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Steel cord for reinforcing a rubber product and pneumatic tire using the same
Stahlseil zur Verstärkung eines Gummiartikels und solche Stahlseile aufweisender Luftreifen
Câble d’acier pour le renforcement d’un article en caoutchouc et pneumatique comportant de tels câbles

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References cited:
GB-A- 1 034 328

- PATENT ABSTRACTS OF JAPAN vol. 8, no. 64 (M-285) [1501], 27 March 1984 & JP 58 214403 A (SUMITOMO GOMU KOGYO K.K.)

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BACKGROUND OF THE INVENTION

Field of the Invention:

[0001] The present invention relates to a steel cord that is used as a reinforcing material for rubber products such as belts for industrial use, and also to a pneumatic tire using such a steel cord.

Discussion of Related Art:

[0002] Conventionally, steel cords have been embedded within rubber products so as to reinforce them. However, when a fissure is formed in a rubber product, water or the like may enter the rubber product and penetrate in the longitudinal direction of the cords, resulting in the expansion of corrosion along the cords. In order to overcome this problem, steel cords are required to allow rubber to penetrate into the interior of the cords.

[0003] For steel cords of a multilayer structure having two or more layers including a core, the following three types of cords have been proposed so as to improve the rubber penetration property.

  (1) Open twist cord in which filaments are excessively formed so that clearances remain between the filaments.
  (2) Cord in which the number and diameter of sheath strands are determined based on the diameter of the core strand so that clearances remain between the seath filaments.
  (3) Cord that has an improved structure such as 1 x 2, 2 + 2, 4 x 2, etc.

[0004] Furthermore, EP 0 040 877 A1 refers to a metal wire cord having strands with parallel filaments consisting of one or more outer strands wound around a core strand wherein the strands comprise two or more filaments and wherein at least the outer strands are laid without torsion, i.e. their filaments are not twisted to one another or are twisted with a substantially infinite pitch or length of lay.

[0005] Patent Abstracts of Japan, vol. 8, No. 64 (M-285)[1501], 27.03.84 discloses a steel cord which is constituted of four first filaments and one strand which is in turn constituted of two second filaments.

[0006] However, it is difficult for cords (1) and (3) to provide sufficient strength. Therefore, although these cords have been used in small tires as a reinforcing layer for protecting the inner layer from external damage, these cords are not suitable for reinforcing layers of medium or large tires. Although cord (2) easily provides sufficient strength, the filaments tend to be disposed unevenly, so that in some cases penetration of rubber becomes instable.

[0007] Meanwhile, a compact cord formed by twisting strands in the same direction at the same pitch has a merit of high productivity. However, when the compact cord is used as a reinforcing material for a rubber compound material, it becomes difficult for rubber to penetrate into the interior of the cord. Therefore, when such a compact cord is used in tires, there is a possibility that element wire that does not adhere to the rubber comes out of the cord (walking wire), thus causing a puncture.

[0008] To solve the above-described problem, there has been proposed an improved compact cord in which the diameters of strands forming a cord are determined such that clearances are formed between the element wires, thereby allowing rubber to penetrate into the interior of the cord.

[0009] This cord having an improved rubber penetration property can solve the problem of walking wire. However, since the penetration of rubber is not perfect, it cannot prevent water or the like from penetrating in the longitudinal direction of the cord, which would cause expansion of a corroded area.

SUMMARY OF THE INVENTION

[0010] An object of the present invention is to provide a steel cord of a multilayer structure or a compact structure that provides an excellent rubber penetration property, excellent resistance to expansion of corrosion, and excellent resistance to buckling fatigue, even though the above structures usually make it difficult for rubber to penetrate into the interior of the cord.

[0011] Another object of the present invention is provide a pneumatic radial tire that uses the above steel cord so as to enhance durability and to decrease the weight of the tire.

