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TWISTLESS SYNTHETIC MULTIFILAMENT YARNS AND PROCESS FOR MAKING THE SAME

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This invention relates to synthetic, thermoplastic, multifilament yarn. More particularly, this invention relates to a process for treating as-spun and zero-twist synthetic, thermoplastic, multifilament yarns and to the novel yarns resulting from said treatment.

Synthetic, thermoplastic yarns, such as nylon (polyamide) and polyester yarns are generally produced by a method which involves spinning the polymer into groups of filaments which are then taken up on a take-up roll or bobbin. Since the yarns at this point are undrawn and untwisted, it is necessary to resort to another separate operation in which the yarn is taken from the first take-up roll, drawn, twisted, and then taken up on a second take-up roll or bobbin. It is recognized that it would be desirable to conduct the spinning and drawing in one operation, however, attempts to do this have not met with a great deal of success. A recent innovation in this respect has been what is termed the "spin-draw" process. When operating in accordance with such a process, the yarn is taken up on the take-up roll at a speed greater than the speed with which it is spun from the spinnerette. Since the speed of the take-up roll may be varied, it is possible to adjust it to any desired draw ratio.

A major drawback to such a process is the inability to impart a twist to the yarn at a point following its exit from the spinnerette and prior to its being taken up on a roll. Thus, the yarn, when taken up, has essentially no twist and is termed "zero-twist yarn." While zero-twist yarn is desirable for some uses, it is very difficult to draw such yarn and efficiently take it up on a roll or bobbin. This is so because of the amount of flare or spreading of the individual filaments. When zero-twist yarns are processed at the speeds required for drawing, it is inevitable that some filaments will spread out since they are free in the yarn bundle. When taken up on a bobbin, these flared filaments cause a great deal of entanglement. In some cases, it is impossible to even remove such yarn from the take-up roll.

Since the economics of the one-unit operation are obviously desirable over that of a two-unit operation, much research effort has been devoted to finding ways to make the one-unit operation efficient.

A recently proposed solution to this problem has been to apply a solvent for the thermoplastic polymer to the yarn after it exits from the spinnerettes and then pass the yarn through a zone heated to a temperature below the melting point of the filaments but high enough to drive off the solvent. Various problems are associated with such a process including uniformity of solvent application, and the like, but a major problem is that the solvent gives the yarn filaments a non-uniform surface area which greatly affects dyeing and textile processing.

It is therefore an object of this invention to provide a synthetic, thermoplastic, multifilament yarn having essentially no twist and which may readily be drawn and processed as a monofilament.

It is a further object of this invention to provide a drawn, synthetic, thermoplastic, multifilament yarn having essentially no twist, the individual filaments of which have an essentially uniform surface area.

It is a further object of this invention to provide a process for treating a synthetic, thermoplastic, multifila-

ment yarn having essentially no twist which yarn is amenable to drawing in the same operation in which it is spun.

It is a further object of this invention to provide a process for bonding a synthetic, thermoplastic, multifilament yarn at random points along the filament lengths.

These and other object will appear hereinafter.

Briefly, in accordance with this invention, there is provided a synthetic, thermoplastic, multifilament yarn having essentially no twist wherein the individual filaments which make up the yarn, have an essentially uniform surface area, are disposed in a generally parallel relationship and are fused to one another at random fusion points along the filament lengths, said random points occupying from about 1 percent to about 15 percent, preferably 3 percent to 10 percent, of the entire filament length.

The yarns of the present invention may readily be drawn and taken up on a roll or bobbin and thereafter easily removed from the roll. Entanglement is minimal. Flaring or spreading of the filaments does not occur to any great extent since only a short length of the filament can leave the yarn bundle due to the fact that the filament contains various random points along its length at which it is fused to another filament.

In accordance with the process of the present invention, a synthetic, thermoplastic, multifilament yarn in an untwisted state, that is, in which the individual filaments which make up the yarn are in a general parallel relationship, are held under tension and passed through a zone heated to a temperature above the softening point of the filaments for a length of time insufficient to produce fusion over an area of more than 15 percent of the filament lengths.

