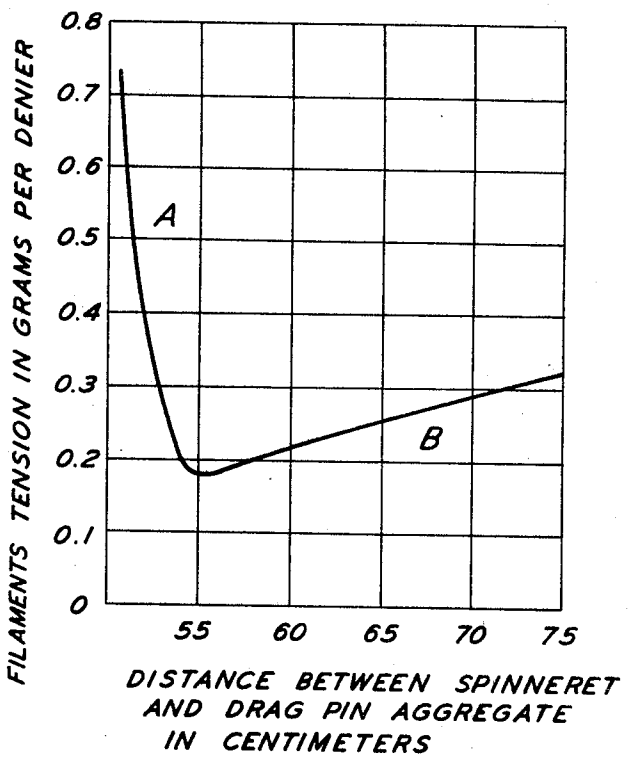


FIG. 2



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PROCESS FOR THE PREPARATION OF SYNTHETIC POLYMER FILAMENTS

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ABSTRACT OF THE DISCLOSURE

A process is described wherein melt-spun oriented synthetic polymer filaments and yarns are prepared from cooled filaments by passing said filaments over a guiding device and around at least one non-drive roll and subjecting the filaments to a predetermined drag imparted by an aggregate of drag pins disposed in predetermined relationship to the filaments. Close temperature control of the filaments as they encounter the guiding device and drag pins as well as of the guiding device and drag pins themselves, produces oriented filaments while imparting a tension of less than 1.0 gram per denier to the filaments.

This invention relates to an improved process for the preparation of oriented synthetic polymer filaments by melt-spinning.

It is the object of this invention to provide a one stage process for the preparation of melt-spun oriented synthetic polymer filaments and yarns by a cheap and simple procedure using conventional withdrawal speeds and a simple and compact apparatus which requires little space and is easy to operate. Other objects of the invention will appear in the specification.

It is well known that filaments useful as textile materials can be prepared by extruding molten synthetic polymers, such as, for example, polyamides, polyesters, copolyamides and polyolefins, through a spinneret, whereafter the filaments are quenched and wound-up as a yarn. It is further known that, to obtain their maximum utility for textile and technical purposes, the filaments should be drawn to several times their original length, whereby the molecules of the filaments are oriented along the fiber axis and the filaments gain considerably in strength. Such drawing requires complex machinery including sets of rolls driven at different speeds and, eventually, arrangements for heating the filaments. The drawing machinery is either combined with the spinning apparatus or is set up separately, but in any case drawing requires additional equipment, additional space, and additional labor, and the various motor-driven rolls and heating devices consume a considerable energy.

It has therefore been tried to prepare oriented synthetic polymer filaments by processes not requiring the use of additional drawing machinery. Thus, French Pat. 976,505 proposes to produce oriented polyamide fibers by withdrawing melt-spun fibers from the spinneret at a speed exceeding 4,500 metres per minute. United States Pat. 2,604,667 describes a similar process for polyethylene terephthalate fibers using speeds exceeding 4,700 metres per minute. These processes always require very high withdrawal speeds. As British Pat. 903,427 observes, the quality of filaments manufactured in this manner, leaves much to be desired.

As an alternative, British Pat. 903,427 describes a process, wherein the filaments emerging from the spinneret are passed through a spinning tube having a length of about 4 metres. The upper zone of the tube is heated, while the lower zone is kept at room temperature or cooled by blowing air, and the filaments which are said

to be drawn while passing through the heated zone, are wound-up at a speed between 1,300 and 2,600 metres per minute.

