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YARN TREATMENT PROCESS

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Fully drawn, high tenacity
multifilament polyester yarn

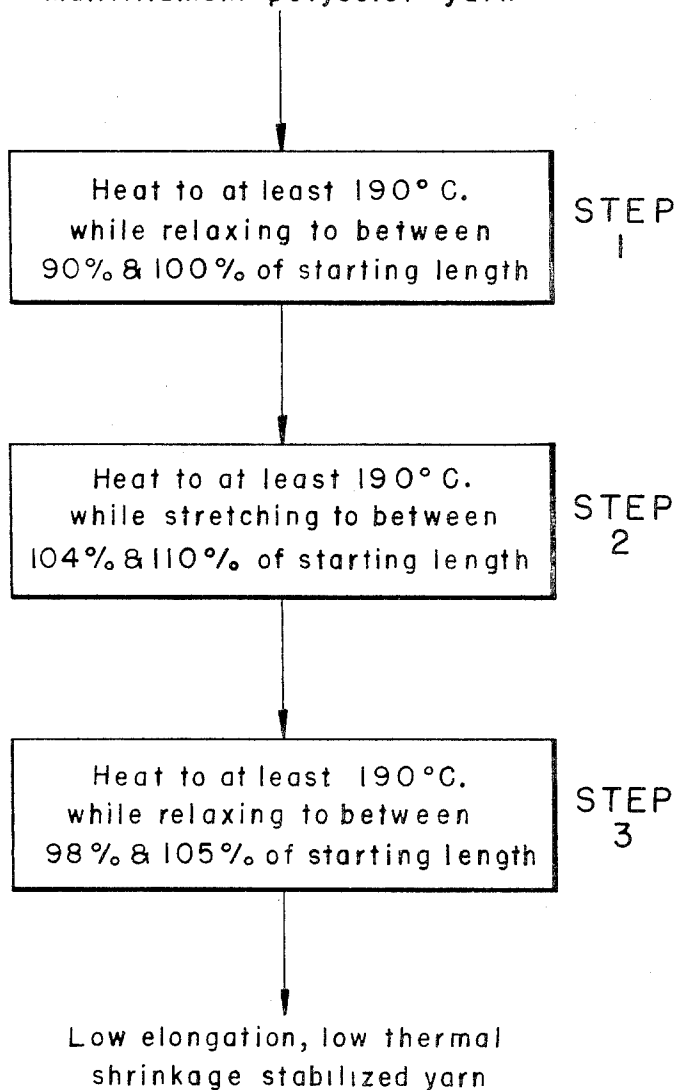


FIG.-1-

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YARN TREATMENT PROCESS

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4 Claims

ABSTRACT OF THE DISCLOSURE

A process for reducing the thermal shrinkage of fully drawn, high tenacity, multifilament polymeric synthetic yarns having substantial thermal shrinkage, by a multiple heat treatment of a running length thereof at substantially constant temperatures each below the sticking temperature of the yarn, which heat treatment consists essentially of the steps of (1) first heating the yarn uniformly for at least about 10 seconds to at least 190° C. while continuously overfeeding it a constant amount so that the yarn shrinks to a length between 90% and 98% of its starting fully drawn length, (2) then heating the yarn uniformly for at least about 10 seconds to at least 190° C. while continuously underfeeding it a constant amount so that the yarn stretches to about 104–110% of its starting fully drawn length, and (3) thereafter heating the yarn uniformly for at least about 10 seconds to at least 190° C. while continuously overfeeding it a constant amount so that the yarn shrinks from its stretched length to about 98–105% of its starting fully drawn length.

This application is a continuation-in-part of application Ser. No. 519,323, filed Jan. 7, 1966 which in turn is a continuation-in-part of application Ser. No. 212,567, filed July 26, 1962, now abandoned.

This invention relates to a method for improving the physical properties of high tenacity multifilament polymeric synthetic yarns such as polyester yarns and nylon yarns.

