

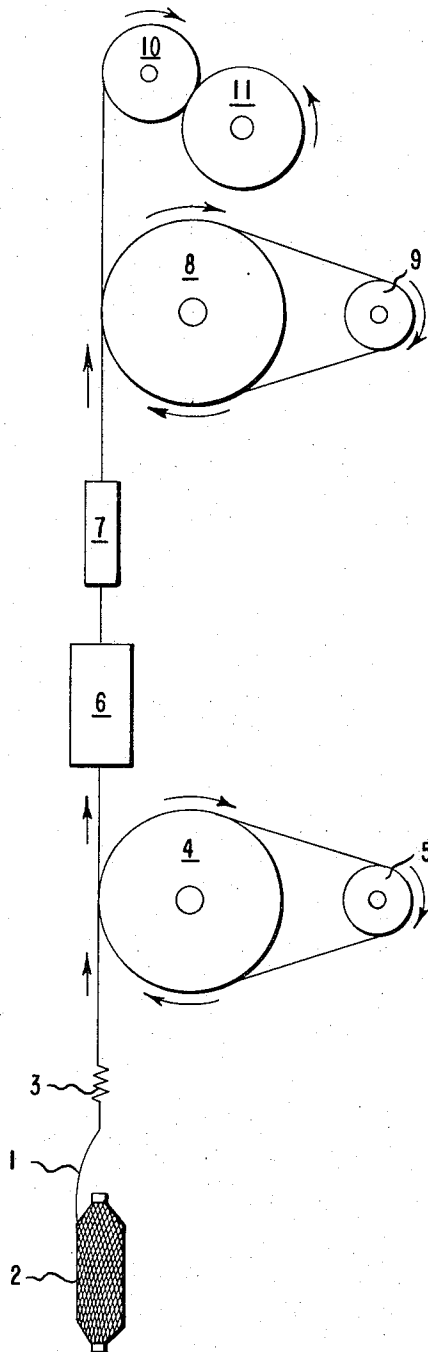
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CREPE FABRIC OF POLYESTER YARNS

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CREPE FABRIC OF POLYESTER YARNS

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ABSTRACT OF THE DISCLOSURE

A plain-weave crepe fabric the filling of which comprises a "torsionally crimped" polyethylene terephthalate textile yarn and the warp of which comprises continuous filament polyethylene terephthalate textile yarns having a shrinkage-modulus in the range from about 0.1 to about 4.0 grams per denier which is less than 0.027 of the percent crimp development of the filling yarn, the warp filaments having a residual shrinkage from about 2% to about 12% with the residual shrinkage of each filament in the warp differing from the residual shrinkage of the other warp filaments by no more than 2%.

This invention relates to woven textile fabrics and more particularly to crepe fabrics comprising polyester textile yarns.

Crepe fabrics composed of natural fibers such as silk, or man-made fibers such as rayon or acetate have long been known. The advent of polyester yarns with their attending beneficial properties such as good dimensional stability and excellent wash-wear characteristics has suggested their use in crepe fabrics. Certain characteristics of polyester yarns such as their residual shrinkage have been adjusted to resemble the characteristics of the classical crepe yarns, thus enabling the substitution of polyester yarns for the classical crepe yarns in the production of crepe fabrics. These experiments have been moderately successful insofar as a polyester crepe fabric is produced, but the appearance or "figure" of these fabrics leaves much to be desired.

This invention provides a woven textile fabric composed of continuous filament polyester textile fibers which possesses an extremely high degree of "crepiness" or "surface pucker." It further provides a crepe fabric which possesses all of the desirable qualities peculiar to polyester fabrics. Other objects will appear hereinafter.

These provisions are realized by a crepe fabric construction of plain weave, the filling of which comprises a "torsionally crimped" polyethylene terephthalate textile yarn and the warp of which comprises continuous filament polyethylene terephthalate textile yarns having a shrinkage-modulus in the range from about 0.1 to about 4.0 grams per denier which is less than 0.027 of the percent crimp development of the filling yarn, the warp filaments having a residual shrinkage from about 2% to about 12% with the residual shrinkage of each filament in the warp differing from the residual shrinkage of the other warp filaments by no more than 2%. The warp yarn preferably has a shrinkage-modulus of about 0.5 to 1.5 grams per denier; the value must be less than 0.027 times the percent crimp development value for the filling yarn in any case.

