United States Patent Office 3,016,684
Patented Jan. 16, 1962

3,016,684

METHOD OF MAKING CORD

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No Drawing. Filed Sept. 22, 1955, Ser. No. 536,040
19 Claims. (Cl. 57—157)

This invention relates to the manufacture of cord from a plurality of filaments and, more particularly, to the production of an improved cord, and/or package thereof, from filaments of materials that exhibit the property of contraction when heated.

Inflatable vehicle tires, belts, hose and many other articles, formed from rubber and related elastomers, are reinforced by incorporating therein cords formed of textile materials. In general, such cords are formed by twisting together a plurality of fibers or filaments to form strands or yarns and several of these strands or yarns are then twisted together to form the cord, the amount and direction of the twisting being determined by the nature of the filaments and the physical characteristics desired; such as flex resistance, tensile strength, and the like. These characteristics frequently require twist directions and amounts such that the resulting cord exhibits excessive liveliness or unbalance; i.e., a length of cord hanging freely in a loop twists or kinks.

Excessive liveliness or unbalance in a cord makes it difficult to handle especially in creels used to form weftless fabric for tires and the like. When the cords are formed of cotton or rayon the excessive liveliness or unbalance can be reduced by heating a cone or package of the cord in a moist atmosphere as, for example, by placing a moist cone or package of the cord in an electrical field of high frequency alternating current so that the cord is dielectrically heated. However, attempts to employ similar dielectric heating of cones or packages of cord formed from materials which exhibit the property of contracting when heated have been unsuccessful. This is due to the fact that the temperatures necessary to effect a material reduction in unbalance of the cord produce contraction or shrinkage forces of such magnitude that the cone or package in which the cord is wound is distorted to an extent such that it cannot be used in a creel.

The principal object of this invention is therefore, to provide an improved method of preparing cord from filaments of material that exhibit the property of shrinking when heated and treating the cord when wound in the form of a cone or package so that the unbalance of the cord, due to the directions and amounts of twists imparted in the formation thereof, is reduced to a value permitting satisfactory operation of the cord in a creel, the reduction of unbalance being effected without damage to the cord itself or appreciable distortion of the cone or package in which it is wound.

A more specific object of the invention is to provide an improved method of preparing cord from filaments of a material that exhibits the property of contracting when heated wherein the twist imparted in forming the cord is effected while the filaments are moist, thereby partially relieving the unbalance normally introduced by the twisting, and the cord is wound, while moist, into a package or cone which is subjected to an electrical field of high frequency alternating current at an energy impart and for a time interval such that the temperature of the cord does not exceed 140° F., thereby further reducing the unbalance of the twisted cord without distortion of the cone or package so that it is satisfactory for use in a creel.

A still more specific object of the invention is to provide an improved method of preparing cord from filaments of a linear polyamide by twisting a plurality of the filaments to form yarns, moistening the yarns, twisting together a plurality of the moistened yarns to form cord with the direction of the latter twist being opposite to that employed in forming the yarns and with the amount of twist approximating but being less than the twist imparted in forming the yarns, winding the cord while moist into a cone or package and subjecting the moist cone or package to dielectric heating for a period of time and at an energy impart such that the residual unbalance of the cord does not exceed six turns per yard.

A further object of the invention is to provide an improved method of making cord from linear polyamide filaments, the method being characterized by moistening yarns of the filaments before twisting the yarns together with the said moisture containing a substance which prevents degradation of the linear polyamide when heated, the cord formed from the twisted yarns thereafter being wound into a cone or package and subjected to dielectric heating for a time interval and at an energy impart sufficient to reduce the residual unbalance of the cord below six turns per yard without raising the temperature of the cord above 140° F.

The manner in which these and other related objects of the invention are attained will be apparent from the following detailed description of the procedural steps employed and the specific examples of cord produced thereby.