Another method is proposed by United States Pat. 3,002,804 which describes passing melt-spun quenched filaments through a liquid drag bath and withdrawing the filaments at a tension of at least 1.0 gram per denier and preferably at a tension between 1.8 and 2.6 grams per denier. The speed at which the filaments are wound-up is given as between about 700 and 12,000 metres per minute. As the filaments carry some fluid when leaving the drag bath, an arrangement for their deflection from a downward course is required to allow the fluid to fall into a receiver from where it is re-pumped to the bath.

The process according to this invention comprises extruding a molten synthetic polymer through a spinneret to form filaments, cooling said filaments and passing said filaments over a guiding device and around at least one non-driven roll, subjecting said filaments to a drag by passing them over at least one drag pin, said guiding device and said drag pin or pins being at such distance from the spinneret that the filaments, when passing said guiding device and said drag pin or pins, are cooled to a temperature above their glass transition temperature and at least 50° C. below their melting point, while said guiding device and said drag pin or pins are kept at a constant temperature at least 10° C. below the temperature of the filaments and above the dew point of the surrounding air, and orienting said filaments by withdrawing them from said drag pin or pins at a tension of less than 1.0 gram per denier.

The required adjustment of tempreature is not only important for orientation of the filaments, but also for their smooth run in the spinning apparatus. If the temperature of the filaments when passing the drag pins is too high, the filaments may become sticky and may adhere to each other, while at too low a temperature, electrostatic forces may cause a mutual repulsion of the filaments. As the filaments leave the spinneret at a temperature above their melting point, they must therefore be cooled, and this cooling is generally effected by the downward movement of the filaments through quiescent or transversely directed air of room temperature. As thin filaments cool down more rapidly than thick ones, the distance from the spinneret, at which the filaments are in the prescribed temperature range, differs considerably for single filaments of different deniers. To give an example, it may be mentioned that, under otherwise equal conditions, a polycaprolactam single filament of 7.5 denier was in the prescribed temperature range at a distance of about 70 cm. from the spinneret, while a polycaprolactam single filament of 55 denier needed a respective distance of about 390 cm. Adjustment of the distance between spinneret and drag pins is therefore an important means to regulate the temperature of the filaments at the stage of orientation.

The cooling of the filaments in their downward movement from the spinneret does however not progress uniformly and uninterruptedly, but, temporarily, the temperature of the filaments rises again when they pass the drag pins. This temperature rise is due to heat generated by friction of the filaments at the drag pins and by changes in the molecular arrangement of the filaments. Such changes comprise, for example, molecular orientation, and in case of crystallizing polymers, also crystallization which is triggered by orientation of the filaments. To prevent the temperature of the filaments from rising too high, the drag pins are therefore kept at a constant temperature at least 10° C. below the temperature of the filaments but above the dew point of the surrounding air in order to avoid condensation of water vapor on the drag

pins. Because there is also some heat transfer from the filaments to the guiding device, this instrument is also kept at a constant temperature which is usually the same as that of the drag pins.

The rise of temperature caused by friction, orientation and crystallization can clearly be observed, and, as an example, it may be reported that a polyethylene terephthalate yarn of 300 denier comprising 20 filaments of 15 denier each had a temperature of about 150° C. before, and of about 180° C. after, it passed the drag pins which were kept at a constant temperature of about 80° C.

The speed at which the oriented filaments are withdrawn from the drag pins can be varied within wide limits. The speeds described in the examples are between 400 and 1000 meters per minute, but higher speeds have been found to be equally suitable. The withdrawal tension is less than 1.0 gram per denier, which is surprisingly low when compared with the tensions required by conventional drawing processes. As an explanation, it is assumed that, under the conditions at which orientation of the filaments is effected according to the invention, i.e. above their glass transition temperature, the filaments, although solidified, are still in a plastic and essentially non-crystalline condition, and that orientation of the filaments in such a condition requires considerably less energy than orientation of filaments which are in a non-plastic and partially crystalline state.

It is also characteristic of the process according to this invention that the denier of the filaments obtained is the same, whether or not the filaments pass over the drag pins, i.e. the oriented filaments have the same denier as the unoriented, asspun filaments. This has certain advantages and permits, for example, preparation of oriented filaments of considerably higher deniers than can be obtained from air-spun filaments by conventional drawing processes.

