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(54) **DYNAMIC CABLE HAVING IMPROVED PROPERTIES AND PROCESS AND PLANT FOR MANUFACTURING SUCH A CABLE**

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(57) **ABSTRACT**

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A cable includes a plurality of strands around a core, where the space between the strands and/or between core and strands is filled with a polyurethane-based polymer material. The cable is produced by depositing the polymer material over the core and/or strands with a coating device a certain distance upstream of the cabling point. The polymer's composition and coating point are determined so that the strands are placed around the core when the polymerization of the compound is sufficiently advanced so that the polymer formed is in a viscoplastic state suitable to form an approximately continuous adherent coating layer, but still sufficiently fluid to insinuate into the interstices between core and strands and between the strands.

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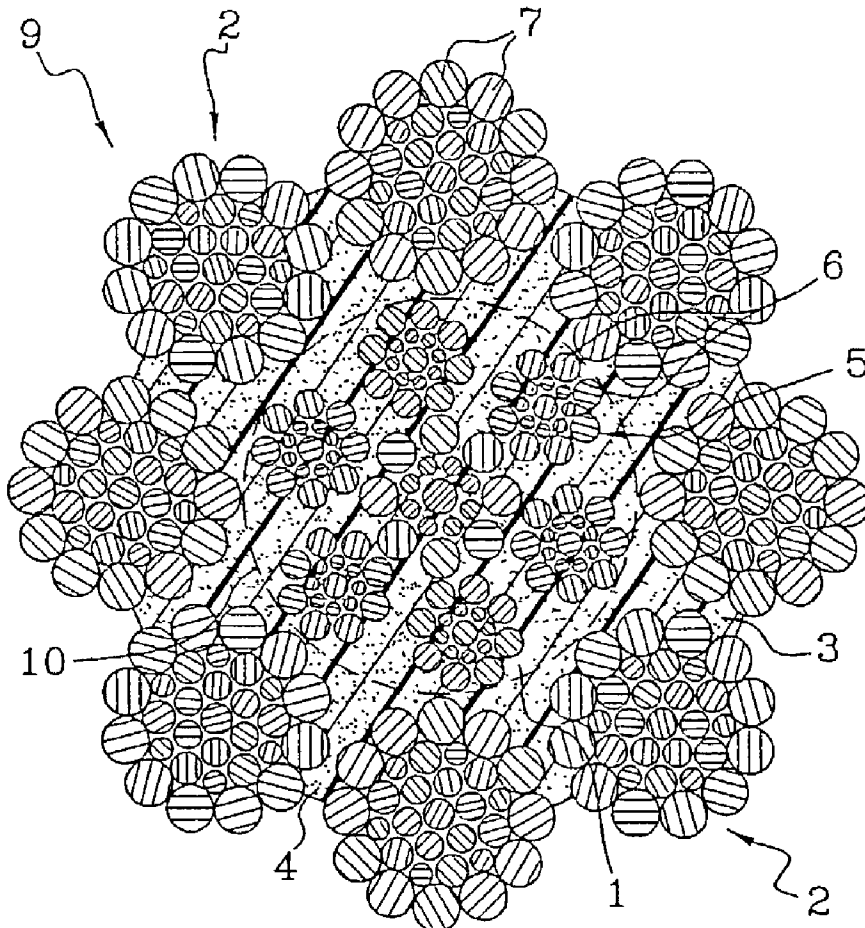
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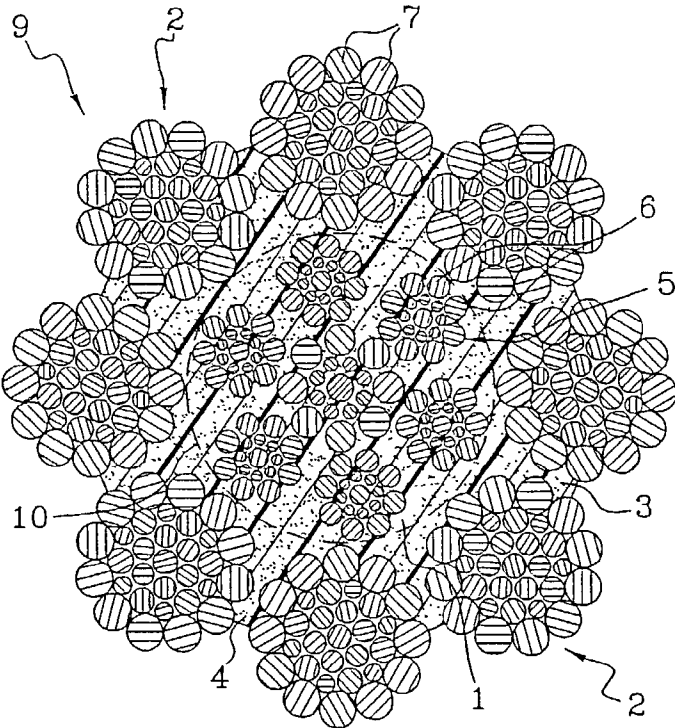