The filling yarn is a torsionally crimped polyethylene terephthalate yarn of conventional type. The drawing is a diagrammatic illustration of a process for crimping yarn in this manner.

In accordance with the teachings of the prior art of crepe fabric manufacture, which invariably specify a warp yarn of a low-shrinkage variety such as acetate or silk, one would reasonably conclude that a low shrinkage

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warp yarn is essential for producing a crepe fabric. Such a rule is supported by consideration of the basic fabric structure of crepe fabrics. If the warp yarn of a fabric shrinks substantially during the conventional shrinkage treatment performed to develop the creping forces of the filling yarn, the warp yarn binds the filling and prevents it from developing adequate creping force so that very little crepe figure is developed in the fabric.

Surprisingly, it has now been found that if a fabric is woven in a crepe fabric structure comprising polyester filling yarn which is normally used in crepe fabrics and polyester warp yarn as specified above, and this fabric is exposed to conventional crepe developing media, such as hot water, it develops a substantial crepe figure even when the residual shrinkage of the warp yarn is as much as 11%. More surprisingly, the crepe figure is accentuated more if the residual shrinkage of the warp yarn is 11% than if its residual shrinkage is 4%.

The term "shrinkage-modulus" as used herein is the reciprocal of the initial slope of the curve plotted on a graph showing percent shrinkage of the yarn in boiling water as the ordinate and the load applied to the yarn during shrinkage as the abscissa. A simple procedure is used to determine this value: A sample yarn is cut into five portions, each portion being approximately 60 cm. long. Each portion is tied to form a loop and suspended from a hook on a wire frame. A 20-gram weight is suspended from the bottom of the first loop; a 13.5-gram weight is suspended from the bottom of the second loop; a 9-gram weight is suspended from the bottom of the third loop; a 4.5-gram weight is suspended from the bottom of the fourth loop, and no weight is suspended from the bottom of the fifth loop. The length of each loop is then measured (L_1). The wire frame with the yarn samples, bearing their respective weights, is then immersed into boiling water for 2 minutes. The samples are then removed from the water and the new length of each loop is measured (L_2). Percent boil-off shrinkage is then calculated for each sample by the following formula:

$$\text{Percent boil-off shrinkage} = \frac{L_1 - L_2}{L_1} \times 100$$

A graph is then constructed using percent boil-off shrinkage as the ordinate and load in grams per denier as the abscissa. The reciprocal of the initial slope of the curve formed by this plot, multiplied by 100, is the "shrinkage-modulus" of the yarn.

It will be apparent from the teachings set forth herein that, for the purpose of describing the present invention, the shrinkage-modulus of unrelaxed yarn should be used, e.g., it is not determined on yarn which has been exposed to high temperatures, of the order of 100° C. in a relatively tension-free state. Thus, when it is stated that the warp yarns of the crepe fabrics have a specified shrinkage-modulus, it is meant that the warp yarns have such a characteristic just prior to their being woven into a fabric and up to the time such fabric is exposed to high temperatures, of the order of 100° C. Of course, after the fiber is exposed to such high temperature the warp yarns do not have the shrinkage-modulus they had prior to such exposure.

Residual shrinkage as used herein is a term applied to the degree of shrinkage that takes place in a yarn upon its exposure to boiling water. Residual shrinkage is measured by subjecting a measured length of a filament, in a tensionless state, to boiling water for two minutes, drying it and again measuring its length. The percentage reduction in length is calculated and referred to as residual shrinkage. The considerations applying to determination of shrinkage-modulus apply equally as well as determination of residual shrinkage.

