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(54) **Cable for wire saw**

(57) A cable (10) for wire saw comprises a multi-strand steel cord (20) wherein the steel cord (20) is coated with a second polymer material (30). The steel cord (20) comprises at least one core strand (40) and plurality layer strands (50), while the core strand (40) is coated with a first polymer material (60) before the construction of the steel cord (20). The fine polymer coatings (60,30)

on the core strand and the steel cord not only prevent the corrosive and abrasive cooling water from entering into the cable, but also maintains the flexibility of the cable to endure the constant change bending load during the sawing operation. A wire saw and a spring loaded diamond bead wire saw comprising a cable incorporating present invention are also provided.

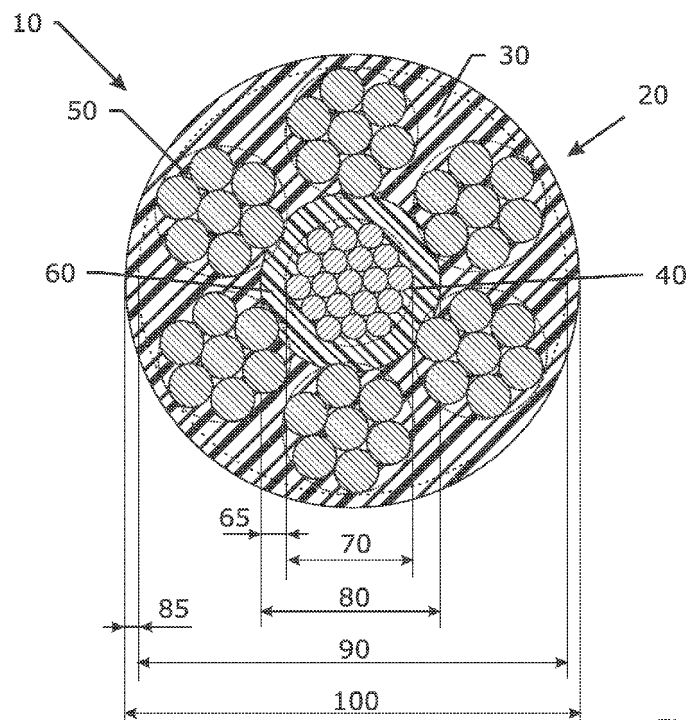


Fig. 1

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Description

Technical Field

5 **[0001]** This invention relates to a cable for wire saws cutting marble, granite, or other natural hard stones, as well as manmade materials. The invention also relates to the use of such a cable in a wire saw and to a wire saw comprising such a cable.

Background Art

10 **[0002]** US2773495A discloses a cable variety stone cutting saw comprising (1) an endless flexible cable which is adapted to be trained around and supported by a pair of spaced apart pulleys with circumferentially grooved rims or peripheries; (2) a plurality of centrally apertured cutting elements which are loosely mounted on the cable in spaced apart relation; and (3) a plurality of spiral compression springs which are mounted on the cable between the cutting
15 elements and serve to space the elements apart while at the same time permitting them to slide to a limited extent lengthwise of the cable during a stone cutting operation. However, this technology suffers two drawbacks. Firstly, the process to construct the endless flexible cable is too complex and time-consuming. Secondly, the cable exposes to the contaminated cooling water and grit during the sawing process, and the corrosive and abrasive effect of the cooling water and grit accelerates the fractures on the cable.

20 **[0003]** To deal with the above mentioned drawbacks, EP0339439A further discloses an improved cable for wire saw. Firstly, the ends of the cable are provided with catches, which fit to each other, to form an endless cable for a wire saw. Secondly, the steel cord is provided with a first plastic coating from soft flexible plastic in order to provide the base material a protective layer. Besides, the gaps between the cutting elements are filled with a second hard and wear resistant plastic coating. However, the double-coating structure leads to a hard and in-flexible cable, which breaks under
25 the constant change bending load during the sawing process.

Disclosure of Invention

30 **[0004]** It is an objective of the present invention to eliminate the drawbacks of the prior arts. It is also an objective of the present invention to provide a cable for wire saw which not only has plastic coating to prevent the corrosive and abrasive cooling water from entering into the cable, but also maintains the flexibility of the steel cord to endure the constant change bending load during the sawing process.

[0005] According to the present invention, a cable for wire saw is provided comprising multi-strand steel cord wherein the steel cord is coated with a second polymer material. The function of this polymer material is to limit the exposure of
35 the steel elements in the cable to cooling water and to grit.

