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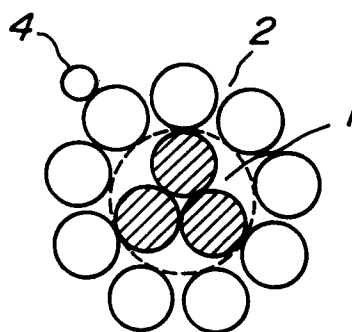
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(54) **Steel cords for reinforcement of rubber articles and pneumatic radial tires.**

(57) A steel cord for the reinforcement of rubber articles has a layer twisting structure of 1 to 4 steel filaments as a core (1) and at least one sheath layer (2,3) comprised of a plurality of steel filaments arranged around the core, and a wrap steel filament (4) spirally wound around an outermost sheath layer in the same twisting direction as in this sheath layer. Further, when such steel cords are applied to a carcass ply of a radial tire, the tire durability can be considerably improved.

FIG. 1



This invention relates to steel cords used as a reinforcement for rubber articles such as pneumatic tires, industrial belts and the like as well as a pneumatic radial tire comprising a carcass ply comprised of such steel cords and having improved durability.

As the rubber article reinforced with steel cords, tires are well-known. Among them, tires for truck and bus or for light truck generally comprise a carcass ply using cords of two or three layer construction.

It is usual that the tensile load of the steel cord lowers during the running of the tire because the sectional area of steel filaments constituting the steel cord is decreased by fretting. In this case, if the decrease of sectional area in some filaments constituting the steel cord becomes conspicuous, such filaments are apt to cause breakage against tensile shock or repetitive bending. Once these filaments are broken, tensile stress in the other filaments increases to promote fatigue breakage of the cord. Therefore, in order to increase the durability of the cord, it is required to avoid that a part of steel filaments constituting the steel cord are precedingly and prematurely broken as compared with the remaining steel filaments, and it is desirable that the tensile loads of all filaments in the cord are equally lowered.

It is, therefore, an object of the invention to improve the durability of the steel cord by equally lowering the tensile loads of the steel filaments in the steel cord due to the decrease of filament sectional area through fretting during the running when the steel cords are applied to the rubber article, particularly the carcass ply of the radial tire for truck and bus.

The inventors have made studies with respect to steel cords formed by spirally winding a wrap steel filament around the steel cord of layer twisting structure for stably preventing the lowering of tensile load in the steel filaments (filament diameter: 0.15-0.25 mm) constituting the steel cord used in the carcass ply during the running of the tire, and found that the lowering of tensile load in the steel filaments constituting the outermost layer of the steel cord is extremely large and a main factor on the lowering of tensile load is a fretting phenomenon with the wrap filament.

Furthermore, the inventors have made studies with respect to steel cords formed by removing the wrap filament, which is the main factor on the lowering of tensile load, for preventing the occurrence of fretting around the wrap filament, and confirmed that the fretting is certainly removed to control the lowering of tensile load of the steel filament, but the restraining property of the cord is poor due to the absence of the wrap filament and when the cord is excessively bent, the steel filaments constituting the cord are scattered and finally broken when abnormal force is applied to the steel filament. In the latter case, the life at break of the cord is largely decreased as compared with the cord stabilized by wrapping the cord with the wrap filament. As a result, in order to prevent the decrease of the cord life based on the application of extreme bending force, it becomes required to restrain the cord with the steel filament in any form.

Under the above circumstances, the inventors have made further studies with respect to the steel cord of layer twisting structure and discovered that it is advantageous to prevent the lowering of tensile load in the steel filaments of the outermost layer by controlling the application of abnormal force to the steel filament while maintaining the restraint of the filaments constituting the cord when a large bending force is applied to the cord and mitigating the fretting between the wrap filament and the steel filament constituting the outermost layer of the cord and as a result, the invention has been accomplished.