Crimp development (C.D.) is the measurement of the

amount of crimp that develops in a fiber upon its exposure to boiling water notwithstanding residual shrinkage so developed. It is measured according to the following procedure: From the known denier of the yarn, the number of turns of a skein reel required to achieve a denier of 1500 (167 Tex.) (the circumference of the reel may be any convenient length), is calculated using the formula:

$$T = \frac{1500}{d}$$

where T designates turns on the skein reel and d is the denier of the yarn. T is rounded off to the nearest even number of turns and a 1500 denier skein is prepared. This corresponds to 300 denier (334 Tex.) when the skein is loaded as a loop. The skein is then hung and a 4.5-gram load is suspended therefrom. The skein bearing the load is immersed in boiling water for 5 minutes, removed and dried. The skein length is then measured (L_1). The 4.5-gram load is replaced with a 301.5-gram load and the skein length again measured (L_2). Crimp development is calculated by the formula:

$$\text{Percent crimp development} = \frac{L_2 - L_1}{L_2} \times 100$$

Yarns suitable for the warp of the fabrics of this invention are comprised of any number of filaments conventionally used for textile purposes. The individual filament denier may be any denier suitable for textile manufacture. Residual shrinkage of these yarns may be as low as about 2%, and surprisingly may be as high as about 12%.

Polyethylene terephthalate homopolymer fibers of the hereinabove described characteristics have been found most desirable for use in the warp of the fabrics of this invention, but polyester copolymers such as poly[ethylene terephthalate/5-(sodium sulfo)isophthalate] disclosed in Griffing et al. U.S. Patent No. 3,018,272, dated Jan. 23, 1962, may be used equally as well.

Shrinkage-modulus of polyester yarns may be adjusted and controlled by many techniques. In general, the exposure of an unrelaxed polyester yarn to heat during processing affects its shrinkage-modulus. Thus, in conventional twist-setting and slashing operations, the annealing temperature and duration are critical to the control of shrinkage-modulus. As the annealing temperature is increased and/or the duration of annealing is increased the shrinkage-modulus of the yarn increases. In the practice of the present invention, slashing must be performed at lower-than-normal temperatures and at higher-than-normal tensions. In slashing the polyester yarns of this invention, the slashing temperature may be from 80° C. to 100° C. and is preferably 93° C., and the tension applied to the yarns during slashing may be from essentially 0 gram per denier to approximately 0.5 gram per denier, and is preferably 0.3 gram per denier.

Although one method of obtaining low shrinkage-modulus yarns is described above, the invention is not restricted thereto, as it will become readily apparent to those skilled in the art, in the light of these teachings, that other methods such as the steam-jet relaxation described in Breen et al. U.S. Patent No. 3,186,155, dated June 1, 1965, may also be used to produce a low shrinkage-modulus polyester yarn. It is noted that slashing conditions described hereinabove may be more severe for steam-jet relaxed polyester yarn and standard slashing conditions may be used.

When using torsionally crimped filling yarns, in order to achieve the benefit of the present invention it is important that the proper relationship between the crimp development of the filling yarn and the shrinkage-modulus of the warp yarn be established. The shrinkage-modulus of the warp yarn (measured in grams per denier) must be less than 0.027 of the percent crimp development of the filling yarn.

Any torsionally crimped polyester yarn may be used

for the filling of the crepe fabrics of this invention, but polyethylene terephthalate yarns have been found to be most desirable.

The term "torsionally crimped" textile yarn is used herein to describe a textile yarn which has been crimped by being twisted, heat-set in its twisted configuration, and untwisted. Methods used for this operation are well-known, as disclosed in Breen et al. application Ser. No. 810,671 filed May 4, 1959, now U.S. Patent No. 3,279,164 dated Oct. 18, 1966. A preferred method for imparting torsional twist to polyethylene terephthalate yarns may be understood by reference to the drawing. Polyethylene terephthalate yarn 1 is unwound from the package 2 and passed through tensioner 3 to feed roll 4, thence it passes partially around feed roll 4 to, and partially around, the auxiliary roll 5, back to feed roll 4, then through heater 6 and twister 7. The yarn then passes partially around drive roll 8, thence to, and partially around, auxiliary roll 9, back to drive roll 8 to take-up package 10 which is driven by its contacting driving drum 11. The heater 6 is maintained at a temperature of from 177° C. to 230° C. and preferably 220° C. The yarn passes through the twister at a speed of from 15 yds./min. (13.7 m.p.m.) to 90 yds./min. (82.2 m.p.m.) and preferably about 75 yds./min. (68.5 m.p.m.). The twist of the yarn while it is in heater 6 is from 70 to 80 turns/inch (27.6-31.5 turns/cm.) and is preferably about 75 turns/inch (29.5 turns/cm.). Feed roll 4 and drive roll 8 are adjusted in their speed so that the peripheral speed of drive roll 8 is from 92 to 100% and preferably 98% of the peripheral speed of feed roll 4.

