United States Patent Office 2,978,788 Patented Apr. 11, 1961

2,978,788

PROCESS FOR TREATING SYNTHETIC YARN

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No Drawing. Filed July 13, 1955, Ser. No. 521,871

11 Claims. (Cl. 28—75)

This invention relates to a process for treating continuous filament yarns and more particularly to a simplified economical process of preparing bulky yarn composed of individually convoluted synthetic filaments.

Since the introduction of synthetic fibers many processes have been proposed to impart to fabrics made from them a handle similar to fabrics made from cotton and wool. Recently a new yarn product called textured yarn has been introduced to the trade. This product is composed of a plurality of substantially continuous individually convoluted filaments. The individual filaments have coils, loops and whorls at random intervals along their lengths. These yarns are characterized by increased bulkiness and when woven into fabrics result in a softer feel and increased warmth.

The bulky textured yarn has the desirable properties of spun staple yarn without the disadvantage of reducing continuous filaments into staple fibers and then reforming the staple into yarn.

The bulky yarn is prepared by a relatively simple process which consists essentially of passing a bundle of continuous filaments into a turbulent atmospheric region. The turbulence is generally produced by introducing air through a jet into an area through which the yarn is passed.

The stability of the textured yarn depends largely upon interfilament friction. This friction may be increased by twisting the yarn before or after passing it through the air jet in order to hold the convolutions more firmly in place. Twisting, however, is expensive because of the time and apparatus required and costs about as much as the texturing operation itself.

An object of this invention is to provide a process for converting producer twist yarn; i.e., from 0 to 3 turns per inch, into textured bulky yarn without further twisting. Another object is to provide a process for producing bulky textured yarn which has adequate stability to prevent pull out of the convolutions and filament loops during subsequent processing of the yarn into woven and knitted fabrics. A still further object is to provide a simple means for stabilizing the yarn in packages which may be shipped or stored between texturing and weaving. Other objects will be apparent as the description of the invention proceeds.

These and other objects are accomplished by applying to a low twist multifilament yarn a high friction water-sensitive size, drying the sized yarn, passing the dried yarn through a high-velocity air jet to form a textured yarn, winding the textured yarn into a package and then subjecting the packaged yarn to warm humid air to reset the size and stabilize the filament convolutions.

The method is particularly applicable to the texturing of smooth surfaced synthetic filament yarns made by a melt spinning process, such as nylon yarn. Bright or semi-dull nylon yarn has been found to require several turns per inch twist depending upon the denier and filament count to sufficiently stabilize the convolutions against excessive pull out during subsequent normal processing of the textured product into fabrics. For example, 80 denier, 68 filament semi-dull nylon yarn requires around 13 turns per inch twist applied before or after passage through the texturing jet. Equal stability is realized with producer twist nylon yarn, about 0.5 turn per inch, by the texturing process of this invention.

The size or finish applied to the yarn before texturing may be any commercial size which is water soluble or at least water sensitive; i.e., one which may be applied in the form of an aqueous solution or if applied in an organic solvent must be sensitive to water to the extent that when subjected to high humidity it becomes soft and tacky. The size must also be one which can be removed subsequently by conventional aqueous scouring of the finished fabric. The main essential characteristic of the size, however, is that it must be sufficiently sensitive to water in the form of water vapor or low-pressure steam to render the size tacky and to reactivate its adhesive properties.

The sizing materials found most useful include the alkali metal salts of carboxymethyl cellulose, particularly the sodium salt sold to the trade by the Hercules Powder Company as 70S-high CMC; various polyvinyl alcohol compositions particularly those containing boric acid as described in Spanagel, U.S. 2,324,604; certain starches and starch derivatives, such as starch ethers as represented by "Penford Gum" sold by Penick & Ford Co.; and water-insoluble copolymers of vinyl and acrylic esters and polymerizable carboxylic acids such as crotonic acid, acrylic acid, maleic acid and the like. Examples of such polymers are 95/5 (mol percent) ethyl acrylate/acrylic acid and 95/5 vinyl acetate/crotonic acid copolymers. Polymers of this type may be rendered water soluble or water sensitive for the purpose of this invention by transforming the free acid to the alkali metal, ammonium or amine salts in which form they are generally used. Any suitable size which can be rendered tacky upon treatment with warm humid air may be used in practicing the invention.