According to a first aspect of the invention, there is the provision of a steel cord for the reinforcement of rubber articles formed by twisting 1 to 4 steel filaments as a core and at least one sheath layer comprised of plural steel filaments arranged around the core, provided that a twisting pitch of at least one sheath layer is different from that of a remaining sheath layer adjacent thereto or that of the core, in which a wrap steel filament is spirally wound around a sheath layer located at an outermost side of the steel cord in the same twisting direction as in this sheath layer.

According to a second aspect of the invention, there is the provision of a pneumatic radial tire comprising a carcass ply of a radial structure toroidally extending between a pair of bead portions and containing steel cords therein, said steel cord being formed by twisting 1 to 4 steel filaments as a core and at least one sheath layer comprised of plural steel filaments arranged around the core, provided that a twisting pitch of at least one sheath layer is different from that of a remaining sheath layer adjacent thereto or that of the core, in which a wrap steel filament is spirally wound around a sheath layer located at an outermost side of the steel cord in the same twisting direction as in this sheath layer.

In a preferred embodiment of the invention, the wrap steel filament is wound around the outermost sheath layer at a twisting pitch of 2-6 mm. When the steel cords according to the invention are applied to the carcass ply of the pneumatic radial tire, the resistance to corrosion fatigue is improved and also the lowering of tensile load of the cord due to the fretting between the outermost sheath layer and the wrap steel filament can be controlled while maintaining the restraint of the steel filaments in the cord.

The invention will be described with reference to the accompanying drawings, wherein:

Fig. 1 is a diagrammatically sectional view of a steel cord having a layer twisting structure of 3+9+1;

Fig. 2 is a diagrammatically sectional view of a steel cord having a layer twisting structure of 1+6+12+1;
 Fig. 3 is a diagrammatically sectional view of a steel cord having a layer twisting structure of 3+9+15+1;
 and

5 Fig. 4 is a schematic view illustrating a fretting depth h .

In Figs. 1 and 2 are sectionally shown embodiments of the steel cord for the reinforcement of rubber article according to the invention having layer twisting structures of 3+9+1 and 1+6+12+1, respectively. In Figs. 1 and 2, numeral 1 is a core comprised of one or three steel filaments, while numeral 2 is a sheath layer comprised of plural steel filaments arranged adjacent to each other around the core 1. The sheath layer 2 is comprised
 10 of nine steel filaments in Fig. 1 and six steel filaments in Fig. 2. Further, a second sheath layer 3 comprised of twelve steel filaments is arranged around the sheath layer 2 in the embodiment of Fig. 2. In Figs. 1 and 2, numeral 4 is a wrap steel filament spirally wound around the outermost sheath layer in the same twisting direction as in the outermost sheath layer.

In Fig. 3 is sectionally shown a third embodiment of the steel cord according to the invention having a layer twisting structure of 3+9+15+1, in which the second sheath layer 3 comprised of 15 steel filaments is arranged
 15 around the first sheath layer 2 comprised of 9 steel filaments. As a modification of this embodiment, there is a steel cord having a layer twisting structure of 3+8+13+1.

In the layer-twisted steel cord, the ununiform lowering of tensile load in the steel filaments, particularly extremely lowering of tensile load in the steel filaments of the outermost sheath layer is due to the fact that
 20 the wrap steel filament is twisted in the direction opposite to the twisting direction of the steel filament in the outermost sheath layer. Since the twisting direction of the wrap steel filament is different from that of the steel filament in the outermost sheath layer, the contact area therebetween becomes small and the contact pressure per unit area is large.

During the running of the tire, torsion is applied to the carcass ply cord at a ground contact portion of the
 25 tire in the axial direction of the cord. When the torsional force is applied in a direction opposite to the twisting direction of the steel filament in the outermost sheath layer, if the twisting direction of the wrap steel filament is opposite to the twisting direction of the steel filament in the outermost sheath layer, torsional force is created in a direction of tightening the twisting direction of the wrap steel filament and hence a relative movement between the wrap steel filament and the steel filament in the outermost sheath layer occurs. Therefore, when
 30 such a relative movement is caused under a large contact pressure, the reduction of sectional area in the steel filament of the outermost sheath layer is promoted by the wrap steel filament and hence the tensile load of the steel filament in the outermost sheath layer lowers.