Fig. 1

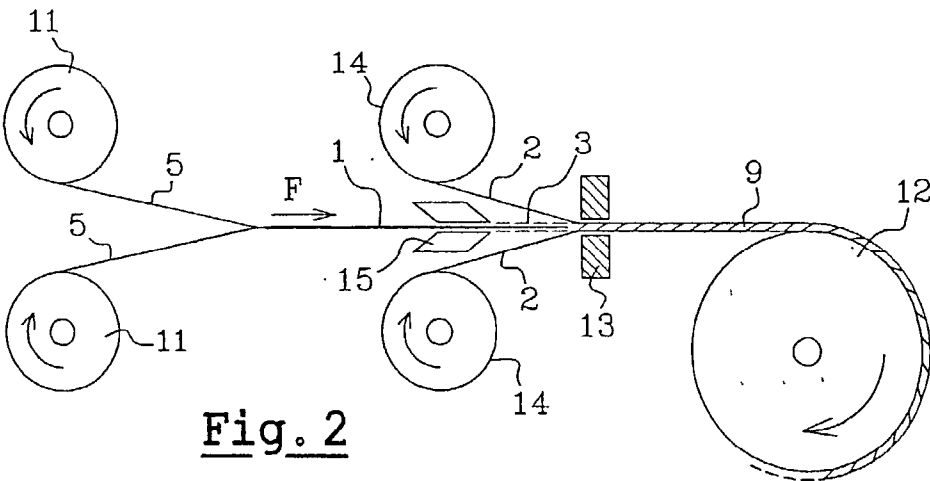


Fig. 2

DYNAMIC CABLE HAVING IMPROVED PROPERTIES AND PROCESS AND PLANT FOR MANUFACTURING SUCH A CABLE

BACKGROUND OF THE INVENTION

[0001] The present invention relates to lifting or traction cables, also called dynamic cables as they normally work in tension, but which are also subjected to bending under loads liable to vary greatly. Such cables are in particular lifting or traction equipment cables wound onto the drum of a winch.

[0002] Cables of the type considered here are conventionally formed by at least one ply of steel wire strands wound in a helix around a central core. The winding is carried out by means of a cabling head encircling the core, the head undergoing a rotation movement about itself and continuously depositing the strands on the running central core.

DESCRIPTION OF THE PRIOR ART

[0003] The characteristics required for the above-mentioned cables are, in particular, high flexibility, good diametral uniformity, ensuring uniform permanent elongation, and good abrasion resistance. For further explanations about the required characteristics of such cables and the constraints with which they have to comply, reference may be made for example to the French patent application filed under No. 93/08648.

[0004] One type of cable normally used for the aforementioned purposes is a hybrid cable consisting of eight steel wire strands wound in a helix around a core made of a natural textile based on hard fibers, such as sisal. A similar cable is also known, but one in which the core itself is hybrid, namely consisting of metal strands and textile filling fibers. The dynamic cables may also be cables consisting of metal strands over a metal core, which may or may not be independent. For example, cables are known which consist of twelve outer strands wound over an independent Warrington-type core, or else cables consisting of nine outer strands over an independent metal core itself consisting of nine strands.

