High Tenacity Low Extensible Nylon 6.6 Cord

A two or three-ply nylon 6.6 cord having the breaking elongation of 8 to 12% and tenacity of which is minimum 9g/dtex is used as tire reinforcement, in particular as cap ply spirally wound on belt package with 0° to 5° to the equatorial plane of the radial pneumatic tire.
DESCRIPTION

HIGH TENACITY LOW EXTENSIBLE NYLON 6.6 CORD

Field of the invention

This invention relates to two and three-ply nylon 6.6 cords having improved properties, more particularly with reduced extensibility and increased tenacity as cap ply reinforcement in pneumatic radial tires.

Background of the invention

It is well known that cap ply reinforcements spirally wound on the belt package with 0° to 5° to the equatorial plane of the tire improves performance and high speed durability of the tire. Nylon 6.6 has been using widely for several years as cap ply due to its high restraining force at high speed conditions, preventing or reducing tire growth and belt edge separations.

In US 4,284,117, belted pneumatic tires characterized by improved tread reinforcing breaker constructions are disclosed. In such applications, the cap ply is disposed directly on the radially outermost belt ply of the tire. Since the cap ply is formed from single twisted yarns rather than cords, the cap ply is thinner than conventional cap plies, has superior flexibility and heat dissipation characteristics. The textile yarns are oriented at a 0° angle to the median equatorial plane of the tire. In this patent exists no information about material properties.

In US 3,849,976 high strength, high modulus and low heat shrinkage nylon 66 cord has been disclosed as tire reinforcement. In such applications nylon 6.6 cord has L5 modulus higher than 60g/d.100% (54g/dtex.100%) . But such cords have relatively low heat shrinkage (less than 4%) to generate sufficient shrinkforce to compensate the modulus-drop of the cap ply.
cord at high speed temperatures of the crown area in the tire and too stiff for sufficient bending fatigue resistance.

In US 3,850,219 and US 3,960,628 nylon cap ply has been mentioned, but no information on tensile and thermal properties of the cord is given.

In US 5,115,853 low-denier (420dx2) nylon cords having maximum 7tpi (276tpm) twist have been disclosed as cap ply. The cap ply (overlay) cord have an elongation at break of 15% to 20%. The heat shrinkage properties of the cap ply cords are not mentioned.

In US 5,908,520 and US 6,609,552 single twisted nylon 66 yarns have been disclosed as cap ply in tire.

Summary of the invention

Nylon 6.6 cap ply reinforcements spirally wound on the belt package in high performance tires improve high speed durability and handling characteristics. Nylon 6.6 cap ply cords generate restraining force against tire growth under high speed conditions due to centrifugal force caused by heavy belt package and tread.

In principle, the three important cord parameters enhancing the restraining force are:

1- Modulus or LASE
2- Shrinkforce at high speed crown area temperature of the tire
3- Residual tension of cap ply cords in tire

All of the three parameters affecting the restraining force of the cap ply cords are controlled dominantly by elongation at break value of the nylon 6.6 cord for a constant cord twist. Higher cord stretching at high temperature during heat-setting process generally results in
reduced elongation at break, but at the same time increased modulus and thermal shrinkforce. Due to the lifting process during curing process of the tire higher modulus cap ply cords generates higher tension upon diameter expansion. According to the invention, the cap ply cords having elongation at break values of 8% to 12% give enhanced tire performance. The modulus (including initial modulus too) and thermal shrinkforce nylon 6.6 cords having higher than 12% elongation at break value are not sufficiently high enough, that's why cap ply layer contain high amount of nylon 6.6 (two or three layers) which cause significant level of flatspotting in tire. When the elongation at break value is less than 8%, the nylon 6.6 cap ply cords become too stiff for sufficient bending and compression fatigue resistance.

