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(54) Title: LAYERED STEEL CORD WITH ALTERNATING CORE

Fig. 1a

(57) Abstract: A steel cord adapted for the reinforcement of rubber products, comprising an inner strand of at least three and no more than seven filaments twisted together in a first twist direction with a first twist step and further comprising a layer of filaments twisted around said inner strand in a second twist direction with a second twist step. One of the filaments of the inner strand is alternatingly taking the position as core filament. The alternating role of the filaments to function as core filament provides a good mechanical anchorage of this core filament in the steel cord and the outer layer provides an outer surface with a decreased roughness so that processability problems are avoided or at least reduced to a minimum.

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Layered steel cord with alternating core

Description

Technical Field

[0001] The present invention relates to a steel cord with an inner strand and a layer.

[0002] The invention also relates to a method of manufacturing such a steel cord and to the use of such a steel cord.

Background Art

[0003] For steel cords for carcass plies of conventional truck tires, generally a (1+6+12) structure wherein one core filament and six filaments as inner layer and twelve filaments as outer layer are twisted together has been used. However, if this kind of steel cord structure is used for breaker or belt ply, there has been the problem that core filament migration would happen easily.

[0004] The core filament migration problem occurs when the cord that is embedded in an elastomer, is cyclically bent. As the central filament is only held by the surrounding layer of steel filaments with relative low friction between the filaments, after repeated number of bendings, as a result of the rotating tyre, the core filament may risk protruding out of the cord and out of the rubber tire.

[0005] JP-A-08-049177 discloses a steel cord of three to six filaments where one of the filaments is alternatingly taking the position of the center. Using this steel cord as reinforcement for the belt or breaker ply of a truck tire leads to processability problems in a steelastic installation. These problems are due to the rough and unequal outer surface of the steel cord. Indeed, the rough and unequal surfaces of various cords lying closely and parallel next to each other before entering the steelastic installation, may cause sleeving or bird caging.

[0006] Besides, there are also other solutions to solve the “core migration” proposed mainly based on good rubber penetration: the rubber can reach the core and thereby fix the core filament(s) by means of the adhesion that occurs between the rubber and the adherent coating of the core filament(s). Obviously, full rubber penetration plays an important role in fixing the core filament(s) steadily compared with poor rubber penetration.

[0007] WO 95/16816 discloses a preformation on the filament. The filament is polygonally preformed to get different curve with different curvature radius perpendicular to the longitudinal axis along the length of the filament. Thus, the convex curve allows for rubber penetration between the individual filaments within a strand. The rubber penetration has improved significantly. In particular, the solution turned out to be very successful in the field of tyre reinforcement regarding fatigue improvement and corrosion prevention. Besides, the polygonally deformed filament helps to better core anchorage, further to prevent core migration and is not found in the prior art type of cords of this application.

[0008] The above techniques all aim at providing a chemical anchoring of the core filament through the adhesion mechanism with the rubber.

Disclosure of Invention

[0009] It is an object of the present invention to avoid problems of prior art.

[0010] It is a further object of the present invention to provide an alternative way for a steel cord to core migration.

[0011] It is also an object of the present invention to provide for a mechanical anchorage of the core filament.

[0012] It is another object of the present invention to avoid or at least to mitigate processablity problems.

[0013] According to the present invention, a steel cord for reinforcing rubber products comprises an inner strand of at least three and no more than seven filaments twisted together in a first twist direction with a first twist step and further comprises a layer of filaments twisted around the inner strand in a second twist direction with a second twist step; one of the filaments of the inner strand alternatingly takes the position as core filament.

[0014] The alternating role of the filaments of the inner strand to function as core filament provides a good mechanical anchorage of this core filament in the cord. In addition, the outer layer provides an outer surface with a decreased roughness so that processability problems are avoided or at least reduced to a minimum.