[0005] The relatively low radii of curvature to which the cable is strained in this type of application create large bending forces throughout the cable, but most especially generate substantial differences in paths between the various strands and also between their constituent wires. There are therefore repeated relative displacements between any one strand and another, which may already cause local wear and elongation simply by rubbing. In addition, the curvature of the cable, when it is moreover under load, that is to say subjected to tensile stresses, creates high transverse compressive forces between the wires in contact with one another, resulting in a loss of transverse speed of the cable and easily causes wear by indentations. These indentations end up by locally reducing the cross section of the wires and are therefore detrimental to the strength and the lifetime of the cables. In addition, these reductions in cross section may promote elongation, something which is particularly to be avoided in applications of the lift cable type.

[0006] It is already known to use cables comprising sisal-type natural or synthetic (polypropylene) fibers, the function of which is to form a cushion inserted between the various plies of strands. The aim is thus to avoid, or at least limit, the

rubbing of the wires or strands against one another, and the resulting risks of indentation. One common aspect of these inserts made of non-metallic materials is that they do not contribute directly to taking up the tension in the cable, that is to say they do not contribute directly to increasing the tensile strength of the cable.

[0007] It has already been proposed, in Document FR-2 783 585, to place between the core and the outer strands a polyamide sheath whose purpose is especially to form a layer distributing the compressive forces exerted radially by the strands on the core that they surround. However, the effect of such a sheath is limited to the interface between core and strands, and fitting the sheath poses problems during manufacture of the cable.

[0008] Cables are also known which comprise, between the core and the outer strands, a layer of a plastic, especially polyethylene. In a first manufacturing phase, the polyethylene is deposited over the core by extrusions so as to coat it. The core thus coated is rewound and stored awaiting use. Then, during cabling, the core is again unwound and the plastic sheath surrounding the core is heated in order to soften it sufficiently and allow the strands to be spiralled around the core, in a conventional manner, but by encrusting them in the plastic softened at the cabling point. However, such a manufacturing process requires several unwinding and rewinding operations and a not inconsiderable consumption of energy needed to soften the plastic during cabling.

[0009] This expenditure on energy could be reduced by means of the process for coating plastic on cables proposed in Document FR-2 553 442, and in which process the core precoated with plastic is assembled with strands which are themselves coated with plastic. The plastic is injected onto the strands at the actual stranding device in such a way that the coating and the assembling of the strands take place simultaneously at the cabling point. However, such a cable manufacturing process still requires several unwinding and rewinding operations since the core must be plastic-coated beforehand so as to ensure the presence of a protective layer between core and strands. In addition, the injected plastic is in a viscous state when the strands are being coated and it is only after assembly that it solidifies. However, during the assembling operation this relatively fluid material can flow, resulting in imbalances in the thickness of the protective layer lying between the strands. In addition, the strands can slide over one another, thus thinning, or even removing, the layer of plastic which separates them.

SUMMARY OF THE INVENTION

[0010] The present invention is aimed at the manufacture of a composite cable having, in the free spaces between strands, a plastic at least partially filling these spaces, the cable obtained being particularly suitable for use as a traction or lifting cable, that is to say, in general, in all applications in which the cable has, in service, to be successively wound onto a drum or the like and unwound therefrom.

[0011] The aim of the invention is in particular to increase the lifetime of such a cable, especially by reducing the phenomenon of wear by mutual indentation of the strands. Its aim is also to allow economic manufacture without substantial modifications to the existing cabling plants. Its aim is also to make it possible to deposit, in a single

operation, a layer of plastic intended to be placed between core and strands and between strands.

[0012] With these objectives in mind, the subject of the invention is a process for manufacturing a dynamic cable comprising a plurality of strands stranded around a core, the spaces between strands and/or between core and strands being at least partly filled with a polymer material, according to which process the cable is formed by depositing, around a running core, a plurality of strands wound in a helix, which process is characterized in that a polymerizable compound is deposited, on the run, over the core and/or the strands at a coating point at a certain distance upstream from the cabling point in the direction in which the core runs, said deposited compound comprising a prepolymer and a polymerization accelerator, the composition of said compound and the distance from the coating point being determined so that the strands are wound around the core when the polymerization that the deposited compound is undergoing is sufficiently advanced so that the polymer formed is in a viscoplastic state, a coating layer which is pasty but still sufficiently fluid to flow into the interstices between core and strands, and between strands, and in that the polymerization is completed only when the cable, once formed, is wound onto the take-up reel.