[0012] In order to achieve the above objects, the present invention provides a steel cord for reinforcing a rubber product which has a multilayer structure consisting of two or more layers including a core, or a structure consisting of seven or more strands twisted in the same direction at the same pitch. In the steel cord, at least one of three strands that are successively adjacent to one another or that are in mutual contact is formed of two filaments that are paired substantially parallel to each other. In the following description, a strand including two such filaments may be referred
to as a “double filament strand.” Each of the remaining strands is formed of a single filament, and the direction of pairing the two filaments of each strand is substantially the same over the entire length of the cord. The substantially same direction of pairing the two filaments over the entire length of the cord is illustrated e.g. in Fig. 22. Each line connecting the two adjacent filaments demonstrates that the filaments are paired parallel to each other. A, B and C in Fig. 22 indicate different locations in the longitudinal direction of the cord. It may be seen from views A, B and C in Fig. 22 that the pairing (the line connecting the filaments) remains the same over the illustrated different locations in the longitudinal direction of the cord. This results in a change of the contact positions between the strand and other element wires. Thus, portions which are not covered by the sheath strands are formed. The rubber may penetrate into these portions thereby preventing the expansion of water and the corrosion along the cords.

[0013] Preferably, each of all the strands is formed of two filaments that are paired substantially parallel to each other.

[0014] More preferably, there exists the following relationship between the diameter Dm of a filament in a single filament strand and the diameter Dd of a filament in a double filament strand:

\[
Dd \leq Dm \leq 2Dd.
\]

[0015] The present invention also provides a pneumatic tire in which a steel cord having a structure that satisfies the above-described requirements is incorporated such that the direction of pairing of the two filaments of a double filament strand becomes substantially the same as the widthwise direction of a belt layer of the tire.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

[0016]

FIGS. 1 - 4 are cross-sectional views of steel cords according to the present invention;

FIG. 5 is a cross-sectional view of a conventional steel cord having a 1+5 structure;

FIG. 6 is a cross-sectional view of a conventional steel cord having a 1+6+12 structure;

FIGS. 7 - 10 are cross-sectional views of steel cords according to the present invention;

FIGS. 11 - 20 are cross-sectional views of steel cords according to the present invention;

FIG. 21 is a cross-sectional view of a conventional compact cord including strands having different diameters; and

FIG. 22 is an explanatory view of a steel cord according to the present invention.

DESCRIPTION OF THE INVENTION AND PREFERRED EMBODIMENTS

[0017] In conventional steel cords of a 1+n structure (see Fig. 5) or 1×2+n structure, spaces into which rubber cannot penetrate are formed even when sheath strands are disposed with clearances being formed therebetween. Similarly, in a compact cord (see Fig. 21) which includes strands having different diameters and in which the sheath strands are disposed so as to form clearances therebetween, the sheath strands are disposed unevenly, so that spaces into which rubber cannot penetrate are formed. Such spaces are indicated by “a” in Fig. 5 and by “b” in Fig. 21. Since the spaces extend continuously in the longitudinal direction, portion corroded by invasion of water through a fissure expands along the cord.

[0018] In order to solve the above-described problem, in the steel cord according to the present invention, at least one of three successively adjacent strands is formed of two filaments that are paired substantially parallel to each other (see FIGS. 1, 2, etc.). Therefore, the spaces as indicated by “a” in Fig. 5 into which rubber cannot penetrate do not extend continuously in the longitudinal direction, so that rubber can easily penetrate into the cord. Alternatively, at least one of three strands that are in mutual contact has a structure similar to the above (see FIGS. 11, 12, etc.). In this case as well, rubber penetration property is improved, so that movement of water or the like is prevented, and corrosion does not expand. In FIGS. 1, 11, etc., each line connecting two adjacent filaments indicates that the two filaments have been paired parallel to each other.

[0019] In the above-described structure, since at least one strand has two filaments that are paired substantially parallel with each other and since the direction of pairing the two filaments of such strand is substantially the same over the entire length of the cord, the cord can be made flat in a predetermined orientation. Therefore, when the steel cord of the present invention is used in a belt layer of a pneumatic tire, the gauge of the belt layer can be made thinner, so that the weight and size of the product can be reduced.

[0020] Especially, in the structure shown in FIG. 1, since the sheath strands are not required to be subjected to primary twisting, productivity is high and the strength of strands is prevented from decreasing.

[0021] As described above, in the structure of the present invention, at least one of three strands that are successively adjacent to one another or that are in mutual contact is formed of two filaments that are paired substantially parallel to
each other. This structure is employed because of the following two reasons.

a) If, as shown in FIG. 4, three successively adjacent sheath strands are ordinary strands each of which consists of a single filament, spaces into which rubber cannot penetrate are formed as indicated by “b” in FIG. 4, and the spaces tend to extend continuously in the longitudinal direction of the cord, so that the rubber penetration property degrades.

b) In a cord having a structure in which all three strands are in mutual contact, the cord can be twisted in a single manufacturing step by making the filaments of at least one of the strands parallel to each other. In addition, since contact positions between the strand and other element wires change at locations in the longitudinal direction (A → B → C in FIG. 22), portions which are not covered by the sheath strands are formed, and rubber penetrates inward at such portions, thereby preventing movement of water.

