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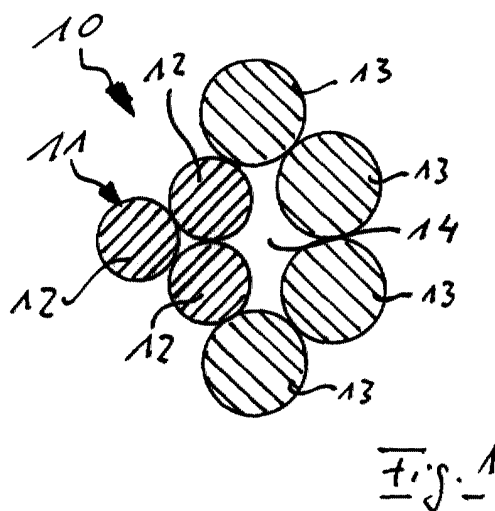
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(54) **Steel cord**

(57) The present invention relates to a steel cord (10) especially for reinforcing rubber articles. The steel cord (10) comprises at least one bundle (11) of several helically shaped filaments (12) and at least one single filament (13). In accordance with the invention the flexural strength of said at least one bundle (11) amounts to at least 50 percent or at most 150 percent of the flexural strength of said at least one single filament (13).

Preferably, the flexural strength of said bundle is between 50 and 150 percent of the flexural strength of the at least one single filament. When twisting the bundle (11) with the single filament (13) the desired helical shape of the filaments (12) of the bundle (11) is achieved automatically. It is no longer necessary to pre-shape said filaments (12) so that production of the steel cord (10) is simplified.



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Description

[0001] The present invention relates to a steel cord especially for reinforcing rubber articles, comprising at least one bundle consisting of a plurality of helically shaped filaments and at least one single filament.

[0002] A steel cord of the above mentioned kind as well as a method of its production are disclosed in WO 97/12091. The filaments of the bundle are helically pre-shaped by means of false twist. Next, one or several single filaments are wrapped around the bundle. The helical shape is necessary to avoid movement of the filaments out of the steel cord.

[0003] Similar steel cords are disclosed in US 4,022,009 and US 4,545,190. Both prior art documents teach pre-shaping the filaments of the bundle.

[0004] It is a drawback of the known steel cords and methods of production that the filaments of the bundle require pre-shaping. At least one additional step is necessary to ensure that the desired helical shape is provided.

[0005] Accordingly, it is an object of the present invention to provide a steel cord which ensures the desired helical shape of the filaments of the bundle while at the same time allowing for a simplified method of production.

[0006] In accordance with a first embodiment of the invention said object is achieved with a steel cord of the above mentioned kind in which the flexural strength of said at least one bundle amounts to at least fifty percent of the flexural strength of said at least one single filament.

[0007] In accordance with a second embodiment of the invention said object is achieved with a steel cord of the above mentioned kind in which the flexural strength of said at least one bundle amounts to at most 150 percent of the flexural strength of said at least one single filament.

[0008] Preferably, said two embodiments are combined so that the flexural strength of the at least one bundle amounts to at least fifty percent and at most 150 percent of the flexural strength of the at least one filament.

[0009] Due to the selection of the flexural strength the filaments of the bundle need no longer be pre-shaped. The desired helical shape is automatically achieved as soon as the bundle and the at least one single filament are twisted around each other.

[0010] The flexural strength of a bundle of filaments as well as of a single filament is determined in accordance with "Internationally Agreed Methods for Testing Steel Tire Cords", BISFA, The International Bureau for Standardisation of Man-Made Fibres, 1995 Edition. The disclosure of said document is incorporated by reference. Flexural strength in accordance with said document is determined by bending a bundle or single filament to be tested for a certain angle, typically 15 degrees. The torque required for bending is measured. Next, the flexural strength is determined based on the measured values. The apparatus for determining the flexural strength is referred to as Taber Stiffness Tester, and the flexural strength is accordingly expressed in Taber Stiffness Units (TSU).

