June 19, 1962 H. F. HUME ETAL 3,039,171

PROCESS OF DRAWING FILAMENTS

Filed June 9, 1960

FIG. 1

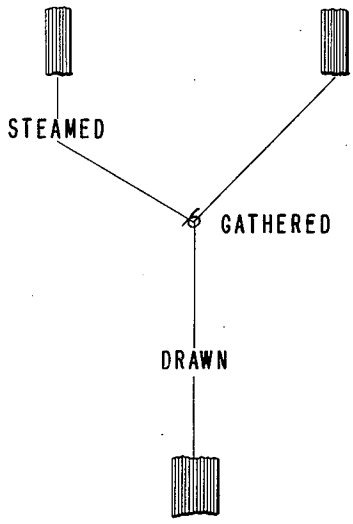


FIG. 2

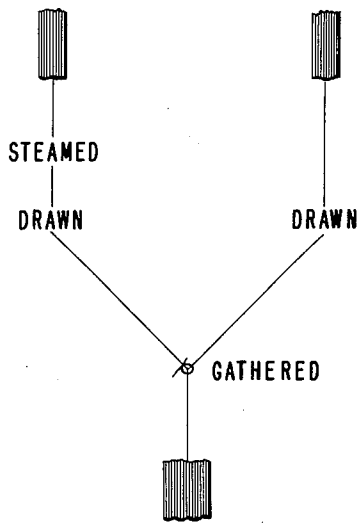


FIG. 3

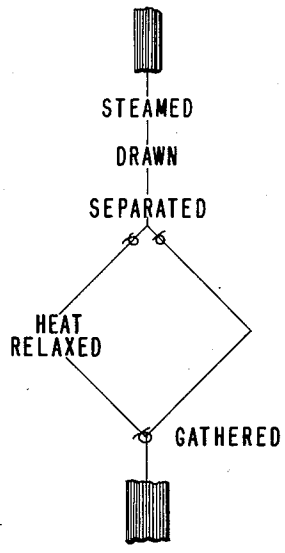
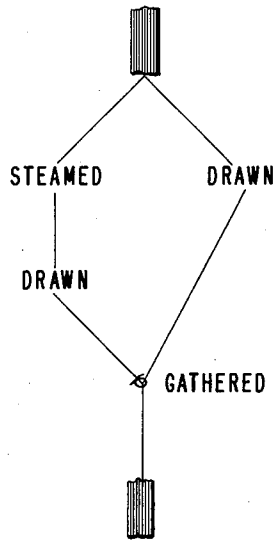


FIG. 4



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3,039,171

PROCESS OF DRAWING FILAMENTS

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This invention relates to novel and useful polyamide filamentary structures, and more particularly, to such structures having increased shrinkage potential.

It is well known to those skilled in the production of synthetic filamentary structures that filaments having a high shrinkage potential provide many improvements. High shrinkage filaments may be combined with filaments having a lower shrinkage to produce a bulky filamentary structure after suitable treatment, e.g., after immersing it in boiling water for a suitable period. Such bulky structures are useful in producing fabrics having an improved surface appearance and particularly in the production of fabrics having the surface appearance of the more expensive spun yarn fabrics.

It has been found particularly difficult to produce highly crystalline polyamide filamentary structures with a high shrinkage potential. While some slight difference in shrinkage values may be achieved by the use of different draw ratios, this procedure causes undesirable differences in the dyeability of the two components in the fabric. In addition, the shrinkage differences obtainable in this manner are not adequate for many end uses.

It is accordingly an object of this invention to provide a process for producing yarns containing polyamide filaments having increased shrinkage potential. Another object is to provide a process for producing a polyamide yarn comprising filaments of high and low shrinkage potential, the high shrinkage filaments having substantially the same dyeing characteristics as the low shrinkage filaments.