The inventive process provides oriented synthetic polymer filaments of good uniformity and is applicable to all polymers which can be melt-spun. Depending on the type of polymer, the process permits to prepare single filaments of about 1–90 denier having a tenacity of about 2–5 grams per denier and a corresponding elongation at break varying between 130 and 10 percent. Filaments, yarns, and staple fibers of such properties are suitable for many end uses, and, if desired, the tenacity of the filaments can, in most cases, be further increased, by subjecting them to additional drawing by both direct and separate drawing processes. Preparation of the filaments can also be followed up by other treatments, such as, for example, by relaxation.

FIG. 1 shows schematically a possible embodiment of an apparatus suitable for preparing single- and multifilaments according to the invention. The filaments **2** extruded from spinneret **1** are exposed to transversely directed air **3**, and are passed over a guiding device **4** consisting of a pin with several U-shaped grooves, one each for a filament or bundle of filaments. The filaments then pass around two non-driven rolls **5** which act like a flywheel and serve to stabilize the run of the filaments. From rolls **5** the filaments pass over two drag pins **6** which are mounted on a turnable socket, so that by turning the socket, the arcs of contact between the filaments and the pins and thereby the drag on the filaments can easily be varied. While preparation of filaments according to the invention is also possible by using one drag pin only, an arrangement as described is preferred, because it permits a finer regulation of the drag to which the filaments are subjected, and, if an increased drag is required, a system of four pins can also be employed. On leaving drag pins **6**, the filaments pass over roll **7** applying a finish preparation and are finally withdrawn by motor-driven rolls **8** and wound-up as usual on bobbin **9**.

Guiding device **4** and drag pins **6** preferably consist of hollow tubes which are connected with a circulation system in which a liquid is kept at a constant temperature by means of a thermostat in combination with means for heating or cooling the liquid. Guiding device **4**, stabilizing rolls **5**, and drag pins **6** form a distinct aggregate within the apparatus with fixed distances between each other, while the distance between this aggregate and the spinneret is variable. The form, dimensions, and arrangement of the various parts of the apparatus must be such as to obtain a smooth run of the filaments at a withdrawal tension of less than 1.0 gram per denier.

The properties of the filaments of a given denier, especially their tenacity and elongation depend on many factors, such as temperature of the extruded polymer, temperature of guiding device and drag pins, temperature of the filaments when passing the drag pins, drag of the filaments at the pins, distance between spinneret and drag pin aggregate, withdrawal speed and withdrawal tension of the filaments. Many of these process conditions are interdependent, and, in practical operation, adjustments can be confined to regulation of the filament temperature, of the drag to which the filaments are subjected, and of the temperature of guiding device and drag pins. As will be shown in the examples, both an increase of the filament temperature, of the filament drag, and of the drag pin temperature effect an increase of the orientation of the filaments.

It has already been stated that adjustment of the distance between spinneret and drag pins is an important means to regulate the temperature of the filaments at the stage of orientation. While this adjustment is carried out, the temperature of guiding device and drag pins and the drag on the filaments at the pins are kept at a predetermined value. Although the suitable distance between spinneret and drag pin aggregate can be found by observing the respective temperature of the filaments, an easier and more exact indirect method is to measure instead the tension of the filaments between drag pins and withdrawal roll. This tension depends on the drag and the temperature of the filaments, and it has been surprisingly found that a graph plotting the filament tension against the distance between spinneret and drag pin aggregate, passes through a distinct minimum, and that, when the aggregate is at a distance corresponding to, or near said minimum, the filaments are in the prescribed temperature range, i.e. between 50° C. below their melting point and above their glass transition temperature.

From that minimum, the filament tension rises, whether the distance between spinneret and aggregate is increased or decreased. However, it has been found that, if the aggregate is in an area where rising tension corresponds with decreasing distance, the filaments obtained have a high uniformity as regards their diameter and their birefringence, and a good tenacity and a low elongation, while if the aggregate is in an area where rising tension coincides with increasing distance from the spinneret, the uniformity of the filaments is poor, their tenacity low, and their elongation high. Also, in the area where rising tension coincides with decreasing distance, the tenacity of the filaments rises, and their elongation drops with rising tension, while in the area where rising tension corresponds with rising distance, relations are reversed.

While, ordinarily, filaments of high uniformity, good tenacity, and low to medium elongation are desired, the filaments of poor uniformity and high elongation may also be interesting for special processes and end uses.