[0015] Viewed from an another perspective, the invention relates to a steel cord for the reinforcement of rubber products, such as a truck or bus tire, more particularly the breaker ply or belt layer in a bus or truck tire. In almost every cross-section, the steel cord has a core filament. Two to six sheath filaments surround this core filament and an outer layer of filaments surround the sheath filaments. Along the length of the steel cord, one of the two to six filaments changes its position with the core filament.

[0016] Preferably, at least one filament in the inner strand is polygonally preformed before being twisted into the steel cord for not only good rubber penetration but also better core anchorage. E.g. two or three of the filaments are polygonally preformed or all of the filaments in the inner strand are polygonally preformed.

[0017] WO 95/16816 discloses the polygonally preformed steel filament. Polygonal performing is a preformation which gives the steel filament projections on a plane perpendicular to the longitudinal central axis. The projections are in the form of curves which are convex curves with a radius of curvature alternating between a maximum and a minimum. The radius of the curvature of the preformed steel filament alternates between two extremes: a minimum at the point where the highest bending has been given and a maximum at the point where the smallest bending has been given.

[0018] A device to manufacture such a preformed steel filament comprises a body having a central axis and a circumferential surface. The body is rotatable around its central axis when a strength element is drawn over an angle of at least 90° over its circumferential surface. The circumferential surface has a radius of curvature which alternates between a maximum and a minimum so as to give to the strength element which passes over it a curve with a radius of curvature which alternates between a maximum and a minimum.

[0019] Preferably, the steel cord according to the invention consists of six filaments with at least one filament polygonally preformed in the inner strand and twelve filaments twisted around the inner strand.

[0020] Again for an excellent rubber penetration, the diameter of the filaments in the outer layer is less than or equal to the diameter of the filaments in the inner strand. The thicker inner filaments open the outer layer so that rubber can reach the inner and thereby fix the inner filaments by means of the adhesion that occurs between the rubber and the adherent coating of the inner filaments.

[0021] The second twist step of the steel cord according to the invention is different from the first twist step. In the first twist step, there is no specified core filament while in the second twist step, the inner strand acted as the core and the twelve filaments as a layer twisted around it.

[0022] Preferably, the second twist direction is the same as the first twist direction. E.g. ZZ/SS. It would significantly improve the fatigue resistance and the breaking load of the steel cord.

[0023] Preferably, each filament of the inner strand takes the position as core filament in a fixed order. I.e., each filament of the inner strand would take the position as core filament again after five other sheath filaments are all pushed in the center and went out in turn. That means each filament is exchanged from the sheath to the core one by one by the same technique and a series of substitution of the core filament is completed.

[0024] Alternatively, the order in which the filaments from the inner strand take the position of core filament, can also be at random.

[0025] According a second aspect of the invention, a process to manufacture the cord is claimed. The steps of said method comprise the standard step used for the production of single lay cords as known in the art but has been adapted with certain inventive features. A number of spools on length are provided with the steel filaments of the respective diameters on them. The filaments in the inner strand are twisted together by a rotary assembly machine. Such an assembly machine is a cabling machine (= rotary tubular machine) or a bunching machine (= double-twisting machine) that obviously has a well defined axis of rotation. The three to seven filaments are deposited towards a first cabling point thus forming an inner strand. Different with the prior art is now that one of said filaments is alternatingly pushed towards the cenAter as core filament, e.g. by varying mechanically its guiding path or by changing its unwinding tension. Such a configuration is inherently unstable as the trapped filament in the center will try to move out. Consequently, another filament acted as a sheath in the inner strand will be compelled to get into the centre thereby exchanging the core filament with a sheath filament. So the entrainment of the filament is intermitted and different filaments of the inner strand can nest on turn in the centre. In a second twist step, the filaments of the outer layer are added to this inner strand with a different lay length but with the same twist direction.

[0026] According to a third aspect of the invention, the steel cord may be used in the breaker or in the belt layer of pneumatic radial tires, and particularly useful for use in truck tires.

Brief Description of Figures in the Drawings

[0027] The invention will now be described into more detail with reference to the accompanying drawings.