The above objects are accomplished by a process comprising exposing a first filamentary structure comprising a synthetic linear polyamide composition to an atmosphere having a relative humidity of at least about 90% and a temperature of at least about 65° C., drawing the structure at a draw ratio between about 1.25 and about 3.5, to provide the structure with a shrinkage potential of at least about 1%, and combining the drawn filamentary structure with a second filamentary structure which has a shrinkage potential at least about 1% less than the shrinkage potential of the first structure.

Additional objectives will become apparent in the following description of the various process variations which have been exemplified and illustrated in FIGURES 1–4.

In a preferred embodiment, the first filamentary structure is combined, after the high humidity heat treatment, with a second filamentary structure, which has not been drawn or subjected to the high humidity heat treatment, and the combined structure drawn at a draw ratio between about 1.25 and about 3.5. This process embodiment has been illustrated schematically in FIG. 1 and described in detail in connection with Example II.

In another embodiment shown schematically in FIG. 2 and described in Examples I and IV, the treated filamentary structure is combined, after drawing at a draw ratio between about 1.25 and about 3.5, with a drawn polyamide filamentary structure, which has not been subjected to the high humidity heat treatment. Preferably, the draw ratios imposed on the filaments are about the same.

In the process embodiment illustrated in FIG. 3 and described in Example V, a filamentary structure composed of undrawn polyamide filaments is exposed to an atmosphere having a relative humidity of at least about 90%

and a temperature of at least about 65° C. and drawn at a draw ratio between about 1.25 and about 3.5. The filaments are then separated into two groups. One of these groups is heated and permitted to relax in length, preferably at least about 4%, at a temperature between about 120° C. and about 200° C. and thereafter recombined with the other group of filaments.

In a highly preferred embodiment, a bundle of filamentary structures is split into at least two groups, one of which is treated under the high humidity conditions and draw ratios as above, and then recombined with the other group or groups. This embodiment has been illustrated schematically in FIG. 4 and described in detail in Example III.

By "shrinkage potential" as used herein is meant that shrinkage in length which occurs when a polyamide filamentary structure is immersed in boiling water for 15 minutes and permitted to dry under little or no tension.

The filamentary structures treated in accordance with this invention include continuous monofilaments, continuous multifilaments, spun yarn, tow, sliver, top, roving or any other desirable shape. The filamentary structures may be crimped or bulked if desired.

EXAMPLE I

Polyhexamethylene adipamide having a relative viscosity of 41 (as described in U.S. Patent 2,385,890) is prepared and extruded in the conventional manner using apparatus of the type disclosed in U.S. Patent 2,217,743. The grid and melt-pool temperature of this apparatus is maintained at 290° C. and the molten polymer is blanketed with an atmosphere of nitrogen. The polymer is extruded through the spinneret, which has 17 holes of 0.009 inch diameter, to produce yarn having a final denier of 90. The filaments are quenched by passing air transversely across the filament bundle as shown in U.S. Patent 2,273,105.

The filaments are then passed at a rate of 10 feet per second through a steam treatment enclosure as described in U.S. Patent 2,289,860. Steam at 7.5 p.s.i.g. (pounds per square inch, gauge) is supplied to the enclosure and the yarn is exposed to the steam for a distance of 48 inches. The filament bundle is then treated with a conventional finish, cold drawn and wound into a package at a speed of 300 y.p.m. in the conventional manner. The draw ratio is varied as shown in the table below. A 225 yard skein of each yarn is placed in boiling water for 15 minutes and the amount of shrinkage determined after drying. Results of these tests are shown in Table I below. For comparison, shrinkage tests were also made on yarns spun in an identical fashion except that the steam treatment was omitted. The tenacities of the various yarn samples were determined in the conventional manner and are shown below.