According to the invention, the twisting direction of the spiral wrap steel filament restraining the steel cord of layer twisting structure is made in the same direction as in the steel filament of the outermost sheath layer,
 35 whereby the contact area between the steel filament in the outermost sheath layer and the wrap steel filament is increased and the contact pressure therebetween is decreased. Further, even if torsional force is applied to the cord, the relative movement between the steel filament in the outermost sheath layer and the wrap steel filament reduces and hence the reduction of sectional area in the steel filament of the outermost sheath layer and the lowering of tensile load accompanied therewith are controlled. Moreover, since the steel filaments are
 40 restrained by the wrap steel filament, even when the cord is extremely bent, the steel filaments constituting the cord are not scattered and hence the breaking life of the cord is not lowered even when abnormal force is applied to a part of the steel filaments.

If the twisting direction is the same between the spiral wrap steel filament and the steel filament in the outermost sheath layer, the filament diameter may be same or different between the core and the sheath. On
 45 the other hand, if the twisting pitch of the steel filament in the outermost sheath layer is the same as that of the spiral wrap steel filament, there is caused the falling down of the wrap steel filament into the outermost sheath layer, so that it is necessary that the twisting pitch of the steel filament in the outermost sheath layer is different from that of the wrap steel filament.

Moreover, it is first possible to wind the wrap steel filament in the same twisting direction as in the steel
 50 filament of the outermost sheath layer by properly controlling the preforming ratio and torsion (residual torsional stress) of the wrap steel filament without obstructing the operability (curling after the cutting).

It is particularly preferable to apply the invention to a steel cord having a layer twisting structure of 3+8+1 in view of the cord durability. That is, when the invention is applied to rubber penetration type cords having a
 55 gap between the steel filaments in the sheath layer, if a large bending force is applied to the cord under a low internal pressure, the movement of the steel filaments becomes small because rubber penetrates into the inside of the cord and hence the resistance to cord breaking-up is improved.

The following examples are given in illustration of the invention and are not intended as limitations thereof.

Example 1

Steel cords are prepared as shown in Table 1 and applied to a carcass ply of a radial tire for truck and bus having a tire size of 11/70R22.5 14PR at an end count of 22.0 cords/5 cm. The fretting depth and cord breakage under large bending force are measured by running such a tire on a drum under the following test conditions:

Speed: 60 km/hr

Internal pressure: 8 kgf/cm² (usual running)

1 kgf/cm² (running under large bending force)

Load: JIS 100% load (usual running)

JIS 40% load (running under large bending force)

As the steel cord, there are steel cord of Comparative Example 1 having a layer twisting structure of 3+9+1 and a wrap steel filament of Z-lay (control), steel cord of Comparative Example 2 having a layer twisting structure of 3+9 and no wrap steel filament, and steel cord of Example 1 having a layer twisting structure of 3+9+1 and a wrap steel filament of S-lay according to the invention. The measured results are shown in Table 1.

Evaluation methods

(1) Fretting depth

The steel filaments of the outermost sheath layer corresponding to two cords are taken out from the tire after the running under usual conditions and broken through a tensile test. Then, the broken sections of these filaments are observed by means of a microscope to measure a fretting depth h shown in Fig. 4 when the section of the original steel filament is circle. When an average of the measured values h is a fretting depth of the cord, the fretting depth is evaluated by an index value according to the following equation:

$$\text{Index} = \frac{\text{fretting depth of test tire/}}{\text{fretting depth of control}} \times 100$$

(2) Cord breakage under large bending force

The presence or absence of cord breakage is measured by taking out the steel cords from the tire after the running over a distance of 10,000 km under the large bending force.