In many end uses for polyester and nylon multifilaments yarns, e.g., in V- and conveyor belts and tire cords, it is necessary that the yarn have low thermal shrinkage and low elongation under loads. Commercially available yarns do not have such properties. For example, 1100/2 Dacron brand of polyester yarn has about a 14% elongation at break, a 3% elongation at 10 pounds load and about 12% thermal shrinkage, i.e., the shrinkage induced by heating the yarn in a relaxed state in an oven heated to about 149° C. for one-half hour. These properties are not considered good for the uses mentioned above.

One means of reducing thermal shrinkage is to heat the yarn up to its sticking temperature under conditions whereby the yarn is permitted to shrink freely or by controlled amounts. However, if this is done, the elongation of the yarn under loads is increased to an undesirable extent. Conversely, the elongation of the yarn under loads can be reduced by heating the yarn up to its sticking temperature while stretching the yarn. However, if this is done, the thermal shrinkage of the yarn is increased to an undesirable amount. If one first subjects the yarn to a heat treatment with stretching and then to a subsequent heat treatment with relaxation, under optimum conditions the thermal shrinkage can be reduced without severely affecting the elongation under load properties of the yarn. However, it has been found that under commercial conditions yarn obtained by such a two-step heat treatment varies significantly in properties along its length. This variation is undesirable from a commercial point

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of view. Also, even under optimum conditions, the elongation under load properties of yarn thus treated are not reduced to the desired minimums.

It is therefore an object of this invention to provide a multiple step heat treatment process for high tenacity multifilament yarn which under commercial conditions produces a yarn having improved elongation under load and thermal shrinkage properties. Other objects will be apparent to those skilled in the art to which this invention pertains.

According to this invention a high tenacity multifilament polymeric synthetic yarn is subjected to a multiple heat treatment which comprises the steps of (1) first uniformly heating the yarn at an elevated temperature while allowing the yarn to relax to a length substantially between 90% and 98% of its starting length, (2) then uniformly heating the yarn a second time at an elevated temperature while stretching the yarn to a length about 104–110% of its original starting length, and (3) thereafter uniformly heating the yarn at an elevated temperature while allowing the yarn to relax from its stretched length to a length about 98–105% of its starting length. It should be understood that the exact percentages set forth above are not critical and can be varied within reasonable tolerances. The sequence of steps, however, is critical.

A flow diagram of the process of this invention is shown in FIG. 1 of the drawing.

The term "fully drawn" is descriptive of a yarn drawn at a maximum draw ratio which is defined in U.S. Pat. No. 3,093,444 (col. 3, line 14). All commercially available yarns are drawn at a draw ratio varying usually between the substantial units of 2:1 to 5:1 which is, for a given yarn, always the maximum draw ratio.

The term "high tenacity" means that the yarn has a breaking strength of greater than about six or seven grams per denier. High tenacity polyester yarns and nylon yarns have substantially different thermal shrinkage and elongation under load properties from those of regular and low tenacity polyester yarns and nylon yarns and require substantially different treatment conditions to improve these properties.

The term "thermal shrinkage" is intended to mean any yarn having a shrinkage in the range from substantially 1 to 20% after emerging in boiling water (212° F.) for one hour at zero tension. Practically all commercial polyester and nylon yarns will fall within this range.

The term "polyester" means that the yarn is formed of the polyester of a polyhydroxy alcohol and a dibasic acid or one of the many modifications there are which are now well known in the art. The most common polyester is that of ethylene glycol and terephthalic acid, e.g., those polyester yarns sold under the trademark "Dacron" (E. I. du Pont de Nemours & Co.). Such yarns can be in untwisted singles or plied form. Preferably, the yarn is plied and twisted into cord form.

The term "nylon" is well known and is intended to include any long chain polymeric amide which has recurring amide groups (—CONH—) as an integral part of the polymeric chain.

This process is particularly beneficial to nylon 6, 7 and nylon 6—6 as well as other commercially available nylons.