[0006] The cable as subject of the invention comprises at least one core strand and plurality layer strands, and the core strand is coated with a first polymer material before the construction of the steel cord.

[0007] The thickness of the second polymer coating of the cable is less than 1 mm, and preferably less than 100 μ m. The optical diameter of the steel cord used to provide a cable as subject matter of the present invention is the diameter
40 of the smallest imaginary circle, which encircles a radial cross section of the steel cord. The optical diameter of the cable of the present invention is the diameter of the smallest imaginary circle, which encircles a radial cross section of the cable. Therefore, the thickness of the polymer is defined as the half of the difference of the optical diameter between the cable and the steel cord. Accordingly, the thickness of polymer on the core strand is defined as the half of the difference of the optical diameter between the core strand and the polymer-coated core strand. The thickness of the first
45 polymer coating of the core strand is less than 1 mm, and preferably less than 100 μ m.

The reason of the limited thickness is to facilitate beads of abrasive material sliding over the cable without having to adapt the inner diameter of these beads.

[0008] The first polymer material for the core strand is preferably either polyamide or polyurethane, while the second polymer material for the steel cord can preferably be either polyurethane or polyester.

50 **[0009]** The core strand can be a 1+6+12 strand, or a 3+9 strand, or a 3+9+15 strand, while the layer strands can be a 7x1 strand, or a 3+9 strand, or a 1+6+12 strand.

[0010] The core strand is a warrington strand with approximately round cross-section.

[0011] A wire saw comprising a cable incorporating present invention.

[0012] A spring loaded diamond bead wire saw comprises:

- 55
- a cable incorporating present invention;
 - beads carrying abrasive cutting material and being loosely mounted on said cable in a spaced apart relationship;
 - spiral compression springs mounted on the cable between said beads to space said beads.

Brief Description of Figures in the Drawings

[0013] The invention will now be described into more detail with reference to the accompanying drawings wherein

[0014] Figure 1 is a cross-sectional view of a cable incorporating the present invention;

[0015] Figure 2 is an enlarged side view of a portion of the wire saw using a cable incorporating present invention.

List of Reference Numbers

[0016]

10 is the cable incorporating present invention.

20 is the steel cord used to provide a cable as the subject matter of present invention.

30 is the second polymer coating on the steel cord.

40 is the core strand of the steel cord.

50 are the layer strands of the steel cord.

60 is the first polymer coating on the core strand.

65 is the thickness of the polymer coating on the core strand.

70 is the optical diameter of the core strand.

80 is the optical diameter of the coated core strand.

85 is the thickness of the polymer coating on the steel cord.

90 is the optical diameter of the steel cord.

100 is the optical diameter of the cable.

110 is the slide-able cutting element or bead.

120 is the spiral compression spring.

Mode(s) for Carrying Out the Invention

[0017] As shown in Figure 1, there is a cross section view of a cable incorporating the present invention. The cable 10 comprises a multi-strand steel cord 20 wherein the steel cord 20 is coated with a second polymer material 30. The steel cord 20 comprises at least one core strand 40 and plurality layer strands 50, while the core strand 40 is coated with a first polymer material 60 before the construction of the steel cord 20. The thickness 65 of the first polymer coating on the core strand 40 is the half of the difference between the optical diameter 70 of the core strand 40 and the optical diameter 80 of the coated core strand. The thickness 85 of the second polymer coating 30 on the steel cord 20 is the half of the difference between the optical diameter 90 of the steel cord and the optical diameter 100 of the cable. Compared with prior arts EP0339439A, present invention firstly coats the core strand 40 with a first polymer material 60 before the construction of the steel cord 20, and then the steel cord 20 is further coated with a second polymer material 30. The core strand 40 is further protected when the polymer material 30 cracks on the surface or peels off from the steel cord 20. Since the core strand 40 is firstly coated with a first polymer material 60 before the construction of steel cord 20, there are always polymer material 60 in-between the core strand 40 and the lay strands 50.

[0018] The thickness 65 of the first polymer material 60 on core strand 40 is less than 1 mm, and preferably less than 100 μ m. The thickness 85 of the second polymer material 30 on steel cord 20 is less than 1 mm, and preferably less than 100 μ m. These thin polymer coatings neither increase the diameter of the cable 10 substantially, compared with the steel cord 20, to fit the cutting elements, nor increase the stiffness of the cable 10 substantially, compared with the cable provided in EP0339439A.