Table 1

	Comparative Example 1	Comparative Example 2	Example 1
Twisting structure	3+9+1	3+9	3+9+1
Twisting direction	S/S/Z	S/S	S/S/S
Twisting pitch	6.0/12.0/3.5	6.0/12.0	6.0/12.0/3.5
Filament diameter (mm)			
(1) core, sheath	0.23	0.23	0.23
(2) wrap	0.15	—	0.15
Fretting depth	100	—	8
Cord breakage	none *	presence	none *

* : no filament breakage

Example 2

Steel cords are prepared as shown in Table 2 and applied to a carcass ply of a radial tire for truck and bus

having a tire size of 11/70R22.5 14PR at an end count of 20.0 cords/5 cm. The fretting depth and cord breakage under large bending force are measured in the same manner as in Example 1 by running such a tire on a drum under the same conditions as in Example 1.

As the steel cord, there are steel cord of Comparative Example 3 having a layer twisting structure of 1+6+12+1 and a wrap steel filament of Z-lay (control), steel cord of Comparative Example 4 having a layer twisting structure of 1+6+12 and no wrap steel filament, and steel cord of Example 2 having a layer twisting structure of 1+6+12+1 and a wrap steel filament of S-lay according to the invention. The measured results are shown in Table 2. Moreover, when the core is comprised of a single steel filament, the twisting pitch of the core is considered to be infinite.

Table 2

	Comparative Example 3	Comparative Example 4	Example 2
Twisting structure	1+6+12+1	1+6+12	1+6+12+1
Twisting direction	-/S/S/Z	-/S/S	-/S/S/S
Twisting pitch	∞ /6.0/12.0/3.5	∞ /6.0/12.0	∞ /6.0/12.0/3.5
Filament diameter (mm)			
(1) core, sheath	0.20	0.20	0.20
(2) wrap	0.15	-	0.15
Fretting depth	100	-	13
Cord breakage	none *	presence	none *

* : no filament breakage

Example 3

Steel cords are prepared as shown in Table 3 and applied to a carcass ply of a radial tire for truck and bus having a tire size of 11/70R22.5 14PR at an end count of 19.8 cords/5 cm. The fretting depth and cord breakage under large bending force are measured in the same manner as in Example 1 by running such a tire on a drum under the same conditions as in Example 1.

As the steel cord, there are steel cord of Comparative Example 5 having a layer twisting structure of 3+9+15+1 and a wrap steel filament of S-lay (control), steel cord of Comparative Example 6 having a layer twisting structure of 3+9+15 and no wrap steel filament, and steel cord of Example 3 having a layer twisting structure of 3+9+15+1 and a wrap steel filament of Z-lay according to the invention. The measured results are shown in Table 3.

Table 3

	Comparative Example 5	Comparative Example 6	Example 3
Twisting structure	3+9+15+1	3+9+15	3+9+15+1
Twisting direction	S/S/Z/S	S/S/Z	S/S/Z/Z
Twisting pitch	5.5/10.5/15.5/3.5	5.5/10.5/15.5	5.5/10.5/15.5/3.5
Filament diameter (mm)			
(1) core, sheath	0.175	0.175	0.175
(2) wrap	0.15	-	0.15
Fretting depth	100	-	17
Cord breakage	none *	presence	none *

* : no filament breakage

Example 4

Steel cords are prepared as shown in Table 4 and applied to a carcass ply of a radial tire for truck and bus having a tire size of 11/70R22.5 14PR at an end count of 31.8 cords/5 cm. The fretting depth and cord breakage under large bending force are measured in the same manner as in Example 1 by running such a tire on a drum under the same conditions as in Example 1.

As the steel cord, there are steel cord of Comparative Example 7 having a layer twisting structure of 3+8+1 and a wrap steel filament of Z-lay (control), steel cord of Comparative Example 8 having a layer twisting structure of 3+8 and no wrap steel filament, and steel cord of Example 4 having a layer twisting structure of 3+8+1 and a wrap steel filament of S-lay according to the invention. The measured results are shown in Table 4.