The optimum concentration of the size solution naturally varies with the yarn characteristics and with the type of size. Convenient methods for applying the size involve the use of a draw twister, spooler or cone winder, which are standard equipment in the textile industry, with an emulsion roll attachment. Using the cone winder, for example, aqueous solutions containing 0.5% to about 1.5% by weight of sodium carboxymethyl cellulose have proven satisfactory for nylon yarn. The polyvinyl alcohol sizes, on the other hand, should be used as aqueous solutions containing in the range of 2% to 8% solids. The size may be applied to the yarn at any time before texturing. It is particularly convenient to apply the size during yarn manufacture. For example, a draw twister is used to impart the one-half turn per inch producer twist to nylon yarn and package the yarn for ultimate sale. Very satisfactory results have been attained in applying the size to the yarn between the drawing and the twisting and packaging steps. After application of the size solution, the yarn should be dried or conditioned to atmospheric conditions, such as 60% R.H. and 75° F. Better uniformity of loop size in the textured product results when a yarn thus conditioned is subjected to the action of the air jet. It has also been found that the yarn can be textured at high speeds when small amounts of an organic hygroscopic agent, such as ethylene glycol, glycerol or polyvinyl alcohol, is added to the size composition.

The texturing operation may be carried out by any known manner, but the method and apparatus shown in Breen U.S. Patent No. 2,852,906 and in Hall U.S. application Serial No. 424,860, filed April 22, 1954 and now abandoned, respectively, are preferred. The only limitation placed on the texturing operation is that the yarn be subjected to a jet of gas, preferably air of such high velocity that under the conditions of treatment the individual filaments of the yarn are separated and whipped about sufficiently to form individual filament con-

volutions. One example of such a jet is shown in the Hall application in which the air pressure is from 20 to 80 pounds per square inch and using a yarn feed speed of about 100 yards per minute and a windup speed of from about 84 to 90 yards per minute.

After the yarn has been textured, it is wound up in a package of any convenient size or type, usually cone or spool winding is preferred. The tension on the yarn while winding must be insufficient to pull out the loops imparted to the yarn by texturing but, on the other hand, must be sufficient to prevent such loose winding that the yarn slips from the cone. Further, the tension must not be so great that the package will be wound too densely to prevent uniform activation when subjected to high humidity. A preferred tension for 80 denier, 68 filament nylon yarn for example, is from 10 to 20 grams.

After the yarn has been wound into a suitable package it is treated with warm humid air which serves to reactivate the water-sensitive size and hold the fine loops and whorls in place. High humidity, for example, 90% R.H. at ordinary room temperature will affect a conciderable improvement in the stability of the textured yarn in a few hours. Higher temperatures, even at somewhat lower humidities, are more effective and preferred. Relative humidities as low as 60% are effective at temperatures around 180° to 200° F. while at temperatures around 100° F. the relative humidity should be at least 90%. Excellent results have been achieved by heating the packaged textured yarn in a standard heat treatment oven set at 150° F. dry bulb temperature and 140° F. wet bulb temperature, corresponding to about 75% R.H. for a period of 15 to 30 minutes. Longer treatment of course can be used, but to little advantage.

The stability of the textured product is measured as relative change in permanent elongation of the textured yarn after specific load conditions. The stability test has proved to be a reliable means of textured yarn characterization. This test is made in the following manner: A one meter length of textured yarn under approximately 0.01 g.p.d. tension is measured and then subjected to a load of 0.5 gram per textured denier for 30 seconds. The weight is then removed leaving 0.01 g.p.d. tension on the yarn and the length again measured. The difference in the original and final measured lengths represents permanent elongation and this expressed as a percent of the original meter length is the stability. A centimeter scale mounted at the bottom of the stability tester makes it possible to read stability directly.

A stability of about 2.5% or less is required for the formation of satisfactory, uniform textile fabrics. With a stability value as high as 4% to 5%, some of the coils, loops and whorls pull out during fabric manufacture from the low twist textured yarn and lower grade, non-uniform fabrics result.

The invention is illustrated by the following examples but it is to be understood that no limitation is placed on the examples except as defined in the appended claims. The invention is not limited to the specific yarns shown but in the examples these may be substituted by yarns prepared from fibers of regenerated cellulose, polyesters, such as "Dacron" polyester fiber, and those based on acrylonitrile. The sizes shown may likewise be replaced by any of those mentioned above.