[0013] A major advantage of the invention is that the integration of said polymer material into the structure of the cable does not require additional operations since it is put in place simultaneously with the cabling operation, thereby making the process particularly economic.

[0014] According to a first method of implementation, the polymerizable compound is deposited only over the core (by an injection head surrounding the core).

[0015] According to an alternative arrangement, the polymerizable compound is deposited by coating jointly the core and the strands, and the possible surplus material on the surface of the cable after cabling is removed after the assembling head and before the cable is wound up onto the take-up reel. This arrangement allows all the interstices between the core and the strands to be effectively filled.

[0016] Also preferably, the polymer material is polyurethane, the use of which during cable manufacture is particularly conducive to good penetration between the strands, as will be seen later. In addition, its cost is moderate and therefore not an imposition on that of the cable obtained.

[0017] The polymerizable compound is in fact produced just before coating, by mixing a prepolymer containing isocyanates with a polymerization accelerator in predetermined proportions.

[0018] The properties of the components of the mixture produced for the coating and the processing conditions must ensure that the deposited compound will be, under the cable manufacturing conditions, especially the temperature and running speed conditions, in a sufficiently pasty state just after coating in order for it to adhere to the core and form thereon, right at the cabling point, a malleable, semi-solid, coating layer similar to modelling clay, and therefore capable of molding the strands which are deposited thereon.

[0019] Its adhesion to the constituent wires and strands of the cable will make it possible to fill, by flow, under the action of the pressure resulting from winding the outer

strands over the core, the spaces not occupied by said strands or the core, without any polymer material undergoing polymerization flowing to the outside of the cable and sticking onto the components of the cabling machine, such as guide rollers or other members that have to be in contact with the cable formed.

[0020] Next, the polymerization must be completed after the cable is formed, for example when it is already wound on the take-up reel of the cabling machine, or at least in a geometrically sufficiently stable state so that the state of polymerization, commonly called the "weak curing" phase, takes place only when the outer strands are no longer capable of moving with respect to one another and with respect to the core in the cable being manufactured.

[0021] The components of the mixture used must in fact be determined so that the kinetics of the polymerization reaction comprise:

[0022] a first polymerization phase taking the mixture to the abovementioned pasty state, this first phase having to be short or even very short in order to ensure that the polymer is well held on the core as soon as it is deposited thereon; and

[0023] a second, polymerization continuation phase in which the polymer remains pasty for as long as possible before reaching the weak curing phase, this taking into account, of course, the run speed of the cable during its manufacture, in order to be able to complete the cabling operation and freeze the relative position of the strands and of the core, while leaving the strands to become encrusted in the polymer material without there being any risk of the polymer formed cracking.

[0024] Polyurethane has proved to be particularly suitable for meeting the abovementioned constraints and objectives. Thus, polyurethane practically fills all the spaces lying between core and strands, on the one hand by coating as close as possible the surface of the core, and even by being inserted between the constituent wires or strands, as the case may be of the outer layer of the core, and, on the other hand, by being extended between any two adjacent outer strands up to the point where said strands are closest to one another, that is to say at the line along which said outer strands may be brought, during use, into permanent or occasional contact with one another.

[0025] In the finished cable, each strand thus has its position determined by the polyurethane which has polymerized in contact with it, making a kind of receiving trough specifically corresponding to the external dimensions and shapes of said strand. Consequently, the risks of undesirable contacting and rubbing between neighboring strands or between strands and core are considerably reduced.

[0026] In addition, not only are the strands held in their respective trough, as indicated above, but, because of the inclination of the wires with respect to the longitudinal direction of the strands, each wire is similarly held in place, at the outer surface of the strand, in its own mini-trough, the dimensions of which are of course smaller than in the case of the strands, but above all inclined with respect to the longitudinal direction of the trough for the strands. This relative inclination results in the strands not being able to slide longitudinally in their respective troughs.