In general, the procedure of this invention comprises the provision of a plurality of yarns each formed from a plurality of filaments of a linear polyamide or other material which exhibits the property of shrinking when heated. These yarns are then moistened and twisted so that the number of turns per inch is in the order of 11.5 to 14, the moisture being in the order of 4% to 10% i.e., 4 parts by weight of liquid to 100 parts by weight of the yarn. This operation, known as wet twisting, is well understood by those skilled in the art so that it is unnecessary to illustrate or describe the apparatus employed. After the yarns are thus twisted, a plurality thereof are wet twisted together to form a cord, the direction of this twisting being the reverse of that previously imparted to the yarns and being of an amount approximating but less than the twist of the individual yarns. For example, if the yarns have been given a Z-twist of 11.5 to 14 turns per inch, the plurality of yarns are twisted together with an S-twist of 10.5 to 13 turns per inch. The moist cord is then wound into a cone or package of a size such that its weight is in the order of 16 to 20 pounds and the package is thereafter dielectrically heated by subjecting it to the action of an electrical field of high frequency alternating current.

The apparatus employed to provide the dielectric heating is conventional and may be of the type disclosed in U.S. Patent 2,421,334 or other well-known construction and hence this apparatus and the operation thereof need not be here illustrated and described. The energy impart to this alternating current field is, however, substantially less than that disclosed in Patent 2,421,334 as employed for cotton, rayon or substantially dry nylon it having been found that high energy inputs, and the resulting high temperatures, when applied to linear polyamides result in shrinkage forces of such magnitude that the cone or package of the cord is distorted or crushed. The heat imparted to the cone or package of the cord is, of course, dependent not only upon the energy imparted to the field but also upon the length of time the package is in the field, the size of the cone or package and the quantity of moisture therein. In general, the temperature of the cord should not exceed 140° F. and the package of cord should not be subjected to such temperature for a period of time in excess of 10 minutes.

Within these limits, a package of wet twisted linear polyamide cord, having twist directions and amounts as defined above, will exhibit a residual twist unbalance in the range of 3 to 6 twists or kinks per yard. Of course, a completely balanced cord is ideal but it is not necessary for satisfactory operation of the cord in a creel that the unbalance be lower than 3 twists or kinks per yard and unbalances of 3 to 6 can be tolerated. Hence, the extra expense of achieving completely dead lay or balanced cord need not be incurred.

The production of cord for use in a creel employed to form weftless ply fabric for inflatable tires of passenger vehicles is exemplary of the manner in which the method of this invention is practiced. Cord of this nature was formed from 840 denier yarns of nylon filaments by giving each yarn a Z-twist of 12 turns per inch, and then wet twisting two of the yarns together with 11 turns per inch of S-twist. The resulting cord was wound, while still moist, upon a paper core or cone to provide a cord package weighing 17 pounds. This package was then wrapped in a moisture resistant paper and placed in an electrical field of high frequency alternating current provided by an apparatus well-known in the art for twist setting rayon.

The moisture content of the package entering the field was 4.44% and the energy input to the field was 15 k.v.a. at a frequency in the range of 9.5 to 10.5 megacycles. The package remained in the field for 9.5 minutes and the temperature of the cord was 120° F. The moisture content of the package on removal from the field was 4.31% and the twist unbalance for lengths of cord, taken from different locations in the package, varied from 3 to 6 twists per yard. The cord was found suitable for use in a creel without excessive kinking or other difficulties that are encountered with cord having unbalance in excess of 6 turns per yard.