Example 1

Producer twist (1/2Z) 80 denier, 68 filament semi-dull nylon yarn was rewound on a cone winder (Universal-Model 50) applying an aqueous solution containing 0.8% by weight of Hercules "70S high" carboxy-methyl cellulose (CMC with an emulsion-roll attachment, the emulsion roll turning at about 3 r.p.m. After drying, the sized yarn was textured using the apparatus and method shown in the above-mentioned applications. The yarn was unwound from the cone under a tension of about 10 to 20 grams. The yarn was supplied to an air jet at 50 y.p.m. The jet used was that shown in the Hall application with a 0.016 inch I.D. needle and a 0.055 inch I.D. throat venturi and was supplied with air at 60 lbs./sq. in. gauge pressure. From the jet, the textured yarn was forwarded by a take-up roll operating at 35% slower speed than the feed roll. The textured yarn was then packaged by means of a windup roll operating at 42 y.p.m., 20% slower speed than the feed roll. The stability of the textured yarn varied from 3% to 13%, whereas unsized, semi-dull nylon yarn with a twist of 13Z t.p.i. after texturing has a measured stability of 1% to 2%. Some of the 1/2Z sized yarn textured as described was allowed to condition at 90% R.H. and 70° F. The stability of this conditioned yarn improved markedly to 2% to 5%. Better stability was obtained by conditioning the yarn in a heat setting oven at 150° F. dry bulb and 140° F. wet bulb temperature (76% R.H.) followed by drying.

Example 2

The effect of other sizes and concentrations of size is illustrated in this example, the results of which are shown below in Table 1. The sizes were applied using the cone winder as described in Example 1. The wind-up tension is the tension on the textured yarn between the take-up roll and the windup roll. Denier is the measured denier of the textured yarn. The starting yarn was 80 denier, 68 filament, 1/2Z twist, semi-dull nylon yarn and the texturing conditions, the same as those of Example 1. The setting treatment was done on the packaged textured yarn for 15 minutes in an oven at 150° F. dry bulb and 140° F. wet bulb temperature.

TABLE 1

Size	Windup Tension, gms.	Denier	Stability, Percent as Textured	Stability, Percent after 48 hrs. at 75° F. and 60% R.H.	Stability, Percent after Setting
0.4% 70S high CMC	14	93.8	5.7	5.0	3.4
0.8% 70S high CMC	19	102.7	2.9	2.5	0.4
1.2% 70S high CMC	16	103.5	4.4	5.0	1.9
1.0% 70S med. CMC	14	99.6	5.5	4.4	2.1
5% solution of Na salt of 95/5 vinyl acetate/crotonic acid copolymer	16	102.6	4.3	4.1	0.8
8% Polyvinyl alcohol boric acid	13	98.0	2.8	2.6	0.2
5% Penford Gum	16	102.9	4.3		2.0

This example also demonstrates the value of the warm, humid air after treatment.

Example 3

Twelve pound samples of the producer twist nylon yarn were sized respectively with 0.8% of Hercules 70S-high CMC and with a 5% aqueous solution of the sodium salt of a copolymer containing 95% vinyl acetate and 5% crotonic acid. After drying, these samples of sized yarn were textured using the apparatus and conditions of Example 1. The results are shown in Table 2.

TABLE 2

Size	0.8% 70S high CMC	5% Na salt of vinyl acetate/crotonic acid copolymer
Windup tension, gms.	13.7	16.4
Jet Operation	good	good
Stability as textured, percent	6.8	5.1
Stability after setting, percent	1.8	2.4
Tenacity, g.p.d.	4.2	4.3
Elongation, percent	28	30
Initial Modulus, g.p.d.	14	13

Similar results were obtained using samples of yarn sized at the draw-twister during yarn manufacture, as previously described.

Fabrics of 120 x 60 construction were woven without difficulty from these textured yarns and exhibited a dry hand with good cover and less pickiness than those of similar construction from unsized 13Z twist nylon yarn. A comparison of the fabrics with a control made from a high twist nylon sample is shown in Table 3.