In carrying out the process of this invention, the starting high tenacity, multifilament polyester yarn or nylon yarn is overfed a constant amount into a heat treatment zone which heats the yarn uniformly for at least about 10 seconds to a temperature between 190° C. and the sticking temperature of the yarn, e.g., 200–245° C., the overfeeding being an amount which permits the yarn to shrink to a length substantially between 90% and 98% of its starting length. The upper temperature limit can readily

be ascertained because overheating of the yarn causes an undesirable stiffening and loss of tensile strength. It is important that the yarn be heated uniformly not only along its length but uniformly around its circumference. Because the yarns conventionally treated by the claimed process are industrial type high denier yarns, e.g., about 250 denier or higher, the use of conventional contact heater plates or rolls is substantially precluded as these ordinarily do not produce the desired degree of uniformity. Ovens which heat the yarn with hot air are preferred although heated fluid bed-type heating can also be employed. The yarn should be heated for at least 10 seconds and more preferably between about 15 and 120 seconds to enable reorientation of the yarn to take place to the desired extent. In the next step the yarn is again heated between 190° C. and the sticking or softening temperature of the yarn, preferably about 200°–245° C. and more preferably about 210°–235° C. The yarn is subjected in the second thermal treatment to the same conditions as those described above for the first step, except that the yarn is underfed into the heat treatment zone so that the yarn while being heated is stretched a constant amount to a length which is 104–110% of the starting fully drawn length, i.e., the length before the first thermal treatment. The yarn is then given a third thermal treatment, under the same conditions as described for the first thermal treatment, except for the preferred temperature range and the fact that the yarn is overfed into the heat treatment zone a constant amount which permits the yarn to shrink from its stretched length to about 98–105% of its starting fully drawn length. Obviously, if the yarn is stretched to only 104% of its starting length in the second heat treatment, its final length after the third heat treatment will be less than 104% of its starting fully drawn length. The preferred temperature range for the third heat treatment is between about 200° and 235° C., more preferably between about 200° and 225° C. The temperature during the underfeeding step is preferably at least 5° higher, and more preferably at least 10° higher, than the temperature of the following overfeeding step.

The following examples are illustrative of the process of this invention but are not to be construed as limiting.

EXAMPLE I

A running length of 1100/2 high tenacity Dacron brand of drawn polyester multifilament yarn having 3.3 turns of twist per inch was passed several turns around a set of driven and idler rolls and then into an oven where the yarn was heated to about 200° C. and then taken several turns around a second set of driven and idler rolls, the speeds of the rolls being adjusted so that the yarn was permitted to shrink a constant 3.9%, i.e., to 96.1% of its starting fully drawn length, while maintaining the yarn in the oven for 20 seconds. The cooled yarn was then passed again into an oven where it was heated to about 232° C. for 20 seconds and then taken several turns around a third set of driven and idler rolls whose speed was adjusted with respect to the second set of rolls so that the yarn was stretched a constant 13%, i.e., so that the yarn was stretched to 108.6% of its starting fully drawn length. The yarn was then again passed into an oven where it was heated for 20 seconds to a temperature of about 205° C. and then taken several turns around a fourth set of driven and idler rolls whose speed was adjusted with respect to the third set of rolls so that the yarn was permitted to shrink in the oven a constant 6%, i.e., so that its final length was 102.0% of its starting fully drawn length. The yarn was then taken up in a conventional manner on a package.

The thus-treated yarn had a tensile strength of 39 pounds, a thermal shrinkage of 1.7%, 2.5% elongation at 10 pounds load and 11.5% elongation at break whereas the starting yarn had a tensile strength of 39 pounds, 12.2% thermal shrinkage, 3% elongation at 10 pounds load and 14% elongation at break. The reduction in ther-

mal shrinkage to less than 2% while at the same time reducing by about 17% the elongation at 10 pounds and at break is of considerable commercial significance. The same starting yarn treated in substantially the same manner but omitting the first relaxation step had substantially higher elongation at 10 pounds load at the break and less uniform thermal shrinkage and elongation under load properties, both of which are undesirable from the commercial point of view.