[0027] Thus, overall, not only are the strands held together and with respect to the core in the direction perpendicular to the longitudinal direction of the cable, but they are also held together in said longitudinal direction. In practice, there can therefore no longer be any relative sliding between strands in the longitudinal direction, thereby preventing rubbing and hence considerably limiting the wear of the constituent wires of the strands. In addition, the relative holding of the strands together in the longitudinal direction ensures that the loads in service are distributed, which distribution may be more uniform than when the strands are able to slide with respect to one another.

[0028] This is because, in the cables according to the prior art, the relative reptational movement of the strands over one another, combined with unequally distributed loads, may lead to over lengthening of some of the strands, this over lengthening possibly going as far as to cause localized swelling of the cable, the overly long strand forming a kind of looped excrescence, also called "birdcage", to the detriment of the strength and durability of the cable. By preventing the strands from sliding with respect to their polyurethane molded troughs, the invention makes it possible to avoid these problems by preventing any tendency of the strands to undergo relative displacement.

[0029] The flexibility of the cable, necessary for its dynamic operation involving successive deflections and straightenings when being wound up on drums or when passing over pulleys, is, however, maintained thanks to the toughness and high level of elastic elongation of polyurethane, which allow it to follow the normal bending deformations of the cable in service, even when combined with high tensile forces, without cracking or deteriorating in other ways. Thus, the inevitable microslipping between neighboring strands or wires during bending of the cable is easily absorbed by the elasticity of the polyurethane, without any reduction in cross section of the polyurethane taking place at the interfaces between said strands or wires.

[0030] The subject of the invention is also a cabling plant comprising means for making a core of a cable run and a cabling head for depositing a plurality of strands in a helix around the core, and comprising coating means for depositing a polymerizable compound over the core and/or the strands, the plant being characterized in that said coating means are at a certain distance upstream of the cabling head with respect to the direction in which the core runs and in that they comprise:

[0031] a prepolymer reservoir,

[0032] a polymerization accelerator reservoir and

[0033] an injection head with a mixing chamber connected to said reservoirs,

[0034] said coating means being controlled so as to deposit, over the running core and/or strands, a layer of said compound thus obtained by mixing.

[0035] According to one particular arrangement, said coating means comprise an injection head surrounding the core and controlled so as to deposit said layer only around the core.

[0036] The subject of the invention is also a cable, obtained according to the process mentioned above, comprising a plurality of strands stranded around a core, wherein

the spaces between core and strands and between wires are filled with a polymer material deposited at least over the core and being insinuated between the strands and/or between the constituent wires after cabling. Preferably, the polymer material is polyurethane.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] Further features and advantages will become apparent from the description, which will be given by way of example, of a cable according to the invention and of its manufacturing plant, with reference to the single appended plate of drawings, in which:

[0038] **FIG. 1** is a cross section through a cable according to the invention;

[0039] **FIG. 2** is a schematic representation of the manufacturing plant.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0040] The cable **9**, shown in cross section in **FIG. 1**, comprises a core **1**, which is for example a metal core formed by assembling strands **5**, which in this case are seven (1+6) in number, each being formed by seventeen stranded steel wires **6** in two plies over a central core (1+8+8). The nature and the construction of the core are, however, in no way a limitation of the invention. The core could also comprise composite strands.

[0041] The core **1**, the boundaries of which are shown symbolically by the circle **10**, is surrounded by a single ply of strands **2** (in this case eight in number), each formed by thirty-one steel wires **7** organized in three plies (1+6+12+12). The strands **2** are wound in a spiral over a kind of polyurethane sheath **3** which grips the core, the strands being roughly encrusted half way into said sheath. Incidentally, it will be noted that there is no bonding or adhesion particularly desirable between the strands or their constituent wires and the polyurethane, the strands being held in position with respect to said sheath essentially by the geometrical interaction between the surface shapes of the strands and the corresponding trough shapes in the mass of polyurethane, said shapes having been mentioned above. An ancillary advantage is that, due to the fact that such adhesion is not sought, there is no need for prior operations on the core or the strands for their preparation, cleaning, degreasing, etc.

[0042] This cable is produced in a cabling plant as shown in **FIG. 2**. This plant includes means for making the core **1** and the cable formed run in the direction of the arrow **F**, these means comprising pay-out reels **11** delivering the strands **5** constituting the core **1** and a take-up reel **12** on which the cable **9** formed is wound.