TABLE 3

Properties of fabrics from producer twist sized yarns

Yarn	96T/80-68-13Z Control	96T/80-68-1/2Z 0.8% CMC	96T/80-68-1/2Z 5% Copolymer Size
Loom Count, Warp/Fill	120/60	120/60	120/60
Finished Fabric Count, Warp/Fill	133/73	134/73	134/70
Weight, oz./yd.^{2}	3.0	3.0	2.9
Thickness, cm	0.025	0.028	0.025
Specific Volume, cm.^{3}/gm	2.5	2.8	2.5
Crease Recovery, Warp/Fill:			
Percent, 10 sec	58/58	60/59	62/63
Percent, 30 sec	64/64	65/63	67/68
Percent, 300 sec	73/72	71/70	74/75
Avg. Bending Length, cm	0.99	0.90	0.94
Avg. Flexural Rigidity, mg.-cm.	10	7	8
Light Transmission, Percent	0.25	0	0
Snag Index	128	5	10
Liveliness, Percent Recovery Warp/Fill	42/56	48/51	50/54

It is evident from this comparison that the process of this invention produces textured yarns of equal or better quality than those obtained using high twist in place of a size. Of particular trade interest and importance are the lower light transmission and snag index of fabrics made from yarn textured in accordance with this invention. The properties as shown in Table 3 were measured after the size had been removed from the fabric by means of a standard scouring treatment.

While this invention has been described with particular reference to its use with nylon yarn, it is obviously applicable to use with other synthetic fibers such as viscose rayon, cellulose acetate, fibers based on polymers of acrylonitrile, linear polyester fibers of the terephthalic acid-dihydric alcohol type polymers and the like. It is particularly applicable to the processing of the melt spun fibers of round cross section which are difficult at best to texture satisfactorily without introducing relatively high twist, either before or after the passage of the yarn through the air jet. The introduction of the high twist at whatever point in the process involves considerable expense, in many cases equalling the expense of the remainder of the texturing process itself. The process of this invention avoids the necessity of adding twist to stabilize the textured product and the cost of installation and operation of the twisting equipment.

The sizing materials must be applied to the yarn before texturing in order that the textured yarn can be wound as a package under sufficient tension as described above required for good package formation, particularly with the smooth surfaced round cross section melt spun fibers such as nylon.

The advantages of this invention are many. The bulky yarn has the desirable properties of spun staple yarn and avoids the necessity of cutting continuous filaments into staple and then reforming the staple into yarn. The bulky yarn is simply and economically prepared, by a process which requires little equipment, directly from the continuous filament bundle initially produced in synthetic-fiber manufacture. The bulky yarn is superior to spun staple for many purposes because of its freedom from loose ends. However, it can be made to resemble spun staple in this respect, if desired, by cutting or singeing the protruding filament loops to provide loose ends. This can also be conveniently accomplished as part of the texturing operation by passing the textured yarn, after it leaves the air jet, lightly against an abrasive element, such as a cylinder of emory paper, sandpaper or the like. The unmodified hand of fabrics made from the bulky yarn usually is stiffer than that of corresponding staple materials, making them more suitable for use in draperies, suits, overcoats, etc.

It will be apparent that many widely different embodiments of this invention may be made without departing from the spirit and scope thereof, and therefore it is not intended to be limited except as indicated in the appended claims.

I claim:

1. The process of preparing bulky yarn which comprises subjecting a continuous synthetic filament yarn having a dry non-tacky, solid, water-sensitive size on its surface to a high velocity jet of air under conditions such that the individual filaments thereof are separated and whipped about to form individual filament convolutions, and thereafter subjecting the yarn to a warm, humid atmosphere until the size becomes tacky.

2. The process of claim 1 in which the size is a water-soluble salt of an organic polymer.

3. The process of claim 1 in which the yarn before builking has a twist of less than 3 turns per inch.

4. The process of claim 1 in which the yarn is subjected to an atmosphere of at least 75% relative humidity and a temperature of at least 140° F. for at least 15 minutes.

5. The process of claim 1 in which the filament is nylon.

6. The process of claim 1 in which the filaments are made from an acrylonitrile polymer.

7. The process of claim 1 in which the filaments are made from a linear terephthalic acid-dihydric alcohol polymer.

8. Process of preparing bulky continuous filament yarn which comprises applying a water-sensitive size adapted to become tacky under warm, humid conditions to a low twist multifilament yarn, drying said yarn, passing the dry non-tacky sized yarn through a high velocity air jet under conditions such that the individual filaments thereof are separated and whipped about sufficiently to form individual filament convolutions, removing the yarn from said air jet and winding same into a package under tension insufficient to straighten said filament convolutions, and subjecting said package of yarn to warm, humid conditions.

9. Process as set forth in claim 8 wherein said size is an alkali metal salt of carboxymethyl cellulose.

10. Process as set forth in claim 8 wherein said size is aqueous starch solution.

11. Process as set forth in claim 8 wherein said size is an alkali metal salt of a water-insoluble copolymer of an ester from the group consisting of vinyl esters and esters of acrylic acid, and a polymerizable organic carboxylic acid.

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