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REINFORCED RUBBER STRUCTURE AND
METHOD OF TREATING NYLON YARN
FOR USE IN MAKING SAME

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1

The present invention relates to improvements in nylon filament yarn and composite rubber structures embodying such yarn as the reinforcing element thereof.

At present, attempts are being made to utilize nylon filament yarn and fabric formed therefrom as the reinforcing element of inflatable rubber tires and the like in place of cotton or rayon yarns and fabrics because of the high tensile strength of such nylon yarns. However, nylon filament yarn elongates considerably when stressed, whereby reinforcing elements provided by such yarn and built into rubber structures permit growth of the structures beyond permissible or predetermined dimensions. Also, considerable difficulty has been encountered in adhering nylon yarn to rubber.

In order to provide for better adhesion between such nylon yarn or fabric and the rubber of the tire structure or the like and to reduce elongation of the yarn, it is customary to treat the yarn with an aqueous rubber compatible resorcin-formaldehyde-latex formulation and to then rapidly dry the yarn at temperatures well above the boiling point of water.

Such formulations have a tendency to permeate the yarn and coat the individual filaments of which the yarn is composed throughout a cross-sectional zone of the yarn extending from the yarn surface to adjacent the core of the yarn. Upon subjecting the yarn to the drying temperatures usually employed, such formulations have a tendency to cause the yarn to be embrittled by reason of the action of the resorcin in the formulation on the nylon.

Tests have indicated that such embrittlement reduces the compression-extension fatigue life of the yarn when built into the rubber structures as the reinforcing element. Also, embrittlement of the yarn makes it difficult for fabric to be woven from the yarn. Another and serious difficulty resulting from the embrittlement of the yarn is that, when the rubber structure is subjected to compression-extension forces, the bond between the nylon yarn and the rubber is impaired, whereby the nylon yarn or fabric loses its effectiveness as a reinforcing element and fails to restrict growth of the structure in the manner desired.

Accordingly, an object of the present invention is to overcome the foregoing difficulties.

Another object is to treat nylon filament yarn to render it suitable for adhesion to rubber without effecting embrittlement of the yarn, whereby the yarn is readily woven into fabric after such treatment.

2

Another object is to increase the compression-extension fatigue life of such yarn without impairing adhesion thereof to the rubber.

Another object is to pretreat the nylon filament yarn in a manner so that the yarn will thereafter be uniformly coated with the formulation for effecting adhesion to the rubber.

Another object is to pretreat such yarn in a manner so that the amount of formulation required to effect adhesion to the rubber is reduced to a minimum which results in a saving of material and a reduction in the cost of treating the yarn and which eliminates deposits of excess coating material at the interstices of the warp and filler of fabric woven from such yarn.

Another object is to provide a simple, practical and economical method of treating nylon filament yarn to accomplish the foregoing.

A further object is to provide tires, belts, hoses and other rubber structures reinforced with such treated yarn or fabric formed therefrom.

A still further object is to effect reduction in growth of inflatable tires reinforced with such treated nylon filament yarn both on initial inflation and when subjected to subsequent running temperatures.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described, or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

In accordance with the present invention, it has been found that the foregoing objects can be accomplished by providing a method of treating nylon filament yarn which generally comprises applying an aqueous dispersion of a fatty acid amide to the yarn, applying a common rubber compatible resorcin-formaldehyde-latex formulation, and then drying the yarn. Preferably, the excess of treating solution is removed before applying the formulation. In carrying out this method, the yarn may be tensioned while wet and dried under tension or the yarn may be treated without substantially tensioning the same.

The method in accordance with the invention can be applied to nylon filament yarn of all types, or cords made up of such yarn, the method being particularly adapted for treating nylon yarn or cord to be built into rubber structures to reinforce the same.

The aqueous dispersion of the fatty acid amide utilized in the present process is prepared from one or a mixture of vegetable fatty oil acids such as coconut, soya, linseed, cottonseed, rape seed

fatty acids or the like. Since these acids contain small amounts of glycerides, the softening powers of the amides are improved.

In general, the amides vary in physical properties from a wax like solid to a soft paste. The longer the carbon chain of the amide the less is the solubility.

The amide utilized in the present process is an emulsified fatty oil acid amide in the form of a soft paste which is readily dispersed in water.