In the above-described process, the yarn can be passed into a dip containing materials which improve the adhesion of the yarn to rubber or other elastomeric materials, e.g., an epoxide modified butadiene-vinyl pyridine latex or a resorcinol-formaldehyde modified butadiene-vinyl pyridine latex, prior to the yarn entering any of the heat treatment zones, or any combination thereof if a multiple dip is employed. The heat treatment then performs the multiple function of stabilizing the yarn and curing the coating on it.

EXAMPLE II

The procedure of this example was the same as that of Example I except as follows:

In the first heating step the yarn was not permitted to shrink while being heated to a temperature of 204° C. for 7.5 seconds. In the second heating step, the yarn was stretched 11% to 110% of the starting length during a heat treatment at 204° C. for 7.5 seconds. In the third heating step, the yarn was permitted to shrink 10% at 204° C. for 7.5 seconds so that its final length is 99% of the starting fully drawn length. Although the physical properties of the starting yarn were substantially the same as those of Example I, the variation in the processing conditions resulted in a treated yarn having a tensile strength of 37.4 pounds, a thermal shrinkage of 3.6%, 4.5% elongation at 10 pounds load and 16.0% elongation at break. Thus the procedure of Example II which was outside the processing conditions of the invention provided a yarn with a thermal shrinkage more than twice that of the yarn of Example I.

EXAMPLE III

The procedure of this example was the same as that of Examples I and II except as follows:

In the first heating step at a temperature of about 204° C. and 20 seconds duration, the yarn was permitted to shrink 11% to 89% of its starting length. In the second heating step with the same time and temperature, the yarn was stretched 19% to 105.9% of the starting length. During the third heating step under the same temperature and time conditions, the yarn was permitted to shrink 10% to a final length of 95.4% of the starting fully drawn length. While the starting fully drawn yarn had substantially the same properties as those of Examples I and II, the treated yarn had a tensile strength of 36.9 pounds, a thermal shrinkage at 3.2%, 2.3% elongation at 10 pounds and 16.1% elongation at break. Thus, the thermal shrinkage of the yarn of this example processed outside the conditions of the invention was almost twice that of Example I.

EXAMPLE IV

The procedure of this example was the same as that of Example I except as follows:

The starting yarn was a 1100/2 of high tenacity Vycron brand of drawn polyester multifilament yarn having 3.5 turns per inch twist sold by Beaunit Mills, Inc. The starting yarn had breaking strength of 38.3 pounds, a thermal shrinkage of 7.2%, an elongation at 10 pounds load of 4.5% and 12.5% elongation at break. In the first heating step at 210° C. for 20 seconds the yarn was permitted to shrink 3.9% to 96.1% of the starting length. During the second heating step at 221° C. for 20 seconds, the yarn was stretched 11% to 106.7% of the starting length. The yarn was permitted to shrink 6% in the third heating step at 204° C. for 20 seconds so

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that the final length was 100.3% of the starting fully drawn length. The treated yarn had a tensile strength of 35.0 pounds, 1.67% thermal shrinkage, 2.5% elongation at 10 pounds load and 10.5% elongation at break. Thus, the treated yarn of this example processed within the conditions of the present invention produced a yarn having a low thermal shrinkage similar to the yarn of Example I.

EXAMPLE V

The procedure of this example was the same as that of Example IV except as follows:

During the first heating step the yarn was permitted to shrink only .04% to 99.6% of its length in a 20 second treatment at 210° C. and then stretched 8.2% to 107.8% of the starting length while heated at 210° C. for 20 seconds. Finally the yarn was permitted to shrink 4.3% at 204° C. for 20 seconds to a final length of 103.2% of the starting length. This example which differs from the procedure of Example IV primarily in the absence of significant shrinkage in the first heating step and is outside the invention, produces a treated yarn with a tensile strength of 37.0 pounds, 5.0% thermal shrinkage, 1.9% elongation at 10 pounds and 9.5% elongation at break. The thermal shrinkage of the yarn of this example is approximately three times that of the yarn of Example IV.