[0011] The flexural strength may be mathematically calculated by the following formula:

$$\text{flexural strength (TSU)} = n * c * f * d^4,$$

with

n number of filaments of the bundle
 c conversion factor
 f material constant
 d diameter of the filaments

[0012] In order to calculate the flexural strength of a single filament the value of n is set to 1.

[0013] Advantageous embodiments of the invention read from the dependent claims.

[0014] In a first advantageous embodiment the flexural strength of said bundle exceeds the flexural strength of said at least one single filament by at most 35 percent, preferably 25 percent and more preferably 5 to 15 percent. The given values provide sufficient deformation of the bundle when twisting with the at least one single filament during production.

[0015] With respect to a second advantageous embodiment the flexural strength of said bundle substantially corresponds to or is slightly lower than the flexural strength of said at least one single filament. With said embodiment the flexural strength of the single filament may be higher than that of the bundle. Accordingly, the bundle will be deformed to a greater extent than the single filament. Therefore, the steel cord in accordance with the invention can be designed to meet the current boundary conditions.

[0016] To advantage the filaments of said bundle are combined in parallel. Said arrangement enhances the properties of the steel cord when in use.

[0017] According to a further aspect of the invention the filaments of said bundle feature the same diameter. Additionally, to advantage the steel cord comprises several single filaments featuring the same diameter, too. The diameter

of the single filaments is larger than the diameter of the filaments of said bundle in order to provide the required ratio of the respective flexural strength. The use of filaments and single filaments with only one respective diameter allows for simplification of manufacture and storage.

[0018] Advantageously said bundle and said at least one single filament are twisted around each other with a variable pitch. The pitch may vary between 6,3 and 25 mm. The properties of the steel cord in accordance with the present invention can be changed by varying the pitch. The desired helical shape of the filaments of said bundle is obtained automatically when twisting said bundle and said at least one single filament.

[0019] Advantageously the diameter of the filaments of said bundle and the diameter of said at least one single filament is between 0,15 and 0,40 mm. The filaments of said bundle as well as the single filament may be provided with a coating, especially of brass. As alternative another organic, inorganic or metallic coating may be provided which ensures proper adhesion to a surrounding rubber mixture. In many applications the filaments are drawn after the coating.

[0020] The invention will now be detailed by way of example embodiments illustrated schematically in the drawings. Like reference signs have been used for parts identical or identical in function.

Figure 1 shows a cross-section of a first embodiment of a steel cord in accordance with the invention;

Figure 2 shows a cross-section of a second embodiment of a steel cord in accordance with the invention;

Figure 3 shows a cross-section of a third embodiment of a steel cord in accordance with the invention;

Figure 4 shows a cross-section of a fourth embodiment of a steel cord in accordance with the invention; and

Figure 5 shows a schematical side view of a fifth embodiment of a steel cord in accordance with the invention.

[0021] Figures 1 to 4 show four different embodiments of a steel cord 10 in accordance with the invention in cross section. The steel cord 10 comprises a bundle 11 consisting of a plurality of helically shaped filaments 12 and several single filaments 13. The filaments 12 and the single filaments 13 feature the same respective diameter, the diameter of the single filaments 13 being larger than the diameter of the filaments 12 of the bundle 11.

[0022] A gap 14 may be formed between the bundle 11 and the single filaments 13. Said gap 14 is advantageously filled with a suitable material not shown in detail in order to prevent corrosion. A suitable material is e. g. disclosed in WO 97/12090 filed by the same applicant. As alternative one or more single filaments 13 with a non-circular, preferably flattened cross-section may be used in order to provide openings through which the gap 14 communicates with the environment. When applying rubber to the steel cord 10 said rubber may penetrate through said openings into the gap 14.

[0023] In order to manufacture the steel cord 10 the filaments 12 are combined in parallel to the bundle 11. It is not necessary to pre-shape said filaments 12. Next, the bundle 11 is twisted with the single filaments 13. The desired helical shape of the filaments 12 of said bundle 11 and of said single filaments 13 is obtained automatically. The required deformation of the filaments 12 of said bundle 11 during twisting is ensured by the ratio of the flexural strengths of the bundle 11 and each single filament 13 in accordance with the invention.