[0028] Figure1a, Figure 1b, and Figure 1c show different cross sections along the length of a first embodiment of the inventive cord.

[0029] Figure 2a and Figure 2b show respectively a longitudinal view and a frontal view of a polygonally preformed filament in the inner strand according to the invention.

[0030] Figure 3a and Figure 3b show different cross sections along the length of a second embodiment of the inventive cord.

Mode(s) for Carrying Out the Invention

[0031] In a first embodiment-depicted in Figure 1a cord 20 with the following geometry was produced.

[0032] Six filaments 22 of 0.245 mm in an inner strand, three of which are polygonally preformed and which on its turn are surrounded by an outer layer of twelve filaments 24 with a diameter of 0.235 mm.

[0033] Another notation has been chosen as it turns out that certain filaments in the inner strand can not longer be identified as being on a circle. There is a filament in the inner strand interchanging between a core and a sheath. In almost every cross-section, the steel cord has a core filament 22a and five filaments (22b, 22c, 22d, 22e, 22f) surround this core filament and an outer layer of twelve filaments surround the five filaments. Figure 1a and Figure 1b and Figure 1c are cross sections from such a cord taken at different places along the cord.

[0034] The filament of a core replaces the filament of a sheath, namely, the filament which forms a core is not specified.

[0035] It is exchanged in the length direction, and one of the filaments 22 which forms the core 22a and certain filament of sheath filaments (22b, 22c, 22d, 22e, 22f) exchange the position every 3-5 cm in average in the length direction. The length of each filament goes into the centre is not affected by the lay length but could be controlled by the production process.

[0036] As one of the filaments 22a is pushed towards the center as core filament when five filaments surround the core at a lay of 14 mm. Such a configuration is inherently unstable as the filament 22a in the center will try to move out; consequently, another filament, such as 22c, will be compelled to get into the centre. Therefore, the filament 22c will take the position as core filament and the filament 22a will act as one of the sheath filaments temporarily. The filament 22c can nest on turn in the center at a length of 3-5 cm and then another sheath filament such as 22e will take the position as core filament at the same way.

[0037] A steel cord 20 with an inner strand and an outer layer according to the invention was built as follows. Starting product is a steel wire rod. This steel wire rod has following steel composition: A minimum carbon content of 0.65%, a manganese content ranging from 0.40% to 0.70%, a silicon content ranging from 0.15% to 0.30%, a maximum sulphur content of 0.03%, a maximum phosphorus content of 0.30%, all percentages being percentages by weight. A typical steel tire cord composition for high-tensile steel cord has a minimum carbon content of around 0.80 weight %, e.g. 0.78 – 0.82 weight %.

[0038] The steel rod is drawn in a number of consecutive steps until the required final diameter. In this example, the round diameter for the filaments in the inner strand is 0.245 mm and 0.235 mm for the steel filaments in the layer.

The drawing steps may be interrupted by one or more heat treatment steps such as patenting.

[0039] The steel filaments are preferably provided with a coating which promotes the adhesion to rubber or with a coating which gives corrosion resistance to the wire. A rubber adherable coating is e.g. brass; a corrosion resistant coating is e.g. zinc.

[0040] After the coating, the filaments are end drawn to their final diameter and are subjected to a twisting operation as described above.

[0041] Some further details of the steel cord 20: the diameter was 1.23 mm with a fairly high difference between maximum and minimum diameter of 0.01mm, the mass per meter was 6.52 gram/m and a breaking strength 2730 N with an elongation of 2.72% was found.

[0042] Different properties of two prior art steel cord constructions are now compared with the steel cord according to the present invention.

[0043] Prior art cord No.1 is a normal three layered structure cord 1+6+12 with core filament diameter and the inner layer diameters equal to 0.245 mm and the outer layer filaments of 0.235 mm and with no filament subjected to a special performing treatment.

[0044] Prior art cord No.2 is also a normal three layered structure cord 1+5+12 with core filament diameter and the inner layer diameters equal to 0.245 mm and the outer layer filaments of 0.235 mm and with no filament subjected to a special performing treatment.