The rubber compatible resorcin-formaldehyde-latex formulation to be employed herein is of the common type which is generally used in treating cords and the like to be built into tires or other rubber structures to reinforce the same. Examples of such formulations are disclosed in United States Letters Patents Nos. 2,211,951 and 2,314,998.

Any suitable apparatus may be utilized in carrying out the process or method of treating the yarn, which apparatus includes dip tanks, squeeze

chamber, was cooled and wound on a tube to form a yarn package.

The yarn treated in the foregoing described manner was built into the walls of a pneumatic rubber tire in the customary manner. This tire was inflated and was then subjected to the well known wheel test which comprises running a tire under varying loads against a cleat belt to simulate road conditions. Another inflated tire of similar construction, but having nylon filament yarn or tire cord, which was treated in the heretofore known conventional manner, built therein, was subjected to the same test.

In the following table, a comparison is made between the resulting growth of the tire tread width, the tire section width, and the tire section height of the conventional tire (identified as Example A) and the tire in accordance with the invention (identified as Example B), both before and after being subjected to the wheel test.

Example	Tread Width			Section Width			Section Height		
	Before	After	Percent Growth	Before	After	Percent Growth	Before	After	Percent Growth
A	Inches 4.85	Inches 5.1	5.15	Inches 7.75	Inches 8.1	4.50	Inches 7.3	Inches 7.54	3.30
B	Inches 4.85	Inches 5.0	3.09	Inches 7.30	Inches 7.6	4.10	Inches 7.32	Inches 7.5	2.45

rolls, a drying chamber, tensioning rolls (if the yarn is to be tensioned while being dried), and mechanism for winding the treated yarn. Since such apparatus is well known in the art, illustration and description thereof is believed to be unnecessary.

In practicing the present invention, nylon filament yarn known as 210 denier/4 ply/2 cable or 840 denier/2 ply tire cord was passed through a dip tank in which there was provided a bath of an aqueous dispersion containing about 2.2% by weight of fatty oil acid amide, and the yarn was passed between squeeze rolls to remove the excess solution so that the yarn appeared to be almost dry to the touch. The fatty oil acid amide treated yarn was then substantially immediately passed through a second dip tank containing a formulation having the following composition by weight:

	Percent
Latex	38.5
Water	53.9
Resorcin	3.8
Formaldehyde	1.9
Caustic (10% NaOH solution)	1.9

The yarn was again passed between squeeze rolls to remove the excess treating formulation. If desired, the yarn may be passed through the latter treating formulation a second time. The yarn treated in this manner was then tensioned while wet to approximately 20% of its dry breaking strength, and was passed through a drying oven while maintaining the yarn under a tension equivalent to approximately 25% of its dry breaking strength.

The oven utilized was of the heat exchanger type wherein recirculated air was heated in the yarn drying chamber of the oven to a temperature of about 400° F. This temperature in general may vary between 300° and 450° F., depending upon the size of the yarn and the processing speed, but the specific temperature applied to the yarn at intervals during the drying process may be as high as 600° F. without adversely affecting the yarn. The yarn, upon leaving the drying

In making the foregoing tests, the conventional tire A was measured for growth after running the equivalent of 2,826 miles and the tire B embodying the present invention was measured for growth after running the equivalent of 3,555 miles. In spite of the fact that tire B was tested for 729 miles more than tire A (about 25% more than tire A), tire B exhibited less dimensional growth than tire A. More specifically, the growth of the tread width, the section width and the section height of the tire B was respectively about 40%, 9% and 26% less than the growth of corresponding sections of tire A.

From the foregoing tests, it is apparent that the treating process in accordance with the invention increases the compression-extension or flex life of the yarn, in fact, the life of the yarn exceeds the useful life of the tire which may end due to failure from other causes.

It has also been found that the yarn treated according to the present process will adhere to rubber as well or better than such yarn treated in the conventional manner. The fatty oil acid amide being of the cationic type is compatible with both the nylon and the resorcin-formaldehyde-latex formulation.

It is believed that the fatty oil acid amide acts as a softener for the nylon in one or more of several ways to prevent embrittlement thereof.

First, it is believed that the fatty oil acid amide is squeezed into the core of the nylon yarn or cord under high squeeze pressure and subsequently is deposited there as the excess water is squeezed out, leaving a soft pliable mass in the core or center of the yarn or cord. When this treated yarn or cord is passed through the resorcin-formaldehyde-latex, the latter would be prevented from penetrating to the core of the yarn or cord. Therefore, a more flexible resin treated nylon cord or yarn would result.