[0024] The following table details the number and the diameter of the filaments 12 used in the bundle 11 and the diameter of the single filaments 13. It depicts the ratio of the resulting flexural strengths, too.

Table

	Bundle	Single Filament	Ratio of respective Flexural Strengths
Figure 1 n*d ⁴	3 x 0,22 0,00702768	0,265 0,00493155	142,5 %
Figure 2 n*d ⁴	2 x 0,175 0,00187813	0,22 0,00234256	80,1 %
Figure 3 n*d ⁴	3 x 0,22 0,00702768	0,28 0,00614656	114,3 %
Figure 4 n*d ⁴	4 x 0,20 0,0064	0,285 0,0065975	97,0 %

[0025] Figures 1 to 4 depict the diameters cited in the above table approximately in the scale 5:1. In the embodiment according to Figure 1, the flexural strength of the bundle 11 exceeds the flexural strength of each single filament 13 by approximately 42 percent. According to Figure 2 the flexural strength of the bundle 11 is slightly lower than the flexural strength of each single filament 13. Figure 3 shows a steel cord 10 in which the flexural strength of the bundle 11 exceeds the flexural strength of each single filament 13 by approximately 14 percent. In the embodiment of Figure

4 the flexural strength of the bundle 11 substantially corresponds to the flexural strength of each single filament 13.

[0026] The ratio of the flexural strengths of the bundle 11 and each single filament may approximately be calculated by means of the formula cited at the beginning of the specification.

[0027] The ratio of the flexural strengths is

$$\frac{n \cdot c \cdot f \cdot d_1^4}{c \cdot f \cdot d_2^4} = n \cdot \left(\frac{d_1}{d_2}\right)^4$$

with

n, c, f: as above,

d₁: diameter of a filament 12 of the bundle 11,

d₂: diameter of a single filament 13.

[0028] The number of filaments 12 of the bundle 11 and the ratio of diameters d₁/d₂ may be calculated for each desired ratio of flexural strengths. With a lower value of 50 percent and an upper value of 150 percent for said ratio, it results:

$$0,5 \leq n \cdot \left(\frac{d_1}{d_2}\right)^4 \leq 1,5$$

which may be transformed to:

$$\sqrt[4]{\frac{0,5}{n}} \leq \frac{d_1}{d_2} \leq \sqrt[4]{\frac{1,5}{n}}$$

n may only be a whole number. The following table shows the ratio of diameters d₁/d₂ for values of n running from 2 to 5 and the above mentioned range from 0,5 to 1,5 for the ratio of the flexural strengths:

n	d ₁ /d ₂
2	0,707 - 0,930
3	0,639 - 0,841
4	0,595 - 0,783
5	0,562 - 0,740

[0029] Depending on the boundary conditions the ratio of diameters d₁/d₂ and/or the number n of filaments 12 of bundle 11 may be calculated from the above formulas. The ratio of the flexural strengths may, accordingly, be set as desired.

[0030] Figure 5 shows a schematic side view of a further embodiment of a steel cord 10 in accordance with the invention. The bundle 11 consists of four filaments 12. There is provided only one, comparatively thick filaments 13. The filaments 12 are combined in parallel to the bundle 11 and subsequently twisted with the single filament 13 with a pitch S. Said twisting automatically provides the desired helical shape of the bundle 11 and its filaments 12 as well as of the single filament 13. The pitch S may vary between 6,3 and 25 mm.

[0031] The steel cord 10 in accordance with the invention allows the use of filaments 12 without pre-shaping due to the special ratio of the flexural strengths. The previously required step of pre-shaping may be omitted.

Claims

1. Steel cord, especially for reinforcing rubber articles, comprising at least one bundle (11) consisting of a plurality of helically shaped filaments (12) and at least one single filament (13), **characterized in that** the flexural strength of said at least one bundle (11) amounts to at least 50 percent of the flexural strength of said at least one single filament (13).