[0045] The breaking load has been determined by a tension test.

[0046] The rubber penetration is determined by measuring the amount of air passing through a rubber block (Air permeability method). The less amount of air passing the greater the rubber penetration.

[0047] In order to determine whether there is core migration or not the steel cord is embedded in a rubber cylinder and this cylinder is then subjected to a number of repeated bendings. If the core filament slip out of the cord there is core migration, in the opposite case there is no core migration.

[0048] Most of the above-cited tests are described more in detail in the paper by Bourgois Luc, “Survey of Mechanical Properties of Steel Cord and Related Test Methods”, Tire Reinforcement and Tire Performance, ASTM STP 694, R.A. Fleming and D.I. Livingston, Eds., American Society for Testing and Materials, 1979, pp.19-46.

[0049] Table:

	Prior Art Cord		Invention Cord
	No.1 1+6+12	No.2 1+5+12	Cord 20 6+12
Diameter (mm)	1.19	1.19	1.23
Mass per meter (gram/m)	6.79	6.41	6.52
Breaking load (N)	2888	2730	2730
Elongation (%)	2.46	2.52	2.72
Rubber penetration (%)	100	75	0
Core migration	yes	yes	No

[0050] As may be derived from the table, core migration is avoided in the cord according to the invention as in prior art cord No.1 and No.2, despite of the fact that the core filament in the invention is alternatingly exchanging the position and better anchorage.

[0051] In a second embodiment, the above results were confirmed on another geometry.

[0052] Seven filaments of 0.245 mm in an inner strand, which are all polygonally preformed and which on its turn are surrounded by an outer layer of twelve filaments with a diameter of 0.235 mm.

[0053] The core filament 26a can be discerned. While originally the filaments of the inner strand are fed into the first cabling point, one of the sheath filaments 26b around the core is pushed towards the centre as core filament by varying mechanically its guiding path and the original core filament 26a is set free to act as a sheath filament. Each filament in the inner strand is circulating as the core filament in an alternating manner by the same way.

[0054] This cord had the following properties: the diameter was 1.19 mm with a fairly high difference between maximum and minimum diameter of 0.01mm, the mass per meter was 6.78 gram/m and a breaking strength 2888 N with an elongation of 2.72% was found.

[0055] Also it is obvious that such an inventive steel cord can easily avoid the core migration problem compared with the conventional steel cord construction 1+6+12.

[0056] It is to be understood that the invention is not limited to the steel cord constructions comprising only one layer around the inner strand, but that it may also be applied to constructions comprising more coaxial layers around the inner strand.

Claims

1. A steel cord comprising an inner strand of at least three and no more than seven filaments twisted together in a first twist direction with a first twist step; said cord further comprising a layer of filaments twisted around said inner strand in a second twist direction with a second twist step; one of the filaments of the inner strand alternatingly taking the position as core filament.

2. A steel cord as claimed in claim 1, characterized in that at least one filament in said inner strand has a polygonal preforming.

3. A steel cord as claimed in claim 2, characterized in that said inner strand consists of six filaments and said layer consists of twelve filaments.

4. A steel cord as claimed in claim 3, characterized in that the diameter of the filaments in said layer is less than or equal to the diameter of the filaments in said inner strand.

5. A steel cord as claimed in claim 4, characterized in that said second twist step is different from said first twist step.

6. A steel cord as claimed in claim 5, characterized in that said second twist direction is the same as said first twist direction.

7. A steel cord as claimed in claim 6, characterized in that each filament of the inner strand takes the position as core filament in a fixed order.

8. A method of manufacturing a steel cord according to one of the previous claims, said method comprising steps of:

- guiding the filaments of the inner strand towards a twisting point;
- thereby alternatingly pushing one of said filaments towards the center.