Once the position of the aggregate comprising guiding device, stabilizing rolls, and drag pins has been fixed, a finer regulation of the filament tension can be made by adjusting the drag on the filaments at the pins and the temperature of guiding device and drag pins. Both an increase of the filament drag and of the drag pin temperature raises the filament tension, and because of the described relations between filament tension, tenacity, and elongation, the adjustments mentioned easily permit to prepare filaments of the properties desired. While the procedure described is the preferred method, there are,

because of the interdependence of process conditions, of course also other possible ways to obtain optimum performance.

The following examples will show details as to preparation and properties of filaments and yarns of different polymers and the effects of variation of process conditions. The melting points of the polymers were determined by differential thermal analysis. Values reported by scientists for the glass transition temperatures differ slightly; the approximate figures given in the examples are based on information by R. G. Beaman, Journal of Polymer Science, IX, 470 (1952). The relative viscosity of polyethylene terephthalate was determined at 25° C. in 100 ml. of a solution containing 0.4 g. of polymer in a mixture of equal parts by weight of phenol and tetrachloroethane, the relative viscosity of polyamides was determined at 20° C. in 100 ml. of a solution of 0.2 g. of polymer in 94% sulfuric acid, and the relative viscosity of polypropylene was determined at 135° C. in 100 ml. of a solution of 0.1 g. of polymer in tetrahydronaphthalene.

The temperature of the filaments was measured with a Hastings Match Temperature Pyrometer, Model TM–2A, made by Hastings Raydist Inc., Hampton, Va., U.S.A. The filament tension was determined with a strain gauge, the filament diameter was measured microscopically, and the filament birefringence was determined as usual with a calcite compensator. Variations of diameter and birefringence were determined by measuring the average variation of 25 different tests on a single filament in percent from their mean value. Shrinkage at boiling was determined by measuring the percent change in length of a single filament kept tension-free during five minutes in boiling water. Crystallinity of the filaments was determined by X-ray examination with a Philips-Norelco diffraction apparatus using a nickel-filtered copper radiation and is indicated on an arbitrary scale from zero to one.

EXAMPLE I

Variation of distance between spinneret and drag pin aggregate

An apparatus is used substantially as shown in FIG. 1, but with a total of four drag pins, two pins each mounted on a turnable socket. The diameter of each pin on the first socket was 19 mm., and the diameter of each pin on the second socket was 12 mm. Guiding device and drag pins were made of hollow metal tubes and were connected with a circulation system in which glycol was kept at a constant temperature of 80° C.

Polyethylene terephthalate (melting point=265° C.; glass transition temperature about 77° C.) having a relative viscosity of 1.29 and a moisture content of less than 0.01% was molten at 284° C. and was extruded through a spinneret of 20 holes, each hole having a diameter of 0.33 mm., at a rate of 32 g. per minute. The filaments leaving the spinneret were cooled by transverse air having a temperature of 21° C., a moisture content of 65%, and an average speed of 30 m. per minute.

The filaments passed over a guiding device, around two non-driven stabilizing rolls, and over the four drag pins. The respective arcs of contact between the filaments and the four pins were successively 84°, 65°, 51°, and 36°, and the oriented filaments were withdrawn at a speed of 950 m. per minute. The yarn obtained had a total denier of 300 and was composed of 20 filaments of 15 denier each.

The properties of the filaments at varying distances between spinneret and the aggregate comprising guiding device, stabilizing rolls, and drag pins are given in Table 1. The distance measured was always the distance between spinneret and the nearest point of the aggregate, i.e. the guiding device. The filament tension was measured between the last drag pin and the wind-up roll, and a graph showing the relation between said tension and the distance between spinneret and aggregate is given in FIG. 2.

TABLE 1

Sample	I-A	I-B	I-C	I-D	I-E	I-F
Distance between spinneret and drag pin aggregate (cm.)	75	60	55	53	52	51
Filament temperature before first drag pin (° C.)	100	140	143	150	153	158
Filament tension (g./denier)	0.31	0.21	0.17	0.31	0.44	0.74
Tenacity (g./denier)	1.4	2.6	2.9	3.8	4.3	4.7
Break elongation (percent)	133	86	78	46	27	13
Variation of diameter (percent)	27	6.4	0.6	0.4	0.3	0.8
Birefringence ($\Delta n. 10^3$)	133	152	167	198	205	215
Variation of birefringence (percent)	36	10	0.6	0.6	0.4	0.9
Shrinkage at boiling (percent)	46	53	26	8	7.5	7
Crystallinity (0–1 scale)	0.01	0.04	0.05	0.14	0.16	0.19