[0019] The first polymer material 60 for the core strand 40 is either polyamide or polyurethane, while the second polymer material 30 for steel cord 20 can be either polyurethane or polyester.

[0020] Figure 2 is an enlarged side view of a portion of the wire saw using a cable incorporating present invention, wherein the plural slide-able cutting elements 110 are mounted on the cable 10, and are separated from each other with plural spiral compression spring 120. The two ends of the cable 10 can be provided with the catchers as disclosed in EP0339439A to form an endless cable for a wire saw.

[0021] In a comparison test, four types of samples are tested under the same working conditions.

[0022] Sample 1, a bare steel cord (1+6+12)+6x7 without polyurethane coating.

[0023] Sample 2, a bare steel cord (1+6+12)+6x7 with (second) polyurethane coating on the steel cord.

[0024] Sample 3, a bare steel cord (1+6+12)+6x7 with first polyurethane coating only on the core strand 1+6+12.

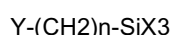
[0025] Sample 4, a bare steel cord (1+6+12)+6x7 with a first polyurethane coating on the core strand 1+6+12 before the construction of the steel cord and a second polyurethane coating on the whole steel cord thereafter.

	Sample 1	Sample 2	Sample 3	Sample 4
Cutting speed (m ² /hour)	8.11	8.91	7.10	11.64
Sawing cable lifetime (m ² /m)	15	11	15	30

[0026] The above test result testifies that the cable incorporating present invention not only increases the cutting speed, but also doubles the lifetime of the cable compared with the bare steel cord without any polymer coating. This double-coated cable, first polymer coating on core strand and second polymer coating on steel cord, prevents steel cord from exposing to the contaminated cooling water during the sawing process, mitigates the corrosive and abrasive effect of the cooling water, and extends the lifetime of cable in the sawing process. Comparatively, this double-coated cable works well with bigger cable, for example a 7x19 steel cord where one core strand 1+6+12 is surrounded with 6 layer strands 1+6+12. The second polymer coating on the steel cord may not penetrate that far to seal the core strand thoroughly because there are always limits for polymer penetrate under certain pressure, while the first polymer coating on the core strand can secure the core strand and protect properly.

[0027] Besides the steel cord disclosed above, there are other types of steel cord can be used to incorporate present invention. For the core strand, 3+9 or 3+9+15 strand, either layered or warrington type, and 7x7 strand, can be a good choice. Comparatively, the warrington type core strand is preferred because the core strand has an approximately round cross-section, which may facilitate the thin polymer coating on the core strand. For the layer strand, 3+9 or 1+6+12 strand, either layered or warrington type, can be a good choice. To facilitate the thin polymer coating on the steel cord, it is preferred that the steel cord has an approximately round cross-section. Therefore, according to the diameter of the layer strands, the number of the layer strands may range from 4 to 12.

[0028] To further improve the adhesion between steel strands and the polymer coating, an adhesive can be applied in between to avoid the immediate separation of the polymer coating from the strands. After an optional cleaning operation, the steel strands are then coated with a primer selected from organo functional silanes, organo functional titanates and organo functional zirconates which are known in the art for said purpose. Preferably, but not exclusively, the organo functional silane primers are selected from the compounds of the following formula:



[0029] wherein :

[0030] Y represents an organo functional group selected from -NH₂, CH₂=CH-, CH₂=C(CH₃)COO-, 2,3-epoxypropoxy, HS- and, Cl-

[0031] X represents a silicon functional group selected from -OR, -OC(=O)R', -Cl wherein R and R' are independently selected from C₁ to C₄ alkyl, preferably -CH₃, and -C₂H₅; and

[0032] n is an integer between 0 and 10, preferably from 0 to 10 and most preferably from 0 to 3

[0033] Besides the organo functional silanes described above, there are other steel PU adhesive commercially available on the market. They are sold under the name Chemosil (made by the German company Henkel) and Chemlock (made by Lord Corporation).

[0034] The primer can be applied onto the strands by dipping or painting or any other technique known in the art. Preferably dipping is used, followed by a drying operation.

[0035] A typical steel cord composition has 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. There are only traces of copper, nickel and / or chromium. 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 %.

[0036] The process to make a cable incorporating present invention may comprise following steps.