If the amount of twist of the yarn while it is in the heating chamber is increased, less "crepiness" will be imparted to fabrics woven from the yarn, and if the peripheral speed of the drive roll is lowered in relation to the peripheral speed of the feed roll less "crepiness" will be imparted to fabrics woven from the yarn.

In addition to the torsionally crimped yarn described hereinabove, other polyester yarns suitable for use as the filling of crepe fabrics may be used in the practice of this invention. Such yarns may be classified into two categories: mixed shrinkage yarns and composite filament yarns.

Mixed shrinkage yarns are those yarns comprising some filaments which have different residual shrinkage characteristics than the others. Such yarns are disclosed in Nott U.S. Patent No. 3,115,744, dated Dec. 31, 1963.

Composite filament yarns are those which comprise filaments in which at least two separate and distinct polymeric species are present in side-by-side relationship and in intimate adherence along the filament length. Such yarns are disclosed in Breen U.S. Patent No. 3,038,236, dated June 12, 1962.

The construction of the fabrics of the present invention may correspond to any of the types conventionally used in crepe fabric manufacture. The most desirable fabrics are obtained by twisting part of the filling yarns in an S direction and part in a Z direction and weaving them alternately by two picks.

Visual observation is the best method to evaluate the amount of "crepiness" of a fabric. In the examples below, the degree of "crepiness" is rated by visual observation. A fabric with no crepe figure will be described as being flat, while a fabric with crepe will be termed as having crepe figure.

The crepe of the fabric of the present invention is usually developed by exposure of the fabric to heat. It has been found most convenient to develop the crepe in one of the normal steps in the process such as the fabric dyeing step.

The term "relative viscosity" (RV) as used in the examples is the ratio of the viscosity of a 10% solution of polyethylene terephthalate in a mixture of 10 parts of phenol and 7 parts of 2,4,6-trichlorophenol (by weight).

to the viscosity of the phenol trichlorophenol mixture, per se, measured in the same units at 25° C.

Intrinsic viscosity as used therein is defined as the limit of the fraction

$$\frac{\ln(r)}{c}$$

as concentration c approaches zero, where r is the relative viscosity as defined above, except that the relative viscosity is measured at several concentrations to facilitate extrapolation to zero concentration; and the solvent employed in this measurement is a mixture of three parts of methylene chloride and one part of trifluoroacetic acid (by weight).

The following examples illustrate preferred embodiments but the invention is not restricted thereto.

Example I

This example illustrates the fact that a polyester crepe fabric comprising a high residual-shrinkage warp yarn can be produced by the teachings of this specification, and compares the quality of this fabric with a fabric comprising a low-shrinkage warp yarn which is not produced in accordance with this specification.

A test crepe fabric is made according to the following procedure:

For the filling, a commercially available 70-denier/34-filament polyethylene terephthalate yarn is torsionally crimped by the previously described process. In the process the heater temperature is 216° C.; the yarn is fed to the twister at 53.8 yds./min. (49.2 m./min.) and drawn from the twister at 52 yds./min. (47.5 m./min.) The amount of twist in the yarn while it is being heated is 76 Z turns/inch (30 turns/cm.). An identical filling yarn is produced in the same manner with the exception that the twister is adjusted so that while the yarn is being heated the yarn has a twist of 76 S turns per inch (30 turns/cm.). The crimp development of this yarn is 40.6%.

For the warp, polyethylene terephthalate of 30 relative viscosity is spun in conventional manner and drawn to an 80-denier/50-filament yarn. The yarn is twisted to 5 Z turns/inch (1.97 turns/cm.) and slashed at 93° C. under 0.31-gram/denier tension. Residual shrinkage of this yarn is 11%; its shrinkage-modulus is 0.81 gram per denier, and its tenacity is 4.25 grams per denier.