As can be seen from Table 1 and FIG. 2, the minimum filament tension of 0.17 gram per denier corresponds to a distance between spinneret and drag pin aggregate of 55 cm. From this point the tension rises, whether the distance between spinneret and aggregate is increased or decreased. But, in the area where rising tension coincides with rising distance (branch B in FIG. 2), the uniformity of the filaments as indicated by the high variation of diameter and birefringence is bad, their tenacity is low, and their elongation high, while in the area where rising tension corresponds to decreasing distance between spinneret and aggregate (branch A in FIG. 2), the filaments have a good uniformity, with variations of diameter and birefringence below 1 percent, a good tenacity up to 4.7 grams per denier, and a medium to low elongation with a minimum of 13 percent. The higher birefringence and crystallinity of the good tenacity filaments also shows that they possess a higher degree of orientation than the filaments of low tenacity. The shrinkage at boiling of the filaments is seen to be in proportion to their elongation at break.

Table 1 further shows that, when other process conditions remain unchanged, a decrease of the distance between spinneret and drag pin aggregate increases the temperature of the filaments and produces higher oriented filaments of higher tenacities and lower break elongations.

Yarn sample I–C having a tenacity of 2.9 grams per denier, an elongation at break of 78 percent, and a birefringence of $\Delta n.10^3=167$ was subjected to additional drawing on a conventional drawing machine comprising feed roll, hot plate, drawing pin, and draw roll. The drawing ratio was 1.8 to 1. The yarn obtained had a tenacity of 7.6 grams per denier, an elongation at break of 6.7 percent, and a birefringence of 244. Contrary to the usual procedure when drawing polyethylene terephthalate yarns, the feed roll needed no heating.

EXAMPLE II

Variation of arcs of contact between filaments and drag pins

Polyethylene terephthalate filaments were spun with the same apparatus and under the same conditions as described in Example I with the following differences: The spinneret had 40 holes, each hole having a diameter of 0.23 mm. The yarn obtained had a total denier of 300 composed of 40 filaments of 7.5 denier each. The denier of the single filaments was therefore only half the denier of the single filaments in Example I, and accordingly the optimum distance between spinneret and drag pin aggregate was between about 34 and 38 cm., as compared with 51 to 55 cm. in Example I. In the tests reported in the following Table 2, the distance between spinneret and drag pin aggregate was kept constant at 35 cm. which was in the area where decreasing distance corresponds to in-

creasing filament tension. The filament temperature before the first drag pin was about 145° C.

TABLE 2

Sample	II-A	II-B	II-C
Arcs of contact between filaments and the four drag pins (deg.).	76 60 25 16	76 63 39 26	76 66 58 41
Filament tension (g./denier)	0.15	0.18	0.33
Tenacity (g./denier)	2.5	3.3	3.6
Break elongation (percent)	78	61	39
Birefringence ($\Delta n.10^3$)	134	177	204

Table 2 shows that, under otherwise equal conditions, an increase of the arcs of contact between the filaments and the drag pins results in an increase of the filament tension and produces higher oriented filaments of higher tenacities and lower break elongations.

EXAMPLE III

Simultaneous variation of distance between spinneret and drag pin aggregate and of arcs of contact between filaments and drag pins

Polyethylene terephthalate filaments were spun as described in Example II, but with simultaneous variation of distance between spinneret and drag pin aggregate and of arcs of contact between filaments and drag pins. This was done to obtain filaments of about equal orientation which however were oriented at different temperatures. The results are shown in Table 3:

TABLE 3

Sample	III-A	III-B
Distance between spinneret and dragpin aggregate (cm.)	34.5	38
Filament temperature before first drag pin (° C.)	155	135
Arcs of contact between filaments and the four drag pins (deg.)	76 65 51 36	76 71 87 66
Filament tension (g./denier)	0.39	0.47
Tenacity (g./denier)	4.1	3.6
Break elongation (percent)	29	31
Birefringence ($\Delta n.10^3$)	215	213
Crystallinity (0-1 scale)	0.21	0.21

The practically identical birefringence and crystallinity of the two samples indicate that they had about the same degree of orientation. However, due to a different distance between spinneret and drag pin aggregate, the filaments were oriented at different temperatures, and Table 3 shows that the filaments oriented at a higher temperature possess a higher tenacity.