The improvement in balance of the cord as the result of employing the method is not dependent solely upon either the wet twisting or the dielectric heating but is a combination of the two. Thus, a cord of like size, number of yarns and twist, but in which the twisting was effected while the yarns were dry, had an unbalance of 20 to 30 twists per yard which could not be reduced to the acceptable range of 3 to 6 twists by dielectric heating without subjecting the cord to temperatures of such high values and/or extended durations as to damage the cord or the package in which it was wound. Moreover, a cord of like size, number of yarns and twist, formed by wet twisting but not dielectrically heated, exhibited an unbalance of 12 to 15 twists per yard which is far in excess of the permissible limit. Therefore, while wet twisting results in less unbalance there is still excessive unbalance unless dielectric heating is also used. The presence of moisture resulting from wet twisting not only reduces the unbalance of the cord but, in addition, this moisture remaining in the cord during the dielectric heating assists in the development of the heat by virtue of the action of the rapidly alternating field on the molecules of the liquid, and the retention of the heated moisture closely adjacent the filaments assists in relieving the stresses therein resulting from the twisting.

It will, of course, be appreciated that satisfactory operation of the method is not restricted to cords and packages thereof having the exact dimensions and receiving dielectric heating for precisely the time and temperature given for the above specific example. Thus, cords having only the permissible unbalance have been prepared from wet twisted nylon yarns wound into packages varying in diameter at the base from 9.75 to 11.0 inches and weighing from 16.0 to 20.0 pounds. Also, the moisture content of the packages may vary from 4% to 10% while the energy impart to the electric field and the time therein are varied in accordance with the amount of unbalance introduced into the cord during the twisting and the size of the cord package treated. However, the temperature of the cord should never exceed the boiling point of water and preferably should not be in excess of 140° F. when measured immediately upon removing the package from the field.

Other cords, having properties desirable for use in reinforcing various articles formed from elastomers but which cords are highly unbalanced as conventionally prepared from heat contractible filaments, may also be prepared in accordance with this invention so as to have satisfactory balance for use in a creel. Thus 4 yarns of 210 denier nylon may be twisted together with 14 turns per inch of Z-twist and 2 of these groups of 4 yarns are then wet twisted to form a cord by imparting 11 turns of S-twist thereto after which the cord is wound into a package while still wet and subjected to the high frequency alternating current field as above described. Alternatively, 3 of the groups of 4 yarns prepared with the aforementioned 14 turns of Z-twist may be formed into a cord by wet twisting them with 10.5 turns of S-twist. Yarns of 840 denier may also be given 11.5, 13 or 14 turns per inch of Z-twist and two such yarns formed into a cord by uniting them with 11 turns per inch of S-twist, or three such yarns may be united by 10.5 turns of S-twist, the twisting in either case being effected after the yarns have been provided with at least 4% moisture. Other twist ratios may, of course, be employed depending upon the physical characteristics which are required of the cord.

It has been previously mentioned that an essential step of the method is effecting the twisting of the yarns to form the cord while the yarns are wet so as to partially relieve the unbalance stresses and to insure the proper moisture content in the wound package of the cord during the dielectric heating. The wet twisting is not, however, necessarily limited to twisting during the uniting of the yarns to form the cord since it is frequently advantageous to effect formation of the yarns by twisting the filaments while in a moist or wet condition. The moistening or wetting of either the filaments or yarns, or both, is accomplished by known methods and apparatus. The moistening agent presently preferred is water which may, however, contain a wetting or penetrating agent.

Linear polyamide cords, especially those employed as reinforcements in vehicle tires, are frequently heated to a temperature near the melting point while the cord is under tension to reduce elongation or growth of the cord. In order to lessen the danger of damage to the cord during such treatment it has been proposed to protect the cord with a substance which retards oxidation and other deleterious effects of heating which are generically termed heat degradation. The provision of such a substance is especially important when the cord is formed of the polyamide known as "Perlon" which is a form of nylon derived from caprolactam and is identified as "nylon 6—6" or simply as nylon. Cords made in accordance with this invention can be provided with a heat degradation resisting substance by incorporating it in the liquid employed for moistening the yarns in the form of a solution or dispersion therein and in a quantity such as to provide a deposit of the substance on the cord of from 0.1% to 10.0% depending upon the effectiveness of the substance employed. A deposit in the order of 0.3% to 3.0% is preferred, however, and hence substances requiring a larger deposit for effective action are not ordinarily employed. The heavier deposits are not favored not only because of cost considerations but also because proper adhesion of the cord to the elastomer in which the cord is incorporated is made more difficult.