EXAMPLE VI

A running length of 840/2, 6—6 nylon having 12.75 turns of twist per inch was passed several turns around a set of driven and idler rolls and then into an oven where the yarn was heated to 218° C., and then taken several turns around the second set of driven and idler rolls, the speed of the rolls being adjusted so that the yarn was permitted to shrink a constant 3.9%, i.e., to 96.1% of the starting fully drawn length while maintaining the yarn in the oven for 20 seconds. The cooled yarn was then passed again into an oven where it was heated to 218° C. for 20 seconds and then taken several turns around a third set of driven and idler rolls. The speed was adjusted with respect to second set of rolls so that the yarn was stretched at a constant 11%, i.e., so that the yarn was stretched to a total length of 105.7% of its starting fully drawn length. The yarn was then again passed into an oven where it was heated for 20 seconds to a temperature of about 218° C. and then taken several turns around the fourth set of driven and idler rolls whose speed was adjusted with respect to the third set of rolls so that the yarn was permitted to shrink in the oven a constant 6%, i.e., to a final length of 99.4% of its starting fully drawn length. The yarn was then taken up in a conventional manner on a package. The thus treated yarn has a tensile strength of 31.7 pounds, a thermal shrinkage of 0.83%, 22.9% elongation at break, and 9.4% elongation under a 10 pound load, whereas the starting yarn has a tensile strength of 32.4 pounds, a thermal shrinkage of 6.7%, an elongation at break of 26.1% and 11.2% elongation at a 10 pound load. Thermal shrinkage was measured in an oven at 300° F. for one hour.

That which is claimed is:

1. A process for reducing the thermal shrinkage of multifilament ethylene glycol terephthalic acid polyester yarns having a tensile strength of about 39 pounds for 1100 denier, a thermal shrinkage of at least 7.2%, an elongation at 10 pounds load of at least 3% and an elongation at break of at least 12.5%, by a multiple heat treatment of a running length thereof at substantially constant temperatures each below the sticking temperature of the yarn, which heat treatment consists essentially of the steps of (1) first heating the yarn uniformly

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for at least about 20 seconds to at least 200° C. while continuously overfeeding it a constant amount so that the yarn shrinks to a length between 90% and 98% of its starting length, (2) then heating the yarn uniformly for at least about 20 seconds to at least 221° C. while continuously underfeeding it a constant amount so that the yarn stretches to about 104–110% of its starting length, and (3) thereafter heating the yarn uniformly for at least about 20 seconds to at least 204° C. while continuously overfeeding it a constant amount so that the yarn shrinks from its stretched length to about 98–105% of its starting length.

2. The process of claim 1 wherein the yarn is heated during the underfeeding step to a temperature at least 5° higher than during the following overfeeding step.

3. The process of claim 1 wherein the yarn is heated during the underfeeding step to a temperature between about 221° and 245° C. and during the following overfeeding step to a temperature between about 204° and 235° C.

4. A process for reducing the thermal shrinkage of multifilament 6—6 nylon yarns having a tensile strength of about 32 pounds for 840 denier, a thermal shrinkage of at least 6.7%, an elongation at 10 pounds load of at least 11.2% and an elongation at break of at least 26.1%, by a multiple heat treatment of a running length thereof at substantially constant temperatures each below the sticking temperature of the yarn, which heat treatment consists essentially of the steps of (1) first heating the yarn uniformly for at least about 20 seconds to at least 218° C. while continuously overfeeding it a constant amount so that the yarn shrinks to a length between 90% and 98% of its starting length, (2) then heating the yarn uniformly for at least about 20 seconds to at least 218° C. while continuously underfeeding it a constant amount so that the yarn stretches to about 104–110% of its starting length, and (3) thereafter heating the yarn uniformly for at least about 20 seconds to at least 218° C. while continuously overfeeding it a constant amount so that the yarn shrinks from its stretched length to about 98–105% of its starting length.

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