Table 4

	Comparative Example 7	Comparative Example 8	Example 4
Twisting structure	3+8+1	3+8	3+8+1
Twisting direction	S/S/Z	S/S	S/S/S
Twisting pitch	5.5/10.5/3.5	5.5/10.5	5.5/10.5/3.5
Filament diameter (mm)			
(1) core, sheath	0.21	0.21	0.21
(2) wrap	0.15	0.15	0.15
Fretting depth	100	-	8
Cord breakage	none *	presence	none *

* : no filament breakage

As mentioned above, the steel cord according to the invention has such a layer twisting structure that the wrap steel filament is spirally wound around the outermost sheath layer in the same direction as in the steel filament of the outermost sheath layer. When such steel cords are applied to the carcass ply of the radial tire,

the fretting between the steel filament of the outermost sheath layer and the wrap steel filament is decreased and also the lowering of tensile load in the steel filaments of the cord becomes equal to improve the cord life, so that the tire durability can considerably be improved.

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Claims

1. A steel cord for the reinforcement of rubber articles formed by twisting 1 to 4 steel filaments as a core (1) and at least one sheath layer (2,3) comprised of a plurality of steel filaments arranged around the core, provided that the twisting pitch of at least one sheath layer is different from that of a remaining sheath layer adjacent thereto or that of the core, and wherein a wrap steel filament (4) is spirally wound around a sheath layer located at an outermost side of the steel cord in the same twisting direction as in the said sheath layer.
2. A steel cord as claimed in claim 1, characterized in that said wrap steel filament (4) is wound around said outermost sheath layer at a twisting pitch of 2-6 mm.
3. A steel cord as claimed in claim 1 or 2, characterized in that said cord has a layer twisting structure selected from 3+9+1, 3+8+1, 1+6+12+1 and 3+9+15+1 types.
4. A pneumatic radial tire comprising a carcass ply of a radial structure toroidally extending between a pair of bead portions and containing steel cords therein, characterized in that said steel cord is as claimed in any of claims 1 to 3.

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FIG. 1

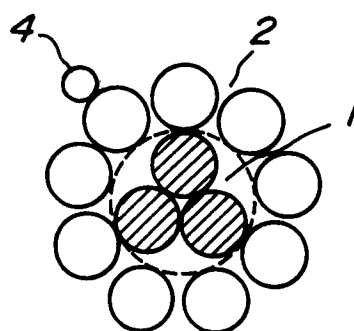


FIG. 2

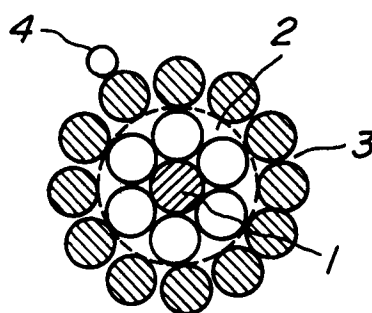


FIG. 3

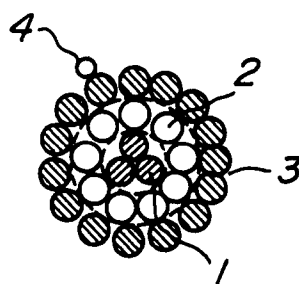
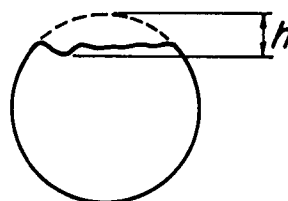


FIG. 4





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 93 30 3148

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	EP-A-0 373 595 (SUMITOMO ELECTRIC INDUSTRIES LTD.) * table 1, columns 9-10 * * figures 5,6 *	1,4	D07B1/06
A	---	2,3	
Y	GB-A-720 149 (DUNLOP RUBBER CO. LTD.) * page 2, line 62 - line 82 *	1,4	
P,X	EP-A-0 488 735 (BRIDGESTONE CORPORATION) * claims 1-3; figures 1-3 * -----	1-4	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			D07B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 22 JULY 1993	Examiner GOODALL C.J.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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