**Detailed description of the invention**

The cap ply layer comprising nylon 6.6 cords arranged side by side at 0° to 5° with respect to the equatorial plane of the tire, each of said cords consisting of two or three yarns twisted together and each cap ply cord has minimum 9 grams/dtex (10g/denier) tenacity and elongation at break value of 8% to 12%. The tensile properties are determined according to ASTM D885 but cords are not allowed to absorb moisture from the testing environment by treating it hydrophobic substances like liquid oils. The maximum allowable moisture content of the cord during testing is 0.5%. Such cord properties means, in case of 8 to 12% elongations, cords exert their maximum resistance (minimum 9g/dtex) against tire growth before breaking. The shorter or reduced breaking elongation means also higher modulus and LASE values than conventional nylon cords having 15 to 25% elongation at break values. In order to obtain such properties, the cords are stretched in heat-setting ovens minimum 25% at 250 to 260°C in 5 to 30 seconds exposure times. High level orientation of the nylon 6.6 molecules during hot stretching process increases also breaking strength (tenacity) of the cords. Such cords
having high molecular orientation due to high stretching at high temperatures have also heat
shrinkage values of 7,0 to 8,5% according to ASTM D885(under 0,05gram/denier or 0,045g/dtex cord pretension, after exposing two minutes to 177°C in Testrite shrinkage measuring apparatus) According to the invention, preferred total linear density of the cords is from 400dtex to 5,000dtex. According to the invention, the twist factor of the cords is from 5,000 to 15,000 which can be calculated according to the following formula:

\[ \text{TWIST FACTOR} = \text{twist(tpm)} \times \frac{V(\text{total nominal cord dtex})}{V} \]

**Definitions:**

**Cap ply:** A belt reinforcing layer placed between tread and top layer of the belt package.

**Cord:** Means a cable formed by twisting together two or more plied yarns

**Denier:** The weight in gramms per 9,000meters(unit for expressing linear density)

**Dtex:** The weight in gramms per 10,000meters(unit for expressing linear density)

**Equatorial plane(EP):** The plane perpendicular to the tire `s axis of rotation and passing through the center of its tread.

**Heat-set cord linear density:** Real linear density determined by weighing sample cord including adhesive dip layer on it.

**LASE:** Load at specified elongation

**L5 Modulus:** The load required to stretch the cord by 5% multiplied by 20 and divided by cord denier or dtex.

**Modulus:** Stress divided by strain, resistance to deformation
**Nominal cord linear density:** Sum of the initial yarn linear densities of the cord (e.g. 1880 dtex for 940x2 cord construction)

**Radial tire:** A belted or circumferentially restricted pneumatic tire in which the body ply or carcass cords which extend from bead to bead are laid at cord angles between 65° and 90° with respect to the equatorial plane of the tire.

**Restraining force:** The force applied by cap ply cords on belt package to resist centrifugal force generated under high speed conditions.

**Tenacity:** Breaking force divided by cord linear density (as g/dtex or g/denier)

**tpm:** Number of turns per meter
CLAIMS

1- A two-ply or three-ply cord in which each individual ply consists essentially of a polyamide 6.6 yarn initially pretwisted in one direction and in which the individual plies are finally twisted together in the opposite direction to form the finished cord is characterized that,

- it has an elongation at break of 8% to 12% determined by ASTM D885, but with maximum 0.5% moisture content,

- it has minimum 9g/dtex(10g/denier) tenacity based on real linear density of the cord

2- The heat shrinkage of the said cord in claim-1 is higher than 7.0% and less than 8% determined at 177°C with 0.045g/dtex pretension after 2 minutes exposure time in heating zone of Testrite shrinkage apparatus.

3- The nominal cord linear density of the said cord in claim-1 is 400 to 5,000dtex

4- The twist factor of the said cord in claim-1 is between 5,000 and 15,000

5- The said cord in claim-1 is used as tire reinforcement, preferably as cap ply in tire which is circumferentially wound on belt package with 0 to 5° to equatorial plane of tire.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
INV. D92G3/48
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC.

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
D02G B50C D01 F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electoral database consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>paragraph s [0029] - [0031], [0039], [0046], [0060], [0066], [0073] ; table 1</td>
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Further documents are listed in the continuation of Box C. See patent family annex.

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
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"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
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Date of the actual completion of the international search
31 March 2016

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