[0022] In the present invention, in order to further improve the rubber penetration property, each of filaments and/or each of strands that form a cord may be formed in a wavy shape or in a spiral shape.

[0023] Also, in order to improve pairing of a cord, to make the gauge thinner, and to increase the strength, it is preferred that all the sheathes have a structure in which two filaments are paired substantially parallel with each other.

[0024] Moreover, in the present invention, from the viewpoint of strength distribution among filaments and manufacture of a cord, it is preferred that the diameter Dm of a filament in a single filament strand and the diameter Dd of a filament in a double filament strand have the following relationship:

\[ Dd \leq Dm \leq 2Dd. \]

Experiments:

[0025] Radial tires for trucks and buses having a size of 10.00 R20 and having belts formed of steel cords shown in Table 1 were experimentally manufactured, and tests were performed so as to determine resistance to corrosion expansion and resistance to buckling fatigue of each tire. The results of the tests are shown in Tables 1 through 5.

[0026] In the test for determining the resistance to corrosion expansion, a tire that had completely worn out due to traveling on bad roads, was examined so as to measure the length of a corroded portion that extended in the longitudinal direction of a cord from a cut portion in a region subjected to external damage. Among the lengths of corroded portions measured in the above-described manner, the maximum value was taken. In the test for determining the resistance to buckling fatigue, a cord was taken out of each tire that had also completely worn out and was subjected to a rotary bending fatigue test. The fatigue limit distortion obtained during the test is shown as an index in the following tables.
<table>
<thead>
<tr>
<th>Structure of cord</th>
<th>Embodiment 1</th>
<th>Embodiment 2</th>
<th>Embodiment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross section of cord</td>
<td>FIG. 1</td>
<td>FIG. 2</td>
<td>FIG. 3</td>
</tr>
<tr>
<td>Filament diameter</td>
<td>2</td>
<td>0.21</td>
<td>0.21</td>
</tr>
<tr>
<td>Pitch (mm)</td>
<td>∞ /16/30</td>
<td>∞ /16/30</td>
<td>∞ 16/30</td>
</tr>
<tr>
<td>core/first sheath/second sheath</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cord strength (kgf)</td>
<td>465</td>
<td>426</td>
<td>408</td>
</tr>
<tr>
<td>Corrosion transmission (mm)</td>
<td>15</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Resistance to buckling fatigue</td>
<td>130</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Table 2</td>
<td>Embodiment 4: 1x2 + 6x2</td>
<td>Embodiment 5: 1x2 + (2+1+2+1+1)</td>
<td>Embodiment 6: 1x2 + (2+1+2+1+1)</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Structure of cord</td>
<td>Cross section of cord</td>
<td>Filament diameter</td>
<td>Pitch (mm)</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0.28</td>
<td>∞/16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Core/first sheath/second sheath</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>273</td>
</tr>
<tr>
<td>Cord strength (kgf)</td>
<td>Corrosion transmission (mm)</td>
<td>Resistance to buckling fatigue</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>13</td>
<td>80</td>
<td></td>
</tr>
</tbody>
</table>
### Table 3