[0043] A cabling head **13**, of type known per se, ensures that the strands **2** coming from respective pay-out reels shown schematically at **14** are wound in a helix around the core **1**.

[0044] Placed in the path of the core, at a certain distance upstream from the cabling head **13**, for example about twenty centimeters therefrom, is an injection head **15** which deposits, on the run, a polymerizable compound **3** over the core. Said polymerizable compound, based on polyurethane, is produced in the injection head **15** by mixing a prepolymer

containing isocyanates with a polymerization accelerator. Other products having equivalent properties may also be suitable.

[0045] For this purpose, the injection head is provided with a mixing chamber connected to two reservoirs, namely a prepolymer reservoir and a polymerization accelerator reservoir. Flow control means are provided at the outlet of said reservoirs. This is because it is necessary to be able to adjust the proportions of the various components of the mixture so as to obtain the desired consistency of the polymer being formed at the moment of assembling the cable.

[0046] Thus, with the abovementioned components, good results are obtained when the ratio by mass of the compounds introduced into the injection head is 20 grams of polymerization accelerator per 100 grams of prepolymer.

[0047] The polyurethane **3** is deposited over the core in the pasty state. If the polyurethane deposited is in excess, it will be wiped off by any suitable means after it has left the cabling head. This may be the case when the construction of the cable results in the inter strand space being relatively large, which space it is desired to fill, or when intentionally the amount of compound deposited over the core is determined so as to be able to flow beyond said line of least distance between adjacent strands, in order to ensure, and be able to check, that at least a peninsula **4** of polymer is present between the wires of two adjacent strands, as may be seen, for example, in **FIG. 1**.

[0048] The invention is not limited to the cable and the process which have been described above solely by way of examples. In particular, the number and the composition of the strands, and the composition of the core, could be modified.

1. A process for manufacturing a dynamic cable comprising a plurality of strands stranded around a core, the spaces between strands and/or between core and strands being at least partly filled with a polymer material, according to which process the cable is formed by depositing, around a running core, a plurality of strands wound in a helix, wherein a polymerizable compound is deposited, on the run, over the core and/or the strands at a coating point at a certain distance upstream from the cabling point in the direction in which the core runs, said compound comprising a prepolymer and a polymerization accelerator, the composition of said compound and the distance from the coating point being determined so that the strands are wound around the core when

the polymerization that the deposited compound is undergoing is sufficiently advanced so that the polymer formed is in a viscoplastic state suitable for forming a coating layer which is pasty but still sufficiently fluid to flow into the interstices between core and strands, and between strands, and wherein the polymerization is completed only when the cable is formed.

2. The process as claimed in claim 1, wherein the polymerizable compound is deposited only over the core.

3. The process as claimed in claim 1, wherein the polymerizable compound is deposited by coating jointly the core and the strands.

4. The process as claimed in claim 1, wherein the polymer material is based on polyurethane.

5. The process as claimed in claim 1, wherein the polymerizable compound is produced just before coating, by mixing a prepolymer containing isocyanates with a polymerization accelerator in predetermined proportions.

6. A cabling plant comprising means for making a core of a cable run and a cabling head for depositing a plurality of strands in a helix around the core, and comprising coating means for depositing a polymerizable compound over the core and/or the strands, wherein said coating means are at a certain distance upstream of the cabling head with respect to the direction in which the core runs and wherein they comprise:

a prepolymer reservoir,

a polymerization accelerator reservoir and

an injection head with a mixing chamber connected to said reservoirs,

said coating means being controlled so as to deposit, over the running core and/or strands, a layer of said compound thus obtained by mixing.

7. The cabling plant as claimed in claim 6, wherein said coating means comprise an injection head surrounding the core and controlled so as to deposit said layer over the core.

8. A cable comprising a plurality of strands cabled around a core, the spaces between core and strands being filled with a polyurethane-based polymer material, where in said material is a compound obtained by mixing a prepolymer with a polymerization accelerator and wherein it has been deposited at least around the core during cabling and wherein it has been insinuated between the strands and/or between the constituent wires.

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