2. Steel cord, especially for reinforcing rubber articles, preferably according to claim 1, comprising at least one bundle (11) consisting of a plurality of helically shaped filaments (12) and at least one single filament (13), **characterized in that** the flexural strength of said at least one bundle (11) amounts to at most 150 percent of the flexural strength of said at least one single filament (13).
3. Steel cord according to claim 1 or 2, **characterized in that** the flexural strength of said bundle (11) exceeds the flexural strength of said at least one single filament (13) by at most 35 percent, preferably 25 percent and more preferably 5 to 15 percent.
4. Steel cord according to claim 1 or 2, **characterized in that** the flexural strength of said bundle (11) substantially corresponds to or is slightly lower than the flexural strength of said at least one single filament (13).
5. Steel cord according to any of claims 1 to 4, **characterized in that** the filaments (12) of said bundle (11) are combined in parallel.
6. Steel cord according to any of claims 1 to 5, **characterized in that** the filaments (12) of said bundle (11) feature the same diameter.
7. Steel cord according to any of claims 1 to 6, **characterized in that** the steel cord (10) comprises several single filaments (13) featuring the same diameter.
8. Steel cord according to any of claims 1 to 7, **characterized in that** said bundle (11) and said at least one single filament (13) are twisted around each other with a variable pitch (S).
9. Steel cord according to claim 8, **characterized in that** the pitch (S) is between 6,3 and 25 mm.
10. Steel cord according to any of claims 1 to 9, **characterized in that** the diameter of the filaments (12) of said bundle (11) and the diameter of said at least one single filament (13) is between 0,15 and 0,40 mm.