The temperature at which the process is carried out is critical only to the extent that it must be high enough to soften at least a portion of the surface of the filaments thus allowing the heat fusion to occur and yet it must be below that temperature at which fusion occurs to an extent that is more than is desired, i.e., over an area of more than 15 percent of the length of the filaments. Furthermore, the amount of fusion that occurs in the yarn is not only dependent on the temperature but also is related to the amount of exposure, in terms of time, of the yarn in the heated zone. Thus, the faster the yarn traverses the heat zone, the higher will be the required applied heat. This temperature-time relationship may easily be determined by observing the yarn which has passed through the hot zone and simply adjusting the applied temperature to obtain the desired amount of fusion at any given yarn speed. Operating within these conditions, it is necessary that the temperature of the zone through which the yarn passes always be above the softening point of the yarn (which is about 15° C. below the melting point). The reason for this is that since the yarn is moving through the zone, enough heat energy must be applied to it to raise the surface temperature, or thread-line temperature, to the softening point before it leaves the zone. Since the melting point and the softening point of many synthetic, thermoplastic yarns are not an abrupt physical change as is the case with most compounds, it is possible to produce fusion between the filaments when the thread-line temperature is below, but near, the melting point of the yarn filaments. It has been found, in accordance with this invention, that the yarn filaments are sufficiently softened at 15° C. below their melting points to allow for the minimum required amount of fusion, that is, 1 percent of the filament length. On the other hand, when the thread-line temperature is higher than 15° C. above the melting point of the filaments, fusion occurs to too great an extent and, filament degradation occurs.

It is also important that the yarn be under tension when it traverses the heated zone. The application of tension maintains the filaments in close proximity with each other

and assures contact between the individual filaments, thus allowing for fusion points between them to form. The only limit on the amount of tension applied lies in the strength of the yarn being processed. A highly desirable feature of the present invention is that the heating of the yarn may occur during the drawing step. Thus, during a spin-draw process the heating of the yarn in accordance with the present invention may take place during the drawing operation by placing the heating zone between the drawing rolls which will of themselves provide the necessary tension. It should be pointed out, however, that the process of the present invention is equally applicable to undrawn or already drawn yarns. When such yarns are processed according to the present invention, the tension that is required is only that which is sufficient to provide contact of the filaments among themselves.

The yarns of the present invention include any synthetic, thermoplastic, multifilament yarns but multifilament nylon (polyamide) and polyester yarns in accordance therewith are especially useful. Among the nylon yarn compositions of the present invention, any nylon 66 (polyhexamethylene adipamide), nylon 6 (polycaprolactam), nylon 610 (polyhexamethylene sebacamide), and the like. Among polyester yarn compositions, polyethylene terephthalate finds particular commercial success but other polyesters are also within the scope of the present invention.

As pointed out above, the products of the present invention include drawn and undrawn yarns. Thus, the process of the invention may be applied to undrawn yarns which are thereafter drawn, to yarns which are being drawn during the process of the invention, or to previously drawn yarns. Since the most commercially practicable synthetic, thermoplastic yarns are those that are drawn, that is, those which are molecularly oriented, it is preferred to apply the process of the present invention to yarns which are in the process of being drawn since this eliminates a second operation of drawing.

The amount of fusion that is necessary in the yarns of the present invention, as pointed out above, is between about 1 percent and about 15 percent of the linear area of the filaments, preferably between 3 and 10 percent. The minimum limit of 1 percent has been found necessary in order to accomplish the object of the bonding, i.e., prevent entanglement by eliminating flaring or spreading of the filaments. While more than 15 percent of the filament lengths may be fused, it has been found undesirable to do so because the yarn then begins to take on the appearance of a fused yarn which is undesirable and also because the heat required to obtain more fusion tends to degrade the yarn in its other properties.

The following examples are given for purposes of illustration only and are not to be construed as limiting in any way.

EXAMPLE I

A zero-twist, previously drawn nylon 66 (polyhexamethylene adipamide) yarn composed of 34 filaments and having a total denier of 70 was passed through a 48-inch slot heated by electrical resistance elements to a temperature between 250° C. and 260° C. The yarn speed through the slot was about 60 feet per minute. During its passage through the slot, sufficient tension was applied to the yarn to maintain the filaments in close proximity to each other although no drawing of the yarn occurred. Temperature measuring crayons indicated that the thread-line temperature of the yarn was between 250° C. and 255° C. By visual analysis of the yarn, it was determined that random fusion points between the filaments occupied about 8% of the filament length and the surface area of the filaments was essentially uniform.