Substances capable of reducing or preventing heat degradation of linear polyamides are known to those skilled in the art of textile treatment and hence need not be here listed in detail. In general, these substances are also standard anti-oxidants or age resistors for rubber such as the aromatic amines, representative of which are phenyl-beta-naphthylamine, reaction products of acetone

with aniline, diphenylamine and the like, alkylated diphenylamines such as heptylated diphenylamine, and the non-staining anti-oxidants including the alkylated phenols and related polyhydroxyl aromatic compounds and their sulfides, di-tert-butylhydroquinone, akyl and aryl ethers of hydroquinone, reaction products of styrene and bisphenol A and the like, tri-phenyl phosphite and other similar materials as are well-known to those skilled in the art.

Incorporation into a linear polyamide cord of a substance preventing heat degradation is particularly desirable during the wet twisting step since there is greater likelihood that the surface of each filament will be provided with a sufficient quantity of the substance than would be the case if the addition were made to the melt from which the filaments are formed or when the substance is provided as a coating for the completed cord. Moreover, although the preferred temperature of the cord during the dielectric heating step is not sufficient to damage the cord, the presence of the anti-oxidant or age-resistor in the cord package during this heating, as the result of incorporating it during the wet-twisting, insures against damage should the temperature of the cord rise above the desired value because of some inadvertence or accident.

Although the invention has been described with particular reference to making cords from linear polyamides such as "nylon 6—6" and "nylon 6," it will be recognized that the improved method is not limited to use with such materials but may be utilized in making cords formed from other compositions of similar nature. It will also be apparent that, although all cords specifically mentioned herein have been those in which the yarns have a Z-twist and the several yarns forming the cord are given an S-twist, the improved method may be employed with equal efficiency in making cords wherein the yarns have an S-twist and are united into a cord by a Z-twist. In short, the method can be employed to produce cords of lesser liveliness and/or unbalance than those of like twists but which are formed without wet twisting and dielectric heating of the moist cord package. In view of these and other adaptations and variations of the method, which will be readily apparent to one skilled in the art, the invention is not to be considered as limited to the exact details herein described for the specific examples except as may be required by the spirit and scope of the subjoined claims.

Having thus described the invention, I claim:

1. The method of producing a substantially balanced cord from twisted synthetic filamentary material that exhibits the property of appreciable contraction when heated which comprises, twisting a cord from filaments of said material while the filaments are moist, winding the twisted cord while still moist into a package suitable for use in a creel, and subjecting the package of wound cord while still containing 4% to 10% moisture to a high frequency alternating electrical field of a magnitude and for a time interval such that the temperature of the cord does not exceed 140° F. and the twist unbalance of the treated cord does not exceed 6 twists per yard.

2. The method of producing a substantially balanced cord from twisted synthetic filamentary material that exhibits the property of appreciable contraction when heated which comprises, twisting a plurality of yarns from filaments of said material, providing the yarns with 4% to 10% moisture, twisting a plurality of the moist yarns to form a cord, winding the twisted cord while still moist into a package suitable for use in a creel, and subjecting the package of wound cord while still containing 4% to 10% moisture to a high frequency alternating electrical field of a magnitude and for a time interval such that the temperature of the cord does not exceed 140° F. and the twist unbalance of the twisted cord does not exceed 6 twists per yard.

3. The method as defined in claim 2 wherein the yarns each have from 11.5 to 14 turns of Z-twist per inch of length and are twisted together with an S-twist of 10.5 to 13 turns per inch.

4. The method as defined in claim 2 wherein the yarns each have in the order of 12 turns of Z-twist per inch of length and two yarns are twisted together with an S-twist in the order of 11 turns per inch.