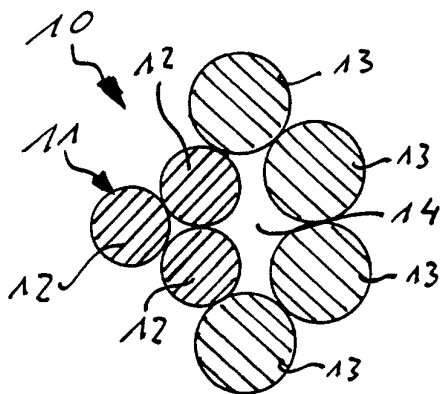


Fig. 1

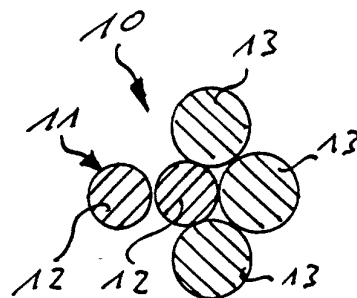


Fig. 2

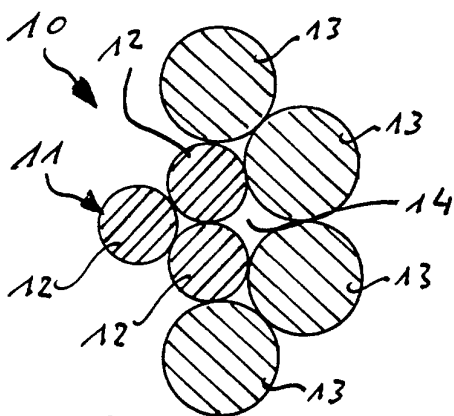


Fig. 3

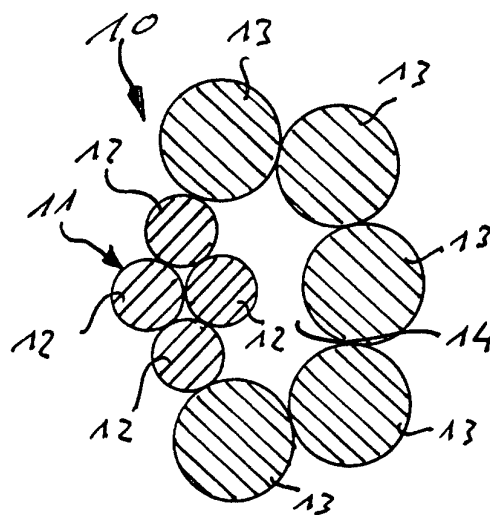


Fig. 4

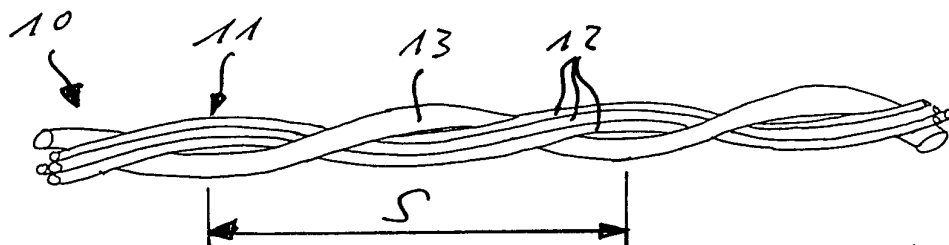


Fig. 5



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 00 11 2909

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.7)
D,X	WO 97 12091 A (DRAHTCORD SAAR GMBH & CO KG) 3 April 1997 (1997-04-03) * page 8, line 10 - page 10, line 11 *	1,2,5-10	D07B1/06
D,X	US 4 022 009 A (L. VAN ASSENDELFT) 10 May 1977 (1977-05-10) * column 3, line 14 - line 40 * * column 4, line 20 - line 29 *	1,5,6, 8-10	
A	---	2	
D,X	US 4 545 190 A (G.W. RYE; K.J. PALMER) 8 October 1985 (1985-10-08) * column 1, line 46 - column 2, line 47 *	1,5,6, 8-10	
A	---	2	
X	US 4 506 500 A (T. MIYAUCHI; O. YONEDA) 26 March 1985 (1985-03-26) * column 3, line 13 - line 18 *	2,6,8-10	D07B
A	-----	1	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 7 November 2000	Examiner Goodall, C
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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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

07-11-2000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9712091 A	03-04-1997	DE 19535598 A	27-03-1997
		AT 187512 T	15-12-1999
		BR 9610722 A	13-07-1999
		CA 2232549 A	03-04-1997
		CN 1202942 A	23-12-1998
		CZ 9800892 A	15-07-1998
		DE 59603883 D	13-01-2000
		EP 0852634 A	15-07-1998
		ES 2142610 T	16-04-2000
		JP 11512787 T	02-11-1999
		SK 36998 A	14-02-2000
		US 6076344 A	20-06-2000
US 4022009 A	10-05-1977	NL 7505523 A	16-11-1976
		NL 7505524 A	16-11-1976
		AT 343014 B	10-05-1978
		AT 338576 A	15-08-1977
		BE 841724 A	01-09-1976
		BR 7602912 A	23-11-1976
		CA 1042739 A	21-11-1978
		DE 2619086 A	25-11-1976
		ES 447638 A	01-11-1977
		FR 2311138 A	10-12-1976
		GB 1524094 A	06-09-1978
		IE 42594 B	10-09-1980
		IT 1059752 B	21-06-1982
		JP 1198907 C	21-03-1984
		JP 52005357 A	17-01-1977
		JP 58031438 B	06-07-1983
		LU 74913 A	14-01-1977
		SU 1170976 A	30-07-1985
		US 4030248 A	21-06-1977
		YU 110776 A	31-10-1982
US 4545190 A	08-10-1985	BR 8404554 A	06-08-1985
		CA 1238248 A	21-06-1988
		DE 3479596 D	05-10-1989
		EP 0138731 A	24-04-1985
		JP 2004384 B	29-01-1990
		JP 60087940 A	17-05-1985
US 4506500 A	26-03-1985	JP 1337104 C	11-09-1986
		JP 58180690 A	22-10-1983
		JP 61001552 B	17-01-1986
		JP 1517351 C	07-09-1989
		JP 58191608 A	08-11-1983

EPO FORM P0459

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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07-11-2000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4506500 A		JP 63066958 B	22-12-1988
		JP 1517352 C	07-09-1989
		JP 58191609 A	08-11-1983
		JP 63066959 B	22-12-1988

EPO FORM P0459

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