EXAMPLE IV

Variation of drag pin temperature

Polyethylene terephthalate filaments were spun as described in Example II, but varying the temperature of the drag pins (and the guiding device). The distance between spinneret and drag pin aggregate was kept constant at 35 cm., the temperature of the filaments before the first drag pin was about 145° C., and the arcs of contact between filaments and drag pins were 76°, 67°, 64°, and 46°, respectively. The results are shown in Table 4:

TABLE 4

Sample	IV-A	IV-B	IV-C	IV-D
Drag pin temperature (° C.)	50	60	65	70
Filament tension (g./denier)	0.18	0.23	0.50	0.71
Tenacity (g./denier)	3.5	3.7	4.3	4.6
Break elongation (percent)	57	55	30	11

Table 4 shows that, when other process conditions are kept unchanged, an increase of drag pin temperature produces filaments of higher tenacities and lower break elongations.

EXAMPLE V

Polycaprolactam filaments (melting point=219° C.; glass transition temperature about 46° C.) having a relative viscosity of 1.21 and a moisture content of less than

0.1 percent were spun in an apparatus substantially as shown in FIG. 1. The apparatus had two drag pins of hollow metal tubes mounted on a turnable socket, the diameter of each pin being 12 mm. Drag pins and guiding device were kept at a constant temperature of 40° C.

The polycaprolactam was molten at 267° C. and was extruded through a spinneret of 40 holes, each hole having a diameter of 0.23 mm., at a rate of 32 g. per minute. The extruded filaments were cooled by transverse air of 21° C. having a moisture content of 65 percent and an average speed of 30 m. per minute. The arcs of contact between the filaments and the two drag pins were 78° and 66°, respectively, and the oriented filaments were withdrawn at a speed of 950 m. per minute.

The yarn obtained had a total denier of 300 comprising 40 filaments of 7.5 denier each. The properties of the filaments obtained are given in Table 5:

TABLE 5

Sample	V-A	V-B	V-C	V-D	V-E
Distance between spinneret and drag pin aggregate (cm.)	85	75	70	68	67
Filament temperature before first drag pin (° C.)	110	115	120	123	125
Filament tension (g./denier)	0.13	0.11	0.22	0.25	0.61
Tenacity (g./denier)	2.9	3.6	4.1	4.3	4.5
Break elongation (percent)	135	96	77	70	66
Shrinkage at boiling (percent)	2.7	2.7	3.9	7.4	9.4
Crystallinity (0-1 scale)	0.200	0.204	0.210	0.218	0.220

The tests correspond to those reported in Example I for polyethylene terephthalate filaments and show the results of changing the distance between spinneret and drag pin aggregate. The distances suitable for polycaprolactam filaments are considerably larger than those for polyethylene terephthalate filaments of the same denier, the distance corresponding to the minimum tension being 75 cm. for polycaprolactam and 35 cm. for polyethylene terephthalate (cf. Examples II, III, and IV).

The shrinkage at boiling of the polycaprolactam filaments is in reverse proportion to their elongation at break contrary to the situation in polyethylene terephthalate filaments (cf. Example I). Sample V-A spun in an area where rising tension coincides with rising distance between spinneret and drag pin aggregate, even has a negative shrinkage value, i.e. the filaments extend when exposed to boiling water.

The crystallinity values also indicate that the filaments of higher tenacities have a higher degree of orientation. All filaments obtained showed a purely hexagonal crystal structure, different from polycaprolactam filaments spun and subsequently drawn on conventional drawing machines the crystal structure of which is monoclinic.

Yarn sample V-B having a tenacity of 3.6 g. per denier and an elongation at break of 96% was subjected to additional drawing on a conventional drawing machine comprising feed roll, hot plate, drawing pin, and draw roll. The drawing ratio was 2.1 to 1, and the yarn obtained had a tenacity of 9.2 g. per denier and an elongation at break of 12 percent.

EXAMPLE VI

Polycaprolactam of the properties described in Example V was molten at 267° C. and was extruded at a rate of 125 g. per minute using a spinneret of 20 holes, each hole having a diameter of 0.33 mm. The extruded filaments were processed in an apparatus substantially as shown in FIG. 1, but having only one drag pin consisting of a hollow metal tube of 19 mm. diameter. The temperature of drag pin and guiding device was kept constant at 65° C.

The filaments were cooled by transverse air as described in Example V along a distance of 1.8 m., and thereafter by quiescent air of room temperature. The total distance between spinneret and drag pin aggregate was 3.9 m. The temperature of the filaments before the drag pin was about 125° C., and the arc of contact between the fila-

ments and the drag pin was 150°. The oriented filaments were withdrawn from the drag pin at a speed of 950 m. per minute and at a tension of 0.31 g. per denier.