5. The method of producing a substantially balanced cord from twisted synthetic filamentary material that exhibits the property of appreciable contraction when heated which comprises, twisting a cord from filaments of said material while the latter contain in the order of 4 to 10% moisture, winding the twisted cord while still moist into a package suitable for use in a creel, and dielectrically heating the package of wound cord while still containing 4% to 10% moisture for a time interval in the order of 10 minutes and at a frequency and field strength such that the temperature of the cord does not exceed 140° F.

6. The method of producing a wound package of twisted polyamide cord having a twist balance satisfactory for use in a creel which comprises, providing a plurality of twisted yarns of linear polyamide filaments containing from 4% to 10% moisture, forming a normally unbalanced cord from said yarns by twisting them together while moist until the number of turns per inch of the cord approximates but is less than the number of turns per inch of the yarns, winding the twisted cord while moist into a package suitable for use in a creel, and dielectrically heating the package of wound cord to a temperature not in excess of 140° F. while still containing 4% to 10% moisture for a period of time such that the package is not substantially distorted by heat shrinkage of the cord and the twist unbalance is reduced to an amount in the order of 3 twists per yard of cord.

7. The method of producing a package of twisted polyamide cord having a twist balance satisfactory for use in a creel which comprises, providing a plurality of yarns each containing a plurality of filaments of a linear polyamide, supplying said yarns with a moisture content in the order of 4% to 10%, twisting each moist yarn a plurality of turns per inch in one direction, forming a cord from said plurality of yarns by twisting them together while moist a plurality of turns per inch in the direction opposite to the direction of twist of the yarns, the number of turns per inch of the cord approximating but being less than the number of turns per inch of the yarns thereby producing a normally unbalanced cord, winding the twisted cords while moist into a package suitable for use in a creel, and dielectrically heating the package of wound cord to a temperature not in excess of 140° F. while still containing 4% to 10% moisture for a period of time such that the package is not substantially distorted by heat shrinkage of the cord and the twist unbalance is reduced to an amount not in excess of 6 twists per yard of cord.

8. The method as defined in claim 7 wherein the said moisture supplied to the yarns is in the form of water containing a substance which prevents heat degradation of linear polyamides.

9. The method as defined in claim 7 wherein the said moisture supplied to the yarns contains a rubber age resistor present in sufficient quantity to provide a deposit on the cord in the order of 0.3 to 3.0% of the weight of the cord.

10. The method of producing a package of twisted polyamide cord having a twist balance satisfactory for use in a creel which comprises, providing a plurality of yarns each containing a plurality of filaments of a linear polyamide, supplying said yarns with a moisture content in the order of 4% to 10%, twisting each moist yarn a plurality of turns per inch in one direction, forming a cord from said plurality of yarns by twisting them together while moist a plurality of turns per inch in the direction opposite to the direction of twist of the yarns, the number of turns per inch of the cord approximating but being less than the number of turns per inch of the yarns thereby producing a normally unbalanced cord, winding the twisted cords while

moist into a package suitable for use in a creel, enclosing the wound package in a non-metallic substantially moisture impervious cover, and dielectrically heating the package of wound cord to a temperature not in excess of 140° F. while still containing 4% to 10% moisture for a period of time such that the package is not substantially distorted by heat shrinkage of the cord and the twist unbalance is reduced to an amount in the order of 3 twists per yard of cord.

11. The method of producing a package of twisted polyamide cord having improved resistance to heat degradation and a twist balance satisfactory for use in a creel which comprises, providing a plurality of twisted yarns of linear polyamide fibers containing from 4% to 10% moisture in the form of water, the said moisture having a substance therein which retards heat degradation of the fibers with the amount of said substance being sufficient to provide a deposit on the said yarns in order of .1 to 10.0% of the weight of the yarns, forming a normally unbalanced cord from said yarns by twisting them together while moist until the number of turns per inch of the cord approximates but is less than the number of turns per inch of the yarn, winding the twisted cord while moist into a package suitable for use in a creel, and dielectrically heating the package of wound cord for a period of time and to a temperature such that the package is not substantially distorted by heat shrinkage of the cord and the twist unbalance is reduced to an amount not in excess of 6 twists per yard of cord.