9. Use of a steel cord according to any one of the preceding claims in a breaker or belt layer of a radial truck tire.

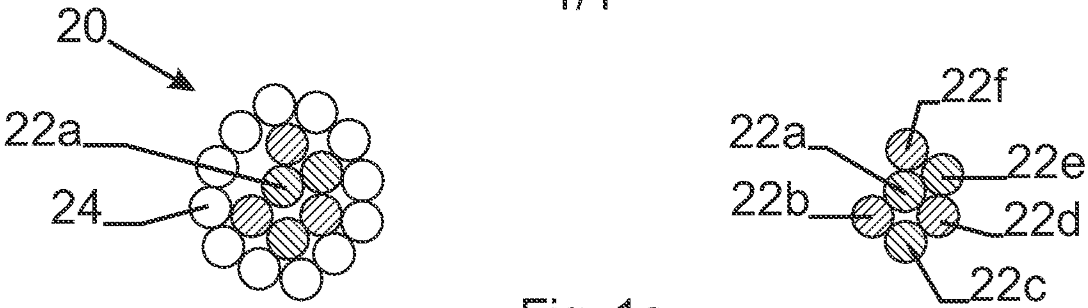

Fig. 1a

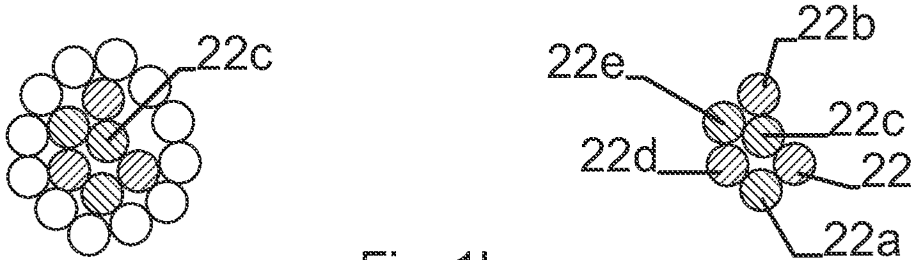

Fig. 1b

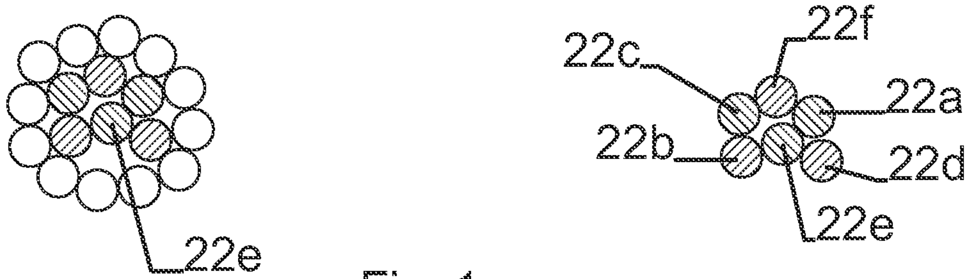

Fig. 1c

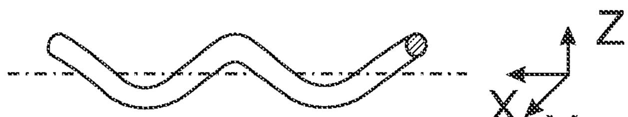

Fig. 2a

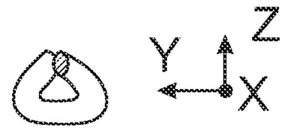

Fig. 2b

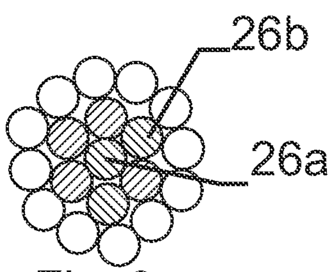

Fig. 3a

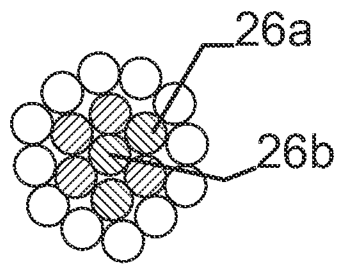

Fig. 3b