The warp and the filling yarn are woven to a fabric of 87 warp ends/inch (34 ends/cm.) by 70 picks/inch (28 picks/cm.), the filling being woven into the warp 2 picks S twist by 2 picks Z twist. The fabric is then immersed into boiling water for 30 minutes and exposed to 170° C. heat for 5 minutes. A very pronounced crepe figure is apparent.

A control fabric is made, using the same filling yarn as used in the test fabric, and using the same warp yarn with the exception that the warp yarn is heat-set for 2 hours at 100° C. and 80% relative humidity and slashed at 93° C. in a relatively tensionless state. The residual shrinkage of this yarn is 3.7%; its shrinkage-modulus is 4.7 grams per denier, and its tenacity is 4.1 grams per denier.

The control fabric is woven to a construction identical to the construction of the test fabric. The fabric is immersed into boiling water for 30 minutes and heat-set at 170° C. for 5 minutes. The fabric is flat with no crepe figure.

Thus it is shown that the shrinkage-modulus of the warp yarn is the important feature in making polyester crepe fabrics and the requirement, heretofore recognized, specifying low shrinkage warp yarns for crepe fabrics is contradicted.

Example II

This example illustrates the fact that crepe fabrics of this invention may be produced with mixed-shrinkage filling yarns.

A crepe fabric is made according to the following procedure: For the filling, a 45-denier/14-filament polytri-

methylene terephthalate yarn is annealed at 140° C. and is found to have a residual shrinkage of 6%. The same type polymer is spun to a yarn of 45 denier/14 filaments but is not annealed. The latter yarn is found to have residual shrinkage of 16%. These yarns are plied with each other and twisted to 25 turns/inch (9.9 turns/cm.), part of the yarn being twisted in an S direction and part being twisted in a Z direction.

For the warp, polyethylene terephthalate is spun to a 70-denier/50-filament yarn. The yarn is relaxed in steam at 100° C. to 98 denier and virtually 0% shrinkage. The yarn is then twisted to 5.0 Z turns/inch (2 turns/cm.) and slashed at 93° C. under 0.32-gram/denier tension. The yarn is found to have a residual shrinkage of 4.7%, a shrinkage-modulus of 0.74 gram per denier, and a tenacity of 3.2 grams per denier.

The mixed-shrinkage filling yarn and the low shrinkage-modulus warp yarn are woven to a fabric of 120 warp ends/inch (47 ends/cm.) by 76 picks/inch (30 picks/cm.). The filling is 2 picks S twist alternating with 2 picks Z twist. The fabric is immersed into boiling water and a desirable crepe figure is observed.

A control fabric is made according to the following procedure:

For the warp a 70-denier/34-filament polyethylene terephthalate yarn is twisted to 7.5 Z turns per inch (2.9 turns/cm.) and slashed in conventional manner at 110° C. The residual shrinkage of this yarn is 2.3% and its shrinkage-modulus is 5.4 grams per denier.

A fabric is prepared to a woven construction of 90 warp ends/inch (35.5 ends/cm.) by 70 picks/inch (2.75 picks/cm.) using the just-described warp yarn and a filling yarn identical to the filling yarn used for the test fabric of this example, alternating the filling yarns 2 picks of the S twist yarns by 2 picks of the Z twist yarns. Upon immersion of the control fabric into boiling water for 30 minutes, very little crepe figure is observed.

Example III

This example illustrates the fact that, in accordance with this invention, crepe fabrics may be produced using composite-filament filling yarns.

A crepe fabric is made according to the following procedure:

For the filling, polyethylene terephthalate of 21 relative viscosity and polytrimethylene terephthalate of 1.4 intrinsic viscosity are concurrently spun using a spinneret similar to that disclosed in Breen U.S. Patent No. 2,931,091, dated Apr. 5, 1960, (particularly column 7, lines 44-53) to produce a 70-denier/34-filament yarn, each filament consisting of the two polymeric species in separate and distinct side-by-side relationship and in intimate adherence along the filament axis. The yarn has a tenacity of 2.8 grams per denier. The yarn is twisted to 20 Z turns/inch (7.9 turns/cm.).