Second, it is believed that the fatty oil acid amide forms a thin protective layer on the surface of the inner filaments. Since nylon is subject to oxidation and degradation by heat, it is felt that the thin protective layer of the fatty

acid amide will reduce this effect and therefore act to prevent embrittlement thereof.

Third, it is believed that the fatty oil acid amide acts as a plasticizer in conjunction with the resorcin-formaldehyde-latex resin to prevent embrittlement thereof.

The yarn so treated with the fatty oil acid amide acts as a plasticizer in conjunction with latex formulation is adapted to be tensioned to extend or elongate the same approximately 10% without decreasing its overall strength or its flex life. This is advantageous because the cost of nylon yarn built into tires or other structures is reduced in the same proportion as the yarn is elongated. Also, the weight of the reinforcing material in the structure is reduced to provide, for example, a tire of less weight.

Other advantages of the present invention are that tires having cords built therein, which have been treated as described herein, create less unsprung load, indicate a reduction of tire growth both on initial inflation and due to subsequent running temperatures, and indicate a reduction of the force exerted by heat on the treated nylon during curing of the tire and such heat caused by running the tire.

The term "rubber" as used herein, is intended to include all naturally occurring and artificially prepared rubber compositions.

As various changes and modifications of the invention can be made without departing from the spirit and scope of the invention and without sacrificing any of its advantages, it is to be understood that all matter herein is to be interpreted as illustrative and not in any limiting sense.

We claim:

1. The method of treating filament nylon yarn for use in composite rubber structures in a manner to resist compression-extension fatigue and thereby increase its flex life, which method comprises applying to the yarn as a pretreating step an aqueous dispersion containing about 2% by weight of an amide of a fatty oil acid, said amide penetrating the outer surface of the yarn and leaving a protective layer of said amide on the surfaces of the yarn filaments substantially throughout the yarn which serves to lubricate the yarn, and thereafter applying to the yarn in its aforementioned condition a rubber compatible resorcin-formaldehyde-latex formulation, said amide acting as a softener for said formulation in contact therewith to prevent embrittlement within the yarn and at the surface thereof, whereby the yarn is maintained pliable, and further acting to protect the yarn filaments against components of said formulation and against degradation by heat during the subsequent drying of the yarn.

2. The method of treating filament nylon yarn for use in composite rubber structures in a manner to resist compression-extension fatigue and thereby increase its flex life, which method comprises applying to the yarn an aqueous dispersion containing about 2% by weight of an amide of a fatty oil acid, squeezing the yarn to cause said

amide to penetrate the outer surface of the yarn and leave a protective layer of said amide on the surfaces of the yarn filaments substantially throughout the yarn which serves to lubricate the yarn, and immediately thereafter applying to the yarn in its aforementioned condition a rubber compatible resorcin-formaldehyde-latex formulation, said amide acting as a softener for said formulation in contact therewith to prevent embrittlement within the yarn and at the surface thereof, whereby the yarn is maintained pliable, and further acting to protect the yarn filaments against components of said formulation and degradation by heat during the subsequent drying of the yarn.

3. The method of treating yarn according to claim 2, wherein said yarn is subjected to a temperature of at least 300° F. but not exceeding about 600° F. for a sufficient duration to dry the same.

4. The method of treating yarn according to claim 3, wherein the yarn is dried while tensioned.

5. A filament nylon yarn for use in composite rubber structures treated in accordance with the method set forth in claim 1, said yarn being characterized in that it is capable of resisting compression-extension fatigue to thereby increase its flex life.

6. Rubber tires and similarly reinforced rubber structures containing, as the reinforcing element therein, a plurality of nylon filament cords treated in accordance with the method set forth in claim 1, said cords having a protective layer of an amide of a fatty oil acid on the surfaces of the filaments substantially throughout the cross-section of said cords and having a coating of a rubber compatible resorcin-formaldehyde-latex formulation on the outer surface thereof serving to adhere said cord to the rubber structure, said amide serving to lubricate the filaments throughout said cords and acting as a softener for said formulation in contact therewith to prevent embrittlement within the cord and at the surface thereof and further acting to protect the filaments against components of said formulation and against degradation by heat, said cords being thereby maintained pliable and being capable of resisting compression-extension fatigue to increase the flex life thereof and serving to inhibit dimensional growth of the reinforced structure whereby the useful life thereof is prolonged.

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