12. The method as defined in claim 11 wherein the said substance is an age resistor for rubber.

13. The method of producing a package of twisted polyamide cord having improved resistance to heat degradation and a twist balance satisfactory for use in a creel which comprises, providing a plurality of twisted yarns of linear polyamide fibers containing from 4% to 10% moisture in the form of water, the said moisture having an age resistor for rubber dispersed therein in an amount which provides a deposit on the said yarns in order of 0.3% to 3.0% of the weight of the yarn, forming a normally unbalanced cord from said yarns by twisting them together while moist until the number of turns per inch of the cord approximates but is less than the number of turns per inch of the yarn, winding the twisted cord while moist into a package suitable for use in a creel, and dielectrically heating the package of wound cord for a period of time and at an energy impart such that the package is not substantially distorted by heat shrinkage of the cord and the temperature of the cord does not exceed 140° F.

14. The method of producing a package of twisted polyamide cord having improved resistance to heat degradation and a twist balance satisfactory for use in a creel which comprises, providing a plurality of twisted yarns of linear polyamide fibers with the said yarns containing from 4% to 10% moisture in the form of water, the said moisture having a substance therein which retards heat degradation of the fibers with the substance being present in an amount which provides a deposit on the said yarns in order of 0.3 to 3.0% of the weight of the yarn, twisting each moist yarn a plurality of turns per inch in one direction, forming a cord from said plurality of yarns by twisting them together while moist a plurality of turns per inch in the direction opposite to the direction of twist of the yarns, the number of turns per inch of the cord approximating but being less than the number of turns per inch of the yarns thereby producing a normally unbalanced cord, winding the twisted cords while moist into a package suitable for use in a creel, and dielectrically heating the package of wound cord for a period of time and at an energy impart such that the package is not substantially distorted by heat shrinkage of the cord and the twist unbalance is reduced to an amount not in excess of 6 twists per yard of cord.

15. The method of producing a package of twisted polyamide cord having a twist balance satisfactory for use in a creel which comprises, twisting a cord from linear polyamide filaments containing 4% to 10% moisture, winding the twisted cord while moist into a package suitable for use in a creel and weighing from 16 to 20 pounds, and subjecting the package of wound cord while still containing 4% to 10% moisture to dielectric heating for a time interval in the order of 10 to 15 minutes and with an energy input in the order of 15 k.v.a. at a frequency in the range of 9.5 to 10.5 megacycles.

16. The method as defined in claim 15 wherein the said moisture is in the form of water containing a substance which is an age resistor for rubber.

17. The method as defined in claim 16 wherein the said age resistor is present in sufficient quantity to provide a deposit on the cord in the order of 0.3% to 3.0% of the weight of the cord.

18. The method of producing a package of twisted polyamide cord having a twist balance satisfactory for use in a creel which comprises, providing a plurality of yarns of linear polyamide filaments each having a Z-twist of 11.5 to 14 turns per inch and containing 4% to 10% moisture, twisting together a plurality of the moisture containing yarns with an S-twist of 10.5 to 13 turns per inch thereby producing an unbalanced cord, winding the twisted cord while moist into a package suitable for use in a creel and weighing from 16 to 20 pounds, and subjecting the package of wound cord while still containing 4% to 10% moisture to dielectric heating for a time interval in the order of 10 to 15 minutes and with an energy input in the order of 15 k.v.a. at a frequency in the range of 9.5 to 10.5 megacycles thereby reducing the unbalance of the cord to value such that it may be used in a creel.

19. The method as defined in claim 18 wherein the said moisture contains a substance which is an age resistor for rubber, the said substance being present in sufficient quantity to provide a deposit on the cord in the order of 0.3% to 3.0% of the weight of the cord.

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