For the warp, polyethylene terephthalate of 30 relative viscosity is spun to a 62-denier/50-filament yarn. This yarn is then fluid-jet relaxed according to the procedure shown in Breen et al. U.S. Patent 3,186,155 dated June 1, 1965, to 80 denier. The yarn is slashed at 93° C. under about 0.25-gram/denier tension. The yarn is twisted to 5 Z turns/inch (2 turns/cm.). The residual shrinkage of this yarn is 5.3%, the shrinkage-modulus is 0.77 gram per denier, and the tenacity is 2.8 grams per denier.

The warp and fill yarns are woven to a fabric of 97 warp ends/inch (38.2 ends/cm.) by 76 picks/inch (30 picks/cm.). After immersing the fabric into boiling water for 30 minutes and heat-setting for 5 minutes at 175° C., a good crepe figure in the fabric is observed.

A control fabric is made using the identical filling yarn as used in the test fabric of this example. The warp yarn is unrelaxed 70-denier/34-filament polyethylene terephthalate yarn with a twist of 7½ Z turns/inch (2.95 turns/cm.). The warp yarn is slashed at 110° C.

The residual shrinkage of the warp yarn is 2.3% and

its shrinkage-modulus is 5.4 grams per denier. A fabric is woven to a construction of 100 warp ends/inch by 80 picks/inch (39.3 ends/cm. by 31.5 picks/cm.). After immersion in boiling water for 30 minutes no crepe figure is observed in the fabric.

Example IV

This example illustrates the fact that the crepe fabrics of the present invention may be scoured under substantial tension and still retain their crepe developing potential.

A test fabric is prepared, identical to the test fabric of Example I. The fabric is scoured at 100° C. for 20 minutes under a warpwise tension of 55 grams per inch in water containing 0.1% of a liquid, non-ionic detergent (fatty alcohol ethylene oxide condensation product) and 0.1% tetrasodium pyrophosphate. A high degree of "crepiness" is observed.

For comparison, a polyester crepe fabric is prepared according to well-known teachings in the following manner:

The warp yarn is identical to the warp yarn used for the control fabric of Example II and the filling yarn is identical to the filling yarn of Example I. The warp and the filling yarn are woven to a fabric of 94 warp ends/inch (34 ends/cm.) by 71 picks/inch (28 picks/cm.), the filling being woven into the warp 2 picks S twist by 2 picks Z twist. The fabric is scoured in the same manner as the first fabric of this example. The fabric is streaky with very little random crepe figure, less than it would have shown had it not been scoured under tension.

In the process of making the crepe fabrics of this invention, an important economic advantage is evident. Because the creping potential of these fabrics is extremely high, substantial tension may be used in the heating step, i.e., the step employed to develop the crepe figure. Example IV illustrates this fact. This factor enables the implementation of continuous finishing operations which necessarily involve the application of substantial tension to the fabric and which could not be used in processing the crepe fabrics of the prior art. Continuous finishing operations allow increased mill productivity and reduced processing costs.

A further advantage is apparent, in the practice of this invention, in that it avoids the necessity of using warp

yarns comprising filaments of different residual shrinkage plied together or alternately inserted in the fabric, although such warps have previously been required for many crepe fabrics. Thus, expensive plying and alternate-feed weaving mechanisms are avoided.

The fabrics of this invention find use in wearing apparel and home furnishings. They are processed of an extremely well-developed and pronounced crepe figure and have excellent wash-and-wear and aesthetic properties.

Since many different embodiments of the invention may be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited by the specific illustrations except to the extent defined in the following claims.

I claim:

1. A crepe fabric construction of plain weave, the filling comprising torsionally crimped polyethylene terephthalate textile yarn for development of crimp upon exposure to hot water, and the warp comprising continuous filament polyethylene terephthalate textile yarn having a shrinkage-modulus in the range from about 0.1 to about 4.0 grams per denier which is less than 0.027 times the percent crimp development of the filling yarn, the warp filaments having a residual shrinkage from about 2% to about 12% with the residual shrinkage of each filament in the warp differing from the residual shrinkage of the other warp filaments by no more than 2 percent, said shrinkage-modulus being determined from the shrinkage under load produced by immersion in boiling water for 2 minutes.

2. The fabric defined in claim 1 wherein the warp yarn has a shrinkage-modulus of 0.5 to 1.5 grams per denier and a residual shrinkage of about 11%.

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