EXAMPLE II

A zero-twist, undrawn nylon 66 yarn composed of 34 filaments and having a total denier of 70 was passed at a speed of 60 feet per minute through a 12-inch slot heated

to a temperature between 260° C. and 280° C. Sufficient tension was applied to the yarn during its passage through the slot to draw the yarn 4.7 times. The yarn was wound onto take-up bobbins and thereafter easily removed from the bobbins. There was no noticeable entanglement. By visual analysis, it was determined that the surface of the filaments was uniform and random fusion points occupied 6 percent of the filament lengths.

EXAMPLE III

The procedure of Example II was repeated with the exception that the yarn treated was nylon 6 (polycaprolactam) and the temperature of the slot was between 220° C. and 240° C. Again, entanglement was minimal, surface area was uniform, and random fusion points occupied about 5 percent of the filament lengths.

EXAMPLE IV

The procedure of Example I was repeated with the exception that the yarn treated was polyethylene terephthalate. Fusion points occupied about 3 percent of the filament lengths.

EXAMPLE V

A 70-denier, 34-filament nylon 66 yarn was passed through a 12-inch slot heated to a temperature between 500° C. and 560° C. at a speed of 300 feet per minute. During its passage through the slot, sufficient tension was applied to draw the yarn 5 times. The yarn was easily removed from the take-up bobbin and random fusion points occupied about 3 percent of the filament lengths and the surface area was essentially uniform.

The foregoing detailed description has been given for clearness of understanding only, and unnecessary limitations are not to be construed therefrom. The invention is not to be limited to the exact details shown and described since obvious modifications will occur to those skilled in the art, and any departure from the description herein that conforms to the present invention is intended to be included within the scope of the claims.

We claim:

1. A synthetic, thermoplastic, multifilament yarn having essentially no twist wherein the individual filaments have an essentially uniform surface area, are disposed in a generally parallel relationship and are fused to one another at random fusion points along the filament lengths, said random fusion points occupying from about 1 to about 15 percent of the entire filament length.

2. The synthetic, thermoplastic, multifilament yarn of claim 1 wherein the random fusion points occupy from about 3 to about 10 percent of the filament lengths.

3. A multifilament, polyhexamethylene adipamide yarn having essentially no twist wherein the individual filaments have an essentially uniform surface area, are disposed in a generally parallel relationship and are fused to one another at random fusion points along the filament lengths, said random points occupying from about 1 to about 15 percent of the entire filament lengths.

4. A multifilament polycaprolactam yarn having essentially no twist wherein the individual filaments have an essentially uniform surface area, are disposed in a generally parallel relationship and are fused to one another at random fusion points along the filament lengths, said random fusion points occupying from about 1 to about 15 percent of the entire filament length.

5. A multifilament polyethylene terephthalate yarn having essentially no twist wherein the individual filaments have an essentially uniform surface area, are disposed in a generally parallel relationship and are fused to one another at random fusion points along the filament lengths, said random fusion points occupying from about 1 to about 15 percent of the entire filament length.

6. A process for treating a synthetic, thermoplastic, multifilament yarn having individual filaments of essentially uniform surface area disposed in generally parallel relationship with essentially no twist which comprises fusing

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the individual filaments to each other by passing said yarn, while under sufficient tension to maintain the filaments in close proximity with each other, through a zone heated to a temperature above the softening point of the filaments for a time sufficient to produce fusion between the filaments over an area from about 1 to about 15 percent of the filament lengths.

7. The process of claim 6 wherein the temperature of the yarn passing through the zone is between about 15° C. below the melting point of filaments and about 15° C. above the melting point of the filaments.

8. The process of claim 6 wherein the time is insufficient to produce fusion between the filaments over an area of more than 10 percent of the filament lengths.

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9. The process of claim 7 wherein the yarn is a poly-hexamethylene adipamide yarn.

10. The process of claim 7 wherein the yarn is a polycaproatamide yarn.

11. The process of claim 7 wherein the yarn is a polyethylene terephthalate yarn.

References Cited

UNITED STATES PATENTS

10 3,058,291 10/1962 Heberlein et al.

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