[0037] The wire rod is firstly cleaned by mechanical descaling and / or by chemical pickling in a H₂SO₄ or HCl solution in order to remove the oxides present on the surface. The wire rod is then rinsed in water and is dried. The dried wire rod is then subjected to a first series of dry drawing operations in order to reduce the diameter until a first intermediate diameter.

[0038] At this first intermediate diameter d₁, e.g. at about 3.0 to 3.5 mm, the dry drawn steel wire is subjected to a first intermediate heat treatment, called patenting. Patenting means first austenitizing until a temperature of about 1000 °C followed by a transformation phase from austenite to pearlite at a temperature of about 600 - 650 °C. The steel wire is then ready for further mechanical deformation.

[0039] Thereafter the steel wire is further dry drawn from the first intermediate diameter d₁ until a second intermediate diameter d₂ in a second number of diameter reduction steps. The second diameter d₂ typically ranges from 1.0 mm to

2.5 mm.

[0040] At this second intermediate diameter d_2 , the steel wire is subjected to a second patenting treatment, i.e. austenitizing again at a temperature of about 1000 °C and thereafter quenching at a temperature of 600 to 650 °C to allow for transformation to pearlite.

[0041] If the total reduction in the first and 2nd dry drawing step is not too big a direct drawing operation can be done from wire rod till diameter d_2 .

[0042] After this second patenting treatment the steel wire is usually provided with either a zinc coating or a brass coating. In the zinc coating process, the steel wire is either zinc-coated with an electrolytic deposition operation or by means of a hot dip operation, wherein the steel wire travels through a bath of molten zinc and leaves the bath zinc-coated. In the brass coating process, copper is plated on the steel wire and zinc is plated on the copper. A thermo-diffusion treatment is applied to form the brass coating.

[0043] The zinc-coated or brass-coated steel wire is then subjected to a final series of cross-section reductions by means of wet drawing machines. The final product is a steel filament with carbon content above 0.60 per cent by weight, with a tensile strength typically above 2000 MPa and adapted for the reinforcement of elastomer products.

[0044] Steel filaments adapted for the reinforcement of elastomer products typically have filaments with a final diameter ranging from 0.04 mm to 0.60 mm, e.g. from 0.04 mm to 0.40 mm. Examples of filament diameters are 0.04mm, 0.06mm, 0.08mm, 0.10 mm, 0.12 mm, 0.15 mm, 0.175 mm, 0.18 mm, 0.20 mm, 0.22 mm, 0.245 mm, 0.28 mm, 0.30 mm, 0.32 mm, 0.35 mm, 0.38 mm, 0.40 mm.

[0045] The steel filaments are firstly twisted into strands, where conventional apparatus such as double-twisters (bunching apparatus) or such as tubular rotary machines (cabling apparatus) may do the twisting operations. When the core strand is done, the coating of first polymer on the core strand can be done by means of injection moulding, powder coating, extrusion, or any other means as known in the art. Preferably extrusion is used. In the extrusion process, the core strand is preheated prior to entering the extruder head, while the first polymer material is injected into the extruder head with pressure. After coating the coated core strand was cooled in water. When both the coated core strand and lay strands are ready, all the strands can be twisted into a steel cord with above mentioned twisting apparatus. When the steel cord is done, the steel cord can be coated with the second polymer coating with above mentioned coating processes to make a cable incorporating present invention.

Claims

1. A cable for wire saw comprising multi-strand steel cord wherein the steel cord is coated with a second polymer material.
2. A cable according to claim 1, wherein said steel cord comprises at least one core strand and a plurality of layer strands, and said core strand is coated with a first polymer material before the construction of the steel cord.
3. A cable according to claim 1 wherein the thickness of the second polymer coating is less than 1mm.
4. A cable according to claim 3 wherein the thickness of the second polymer coating is less than 100µm.
5. A cable according to claim 1 wherein the first polymer material coating centre strand is polyamide or polyurethane and the second polymer material coating the steel cord is polyurethane or polyester.
6. A cable according to claim 2 wherein the core strand is a 1+6+12 strand or a 3+9 strand, or a 3+9+15 strand and the layer strand is a 7x1 strand, or 3+9 strand or 1+6+12 strand.
7. A cable according to claim 2 wherein the core strand is a warrington strand.
8. Use of a cable according to any one of the preceding claims in a wire saw.
9. Wire saw comprising a cable according to any one of claims 1 to 7.
10. Spring loaded diamond bead wire saw comprising:
 - a cable according to any one of claims 1 to 7;
 - beads carrying abrasive cutting material and being loosely mounted on said cable in a spaced apart relationship;
 - spiral compression springs mounted on the cable between said beads to space said beads.