The yarn obtained had a total denier of 1100 comprising 20 single filaments of 55 denier each, a tenacity of 3.5 g. per denier and an elongation at break of 48 percent. When testing the filaments with an Uster Eveness Tester, Model C, made by Zellweger AG, Uster, Switzerland, which measures denier variations by means of a capacity gauge electronically, an average variation of 1.25% on an arbitrary scale was indicated which is very satisfactory.

EXAMPLE VII

Polycaprolactam of the properties described in Example V was molten at 261° C. and was extruded at a rate of 76 g. per minute using a spinneret of 20 holes, each hole having a diameter of 0.33 mm. The extruded filaments were processed in an apparatus substantially as shown in FIG. 1, the two drag pins consisting of hollow metal tubes, the diameter of each being 19 mm. The temperature of drag pins and guiding device was kept constant at 60° C.

The filaments were cooled by transverse air as described in Example V along a distance of 1.8 m., and thereafter by quiescent air of room temperature. The total distance between spinneret and drag pin aggregate was 3.9 m. The temperature of the filaments before the first drag pin was about 120° C., and the arcs of contact between the filaments and the drag pins were 85° and 60°, respectively. The oriented filaments were withdrawn from the drag pins at a speed of 400 m. per minute and at a tension of 0.38 g. per denier.

The yarn obtained had a total denier of 1700 comprising 20 single filaments of 85 denier each, a tenacity of 2.7 g. per denier, and an elongation at break of 80 percent. As the distance between spinneret and drag pin aggregate was the same as that employed in Example VI for filaments of 55 denier, the increased cooling required by the 85 denier filaments was provided by reducing the withdrawal speed from 950 to 400 m. per minute.

It may be mentioned that preparation of oriented single filaments of 55 or 85 denier as described in Examples VI and VII is hardly possible by conventional methods using air spinning and subsequent drawing, because it would require spinning and cooling of filaments of about 200–400 denier.

EXAMPLE VIII

Polyhexamethylene adipamide filaments (melting point=258° C.; glass transition temperature ≅46° C.), having a relative viscosity of 1.17 and a moisture content of less than 0.1 percent were spun in an apparatus substantially as shown in FIG. 1 having two drag pins, the diameter of each pin being 12 mm. Drag pins and guiding device were kept at a constant temperature of 45° C., and the distance between spinneret and the drag pin aggregate was 70 cm.

The polymer was molten at 285° C. and was extruded through a spinneret of 40 holes, each hole having a diameter of 0.23 mm., at a rate of 32 g. per minute. The extruded filaments were cooled by transverse air as described in Example V, and had before the first drag pin a temperature of about 110° C. The arcs of contact between the filaments and the two drag pins were 110° and 100°, respectively, and the oriented filaments were withdrawn at a speed of 950 m. per minute and at a tension of 0.55 g. per denier.

The yarn obtained had a total denier of 300 comprising 40 filaments of 7.5 denier each, a tenacity of 4.0 g. per denier, an elongation at break of 63 percent, and a shrinkage at boiling of 7 percent.

EXAMPLE IX

Filaments of a copolyamide made from 95% hexamethylene diamine adipate and 5% caprolactam (melting point=258° C.; glass transition temperature≅45° C.), having a relative viscosity of 1.14 and a moisture content of less than 0.1% were spun in an apparatus substantially as shown in FIG. 1, having two drag pins, the diameter of each pin being 12 mm. Drag pins and guiding device were kept at a constant temperature of 40° C., and the distance between spinneret and drag pin aggregate was 60 cm.

The copolyamide was molten at 278° C. and was extruded through a spinneret of 40 holes each hole having a diameter of 0.23 mm., at a rate of 32 g. per minute. The extruded filaments were cooled by transverse air as described in Example V, and had before the first drag pin a temperature of about 125° C. The arch of contact between the filaments and the two drag pins were 72° and 67°, respectively, and the oriented filaments were withdrawn at a speed of 950 m. per minute and at a tension of 0.37 g. per denier.

The yarn obtained had a total denier of 300 comprising 40 filaments of 7.5 denier each, a tenacity of 4.3 g. per denier, an elongation at break of 64 percent, and a shrinkage at boiling of 7.8 percent.