Table I

Draw ratio	Boil-off shrinkage, percent		Tenacity, g.p.d.	
	Steamed	Unsteamed	Steamed	Unsteamed
1.0	0	0	1.5	1.3
1.5	1.8	0	2.3	1.9
2.0	14.9	4.0	3.0	2.5
2.5	14.0	8.8	3.5	3.1
3.0	12.6	10.2	4.2	3.7
4.0	10.5	10.5	5.7	4.7

The steam treated filaments, drawn at a draw ratio of 2.5, are combined with unsteamed yarn of the same denier and draw ratio and the combined yarn woven into a tricot fabric in the conventional manner. The tricot fabric, after the customary finishing treatments, is observed to have a softer handle and better covering power

than tricot fabrics made from yarn having no difference in shrinkage potential of the filaments. The difference in shrinkage values between the high and low shrinkage filaments in the yarn is about 5–6%.

EXAMPLE II

Polyhexamethylene adipamide is prepared and extruded as described in Example I except that the polymer is extruded through two adjacent spinnerets, one spinneret having 7 holes of 0.009 inch diameter and the other spinneret having 6 holes of the same diameter. The filaments from the spinnerets having 7 holes are steam treated as in Example I while the filaments from the other spinneret by-pass the steam enclosure. The filament bundles are then combined, treated with a conventional finish, cold drawn to a ratio of 2.0× and wound on a package in the conventional manner. The denier of the yarn is 40. When placed in boiling water, the yarn becomes bulky due to the higher shrinkage of part of the filaments. The difference in shrinkage values between the high shrinkage filaments and the low shrinkage filaments is 8–10% when measured under tension free conditions.

EXAMPLE III

Example II is repeated except that the filament bundles are drawn separately to substantially the same ratio and then combined. The difference in shrinkage and other characteristics of the yarn are substatially the same as in Example II.

EXAMPLE IV

Example I is repeated except that the spinning speed is 900 yards per minute instead of 300 yards per minute. The boil-off shrinkage values at various draw ratios are shown in Table II. For comparison, shrinkage values are shown for filaments spun in an identical fashion except that the steam treatment was omitted. When those steamed and unsteamed filaments, drawn at a ratio of 2.0, are combined and the yarn subjected to boiling water, a bulky yarn is produced because of the difference in shrinkage values of the steamed and unsteamed filaments.

Table II

Draw ratio	Boil-off shrinkage, percent	
	Steamed	Unsteamed
1.0	2.0	0
1.5	15.0	2.0
2.0	17.4	5.0
3.0	13.0	8.5
4.0	10.2	10.0

EXAMPLE V

Polyhexamethylene adipamide yarn of 70 denier and 24 filaments is prepared, extruded, quenched, steamed and finished as described in Example I. The filaments are then divided into two bundles each of 35 denier and 12 filaments and the two resulting yarns wound into separate shapes.

Bobbins of the 35 denier 12 filament yarn are placed in adjacent positions on a draw twisting machine. One of the yarns is drawn 2.5× in the conventional manner, then passed through a steam chamber where it is heated to a temperature of about 120° C. by the action of the steam, after which it is passed around the end of the draw roll, which is of smaller diameter than the rest of the roller, to permit the yarn to shrink about 10%. The yarn is then passed to the adjacent position on the machine where it is combined with the other yarn which has previously been drawn 2.5× without the steam treatment. The yarn is then twisted 1 to 2 turns per inch as it is wound into a pirn.

When the yarn is subjected to boiling water as in Example I the yarn becomes bulky due to the difference in shrinkage of the filaments. The difference in shrinkage values between the high shrinkage and low shrinkage filaments is 8%.

Optimum product characteristics are provided only when filamentary structures are treated under conditions of high humidity and temperature and drawn at ratios within a critical range. The filamentary structures are conveniently heated with steam to provide the proper conditions of temperature and humidity, although other methods may also be employed. The filamentary structures may, for example, be wet with water or aqueous finish solution and then heated by any suitable means to the required temperature.