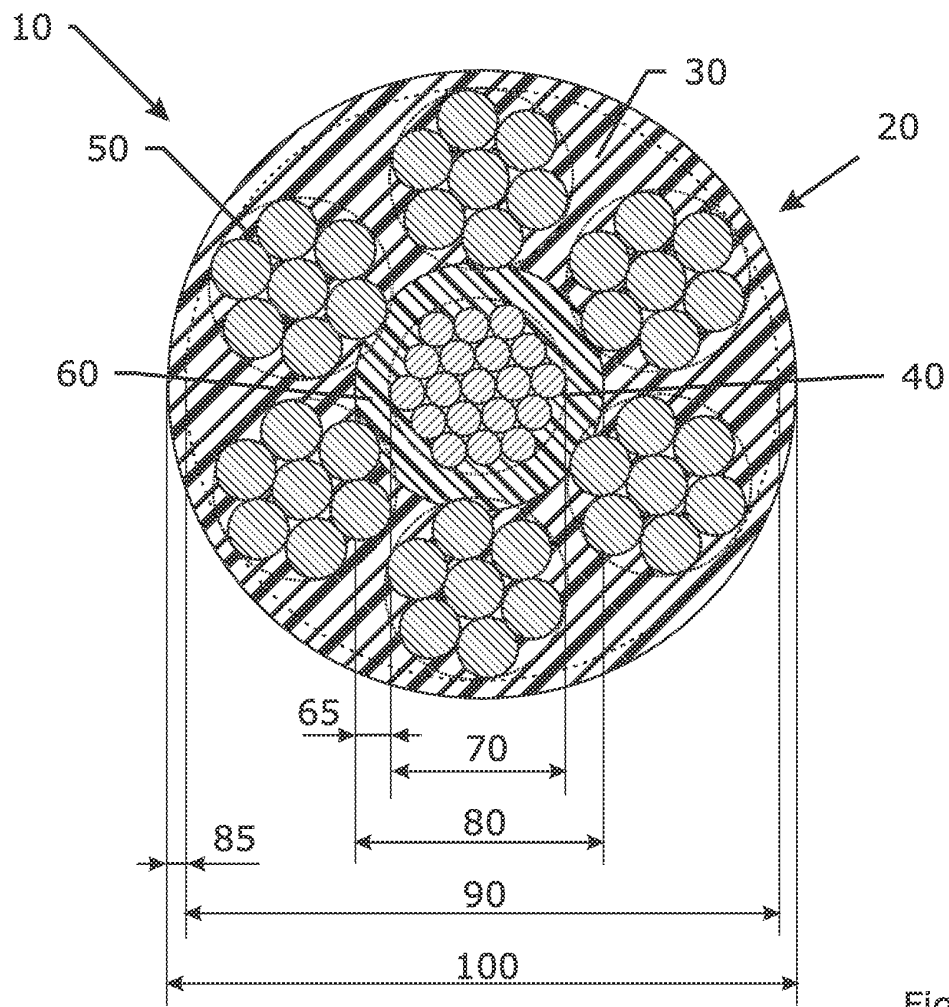


Fig. 1

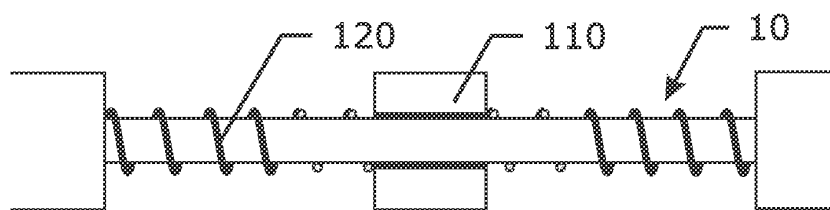


Fig. 2



EUROPEAN SEARCH REPORT

Application Number
EP 11 17 0350

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Y	* paragraphs [0001], [0025], [0026], [0034], [0053]; figure 1 *	4,6-10	
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The present search report has been drawn up for all claims			B28D D07B B21J B24B B23D
Place of search		Date of completion of the search	Examiner
The Hague		7 December 2011	Matzdorf, Udo
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
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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