EXAMPLE X

Polypropylene filaments (melting point=160° C.; glass transition temperature≅8° C.), having a relative viscosity of 0.95 were spun in an apparatus substantially as shown in FIG. 1, with two drag pins, the diameter of each pin being 12 mm. The distance between spinneret and drag pin aggregate was 1.6 m., the filament temperature before the first drag pin was about 85° C., and the arcs of contact between the filaments and the two drag pins were 45° and 36°, respectively. The temperature of the drag pins (and the guiding device) was varied, and, as already reported in Example IV, it can be seen from Table 6 that, other conditions kept unchanged, an increase of drag pin temperature produces filaments of higher tenacities and lower elongations at break:

TABLE 6

Sample	VI-A	VI-B	VI-C
Drag pin temperature (° C.)	25	45	65
Filament tension (g/denier)	0.30	0.52	0.88
Tenacity (g./denier)	3.4	3.6	3.8
Break elongation (percent)	126	72	47

It is claimed:

1. Process for the preparation of orientated synthetic polymer filaments of a synthetic polymer whose utility for textile and technical purposes is improved by drawing with resultant orientation which comprises extruding molten polymer selected from the group consisting of polyamides, polyesters, polyolefins and copolyamides from hexamethylene diamine adipate and caprolactam through a spinnerette to form filaments, cooling said filaments, passing said filaments over a guiding device and at least one non-driven roll, subjecting said filaments to a drag by passing them over at least one drag pin before contacting the filaments with a driven roll, locating said guiding device and said drag pin at such distance from the spinnerette that the filaments when passing over said guiding device and said drag pin are cooled to a temperature above their glass transition temperature and at least 50° C. below their melting point, maintaining said guiding device and said drag pin at a substantially constant temperature at least 10° C. below the temperature of the filaments in contact therewith and above the dew point of the surrounding air, and orientating said filaments by withdrawing them from said drag pin at a tension less than one gram per denier.

2. Process as claimed in claim **1**, wherein the denier of the filaments is between 1 and 90.

3. Process as claimed in claim **1**, wherein said polymer is polyethylene terephthalate.

4. Process as claimed in claim **1**, wherein said polymer is a polyamide or copolyamide.

5. Process as claimed in claim 1, wherein said polymer is polycaprolactam.

6. Process as claimed in claim 1, wherein said polymer is polyhexamethylene adipamide.

7. Process as claimed in claim 1, wherein said polymer is polypropylene.

8. Process for the preparation of orientated synthetic polymer filaments of a synthetic polymer whose utility for textile and technical purposes is improved by drawing with resultant orientation, and which filaments have an elongation at break which does not exceed 70% which comprises extruding a molten polymer selected from the group consisting of polyamides, polyesters, polyolefins and copolyamides from hexamethylene diamine adipate and caprolactam through a spinnerette to form filaments, cooling said filaments, passing said filaments over a guiding device and at least one non-driven roll, subjecting said filaments to a drag by passing them over at least one drag pin, locating said drag pin at a distance from the spinnerette so that a decrease of said distance results in an increase of the filament tension and the filaments when passing over the drag pin are cooled to a temperature above their glass transition temperature and at least 50° C. below their melting point, maintaining the drag pin at a constant temperature at least 10° C. below the temperature of the filaments in contact therewith and above the dew point of the surrounding air, and then orientating said filaments by withdrawing them from said drag pin by contact with a driven roll.

9. A process in accordance with claim 8 including withdrawing the filaments from said drag pin at a tension of less than one gram per denier.

10. A process in accordance with claim 8 including maintaining the temperature of the drag pin between 25° C. and 85° C.

11. In the process for the preparation of orientated synthetic polymer filaments of a synthetic polymer whose utility is improved by drawing with resultant orientation, and which filaments have an elongation at break not exceeding 70 percent, which comprises extruding a molten polymer selected from the group consisting of polyamides, polyesters, polyolefins and copolyamides from hexamethylene diamine adipate and caprolactam through a spinnerette to form filaments, cooling said filaments, passing said filaments over a guiding device and at least one non-driven roll, subjecting said filaments to a drag by passing them over at least one drag pin, and orientating said filaments by withdrawing them from said drag pin, the improvement comprising locating said drag pin at a distance from the spinnerette so that a decrease of said distance results in an increase of the filament tension, cooling the filaments when passing them over the drag pin to a temperature above their glass transition temperature and at least 50° C. below their melting point, and maintaining the drag pin at a constant temperature of at least 10° C. below the temperature of the filaments in contact therewith and above the dew point of the surrounding air.

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