<table>
<thead>
<tr>
<th></th>
<th>Comparative embodiment 1</th>
<th>Comparative embodiment 2</th>
<th>Comparative embodiment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structure of cord</strong></td>
<td>1 + 6 + 12</td>
<td>1x2 + (2+1+1+1+2+1)</td>
<td>1x2 + (2+1+1+1+2+1) + (2+1+1+2+1+1+1+2+1+1)</td>
</tr>
<tr>
<td>Cross section of cord</td>
<td>FIG. 6</td>
<td>FIG. 10</td>
<td>FIG. 4</td>
</tr>
<tr>
<td>Filament diameter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>--</td>
<td>0.28</td>
<td>0.21</td>
</tr>
<tr>
<td>1</td>
<td>0.28</td>
<td>0.38</td>
<td>0.28</td>
</tr>
<tr>
<td>Pitch (mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>core/first sheath/second sheath</td>
<td>∞/16/30</td>
<td>∞/16</td>
<td>∞/16/30</td>
</tr>
<tr>
<td>Cord strength (kgf)</td>
<td>375</td>
<td>240</td>
<td>401</td>
</tr>
<tr>
<td>Corrosion transmission (mm)</td>
<td>200 or more</td>
<td>100</td>
<td>120</td>
</tr>
<tr>
<td>Resistance to buckling fatigue</td>
<td>105</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>Cross section of code</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Diameter of single filament (mm)</td>
<td>--</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>Diameter of each of paired filaments (mm)</td>
<td>0.21</td>
<td>0.21</td>
<td>0.21</td>
</tr>
<tr>
<td>Pitch (mm)</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Strength (kgf)</td>
<td>280</td>
<td>286</td>
<td>272</td>
</tr>
<tr>
<td>Corrosion transmission (mm)</td>
<td>15</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Resistance to buckling fatigue</td>
<td>100</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>
In the steel cord for reinforcing a rubber product according to the present invention, rubber penetrates into the interior of the cord, so that the cord can have excellent resistance to corrosion transmission as well as excellent resistance to buckling fatigue. Also, when the cord of the present invention is applied to the belt layer of a pneumatic radial tire, the weight of the pneumatic tire can be decreased.

**Claims**

1. A steel cord for reinforcing a rubber product which comprises seven or more strands, wherein at least one of three successively adjacent strands is formed of two filaments that are paired substantially parallel to each other and one of the remaining strands is formed of a single filament, characterized in that the direction of pairing said two filaments is substantially the same over the entire length of said cord.
2. A steel cord for reinforcing a rubber product which comprises seven or more strands, wherein each of all said strands is formed of two filaments that are paired substantially parallel to each other, characterized in that the direction of pairing said two filaments is substantially the same over the entire length of said cord.

3. A steel cord for reinforcing a rubber product according to claim 1 or 2, characterized in that said steel cord including seven or more strands has a multilayer structure consisting of two or more layers including a core, said core is a strand formed of two filaments that are paired substantially parallel to each other, and each layer other than said core includes three successively adjacent strands.

4. A steel cord for reinforcing a rubber product according to claim 1 or 2, characterized in that each of said seven or more strands is twisted in the same direction at the same pitch, and said three adjacent strands are disposed in a triangular pattern in which said adjacent strands are in mutual contact.

5. A steel cord for reinforcing a rubber product according to claim 3 or 4, characterized in that there exists the following relationship between the diameter Dm of a filament in a single filament strand and the diameter Dd of a filament in a double filament strand:

\[ Dd \leq Dm \leq 2 Dd. \]

6. A steel cord for reinforcing a rubber product according to claim 5, characterized in that said filament itself has a wavy shape.

7. A steel cord for reinforcing a rubber product according to claim 5, characterized in that said filament itself has a spiral shape.

8. A pneumatic tire in which said steel cord described in claim 3 or 4 is incorporated such that the direction of pairing of the two filaments of a double filament strand becomes substantially the same as the widthwise direction of a belt layer of the tire.

Patentansprüche

1. Stahlseil zur Verstärkung eines Kautschukprodukts, das sieben oder mehr Stränge umfasst, wobei mindestens einer der drei aufeinanderfolgend benachbarten Stränge aus zwei Filamenten besteht, die im wesentlichen parallel zueinander paarweise angeordnet sind, und wobei einer der verbleibenden Stränge aus einem Einzelfilament gebildet ist, dadurch gekennzeichnet, dass die Paarungsrichtung der beiden Filamente über die gesamte Länge des Seils hinweg im wesentlichen die gleiche ist.

2. Stahlseil zur Verstärkung eines Kautschukprodukts, das sieben oder mehr Stränge umfasst, wobei jeder der Stränge aus zwei Filamenten gebildet ist, die im wesentlichen parallel zueinander paarweise angeordnet sind, dadurch gekennzeichnet, dass die Paarungsrichtung der beiden Filamente über die gesamte Länge des Seils hinweg im wesentlichen die gleiche ist.