In order to provide the necessary increment of shrinkage over normal yarns, the filamentary structures must be drawn within the critical draw ratio range as well as subjected to the high heat and humidity conditions. While appreciable differences in shrinkage may be obtained over the draw ratio range of 1.25 to 3.5, draw ratios within the range of 2.0 to 2.5 are preferred for the best combination of yarn strength and shrinkage. The peak shrinkage value at these draw ratios is indeed surprising and is contrary to what would be expected, i.e., higher draw ratios have been considered in the past to provide higher shrinkage potential values.

Improved yarn properties, particularly cover and hand, are obtained when the high and low shrinkage filamentary structures differ by as little as 1% in shrinkage potential, but preferred results are obtained when these values differ from at least 5 to about 15%. Shrinkage potential values up to about 20% have been obtained and even higher values are deemed feasible. In this regard, it is necessary to balance the shrinkage potential and tenacity values desired for the particular fabric to be produced.

In addition to their usefulness in combination with lower shrinkage polyamide filaments, the highly shrinkable filaments of this invention may obviously be combined with low shrinkage filaments composed of other polymers to obtain yarns having desirable properties.

Among the suitable organic polymeric compositions there are included polyesters, such as poly(ethylene terephthalate); polyacrylonitrile and copolymers containing at least 85% by weight combined acrylonitrile, such as acrylonitrile (92%) methyl acrylate (7.5%) and sodium styrene sulfonate (0.5%); polyhydrocarbons, such as polyethylene and polypropylene and many others.

The preferred polyamides for use in the process of this invention are poly(hexamethylene adipamide) and polyepsilon caproamide. Other suitable polyamides include those described in U.S. Patents 2,071,252, 2,130,523, and 2,130,948.

We claim:

1. The process comprising exposing a first filamentary structure comprising a synthetic, linear polyamide composition to an atmosphere having a relative humidity of at least about 90% and a temperature of at least about 65° C., drawing said structure at a draw ratio between about 1.25 and about 3.5 to provide the structure with a shrinkage potential of at least about 1%, and gathering said first filamentary structure and a second filamentary structure into a bundle, said second structure having a shrinkage potential at least about 1% less than the shrinkage potential of said first filamentary structure.

2. The process of claim 1 wherein the first filamentary structure is composed of poly(hexamethylene adipamide) filaments.

3. The process of claim 2 wherein the atmosphere comprises steam.

4. The process of claim 3 wherein said first and second filamentary structures are both composed of poly(hexamethylene adipamide) filaments.

5. The process comprising exposing a first filamentary structure comprising a synthetic linear polyamide composition to an atmosphere having a relative humidity of at least about 90% and a temperature of at least about

65° C., gathering said first filamentary structure and an undrawn second filamentary structure into a bundle and drawing the bundle at a draw ratio between about 1.25 and about 3.5, the shrinkage potential of the second filamentary structure being at least 1% less than the shrinkage potential of the first filamentary structure.

6. The process comprising exposing a filamentary structure composed of a plurality of undrawn filaments comprising a synthetic, linear polyamide composition to an atmosphere having a relative humidity of at least about 90% and a temperature of at least about 65° C., drawing said filamentary structure at a draw ratio between about 1.25 and about 3.5, separating the filaments of the drawn filamentary structure into a first and a second group of filaments, heating said first group at a temperature between about 120° and about 200° C. while permitting the filaments therein to relax in length, and gathering said first and second groups into a bundle.

7. The process comprising providing a bundle of filamentary structures comprising a synthetic, linear polyamide composition, dividing said bundle into at least two groups of filamentary structures, exposing one of said groups to an atmosphere having a relative humidity of at least about 90% and a temperature of at least about 65° C., subsequently drawing said one group at a draw ratio between about 1.25 and about 3.5 to provide the structures therein with a shrinkage potential of at least about 1% and gathering said groups of structures into another bundle, the structures of said second group having a shrinkage potential at least 1% less than the shrinkage potential of the filamentary structures of the first group.

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