3. Stahlseil zur Verstärkung eines Kautschukprodukts nach Anspruch 1 oder 2, dadurch gekennzeichnet, dass das Stahlseil mit sieben oder mehr Strängen eine mehrlagige Struktur aufweist, die aus zwei oder mehr Lagen unter Einschluss eines Kerns besteht, wobei der Kern ein aus zwei Filamenten, die im wesentlichen parallel zueinander paarweise angeordnet sind, gebildeter Strang ist und die einzelnen Lagen, die nicht zum Kern gehören, drei aufeinanderfolgende benachbarte Stränge umfassen.

4. Stahlseil zur Verstärkung eines Kautschukprodukts nach Anspruch 1 oder 2, dadurch gekennzeichnet, dass die einzelnen Stränge der sieben oder mehr Stränge in gleicher Richtung mit gleicher Ganghöhe gedreht sind und diese drei benachbarten Stränge in einem Dreiecksmuster angeordnet sind, bei dem die benachbarten Stränge in wechselseitigem Kontakt miteinander stehen.

5. Stahlseil zur Verstärkung eines Kautschukprodukts nach Anspruch 3 oder 4, dadurch gekennzeichnet, dass die folgende Beziehung zwischen dem Durchmesser Dm eines Filaments in einem Einzelfilamentstrang und dem Durchmesser Dd eines Filaments in einem Doppelfilamentstrang besteht: Dd \leq Dm \leq 2 Dd.

7. Stahlseil zur Verstärkung eines Kautschukprodukts nach Anspruch 5, dadurch gekennzeichnet, dass das Filament selbst eine spiralförmige Gestalt aufweist.

8. Pneumatischer Reifen, bei dem das in Anspruch 3 oder 4 beschriebene Stahlseil so eingebaut ist, dass die Paarungsrichtung der beiden Filamente eines Doppelfilamentstrangs im wesentlichen die gleiche ist wie die Breitenrichtung einer Gürtellage eines Reifens.

Revendications

1. Fil carcasse en acier pour le renforcement d'un produit en caoutchouc comprenant sept torons ou davantage, dans lequel au moins un de trois torons successivement adjacents est formé de deux filaments qui sont appariés sensiblement parallèlement l'un à l'autre et l'un des torons restants est formé d'un filament unique, caractérisé en ce que la direction d'appariement desdits filaments est sensiblement la même sur l'ensemble de la longueur dudit fil carcasse.

2. Fil carcasse en acier pour le renforcement d'un produit en caoutchouc comprenant sept torons ou davantage, dans lequel chacun de tous lesdits torons est formé de deux filaments qui sont appariés sensiblement parallèlement l'un à l'autre, caractérisé en ce que la direction d'appariement desdits deux filaments est sensiblement la même sur l'ensemble de la longueur dudit fil carcasse.

3. Fil carcasse en acier pour le renforcement d'un produit en caoutchouc selon la revendication 1 ou 2, caractérisé en ce que ledit fil carcasse en acier comprenant sept torons ou davantage a une structure multicouche consistant en deux couches ou davantage comprenant une âme, ladite âme étant un toron formé de deux filaments qui sont appariés sensiblement parallèlement l'un à l'autre, et chaque couche autre que ladite âme comprend trois torons successivement adjacents.

4. Fil carcasse en acier pour le renforcement d'un produit en caoutchouc selon la revendication 1 ou 2, caractérisé en ce que chacun desdits sept torons ou davantage est torsadé dans la même direction au même pas, et lesdits trois torons adjacents sont disposés selon un motif triangulaire dans lequel lesdits torons adjacents sont en contact mutuel.

5. Fil carcasse en acier pour le renforcement d'un produit en caoutchouc selon la revendication 3 ou 4, caractérisé en ce qu'il existe la relation suivante entre le diamètre Dm d'un filament d'un toron à filament unique et le diamètre Dd d'un filament d'un toron à double filament :

\[ Dd \leq Dm \leq 2 \times Dd. \]

6. Fil carcasse en acier pour le renforcement d'un produit en caoutchouc selon la revendication 5, caractérisé en ce que ledit filament a lui-même une forme ondulée.

7. Fil carcasse en acier pour le renforcement d'un produit en caoutchouc selon la revendication 5, caractérisé en ce que ledit filament a lui-même une forme en spirale.

8. Pneumatique dans lequel ledit fil carcasse en acier est décrit dans la revendication 3 ou 4 est incorporé de telle manière que la direction d'appariement des deux filaments d'un toron à double filament devient sensiblement la même selon la largeur d'une couche de ceinture du pneu.
FIG. 6
PRIOR ART

FIG. 7

FIG. 8