

Description

MEDIUM-VOLTAGE CABLE AND METHOD FOR MANUFACTURING MEDIUM-VOLTAGE CABLE

Technical Field

The preset invention relates to the technical field of cables, and in particular relates to a medium-voltage cable and a method for manufacturing the medium-voltage cable.

Background Art

Petroleum is the lifeblood that drives economic development, with a global daily consumption of up to 80 million barrels of petroleum. In the latest ten years, 60% of the newly discovered oil and gas fields are in the ocean, and it is expected that 40% of global oil and gas reserves will be concentrated in deep-sea areas in the future. Floating Production Storage and Offloading (FPSO) ship is an offshore floating production, storage and offloading device that integrates production, oil storage, and oil unloading. This device involves petroleum processing, and harmful gases exist in non-safe areas. If conventional cables are used, harmful gases can spread to safe areas through the gaps between cable cores of cables, affecting personnel safety.

Contents of the Invention

The present invention provides a medium-voltage cable and a method for manufacturing the medium-voltage cable, so as to solve the defect present in the prior art that there are gaps between cable cores of conventional cables and harmful gases can spread through the gaps between cable cores.

The present invention provides a medium-voltage cable comprising a plurality of wire core units, the plurality of wire core units are twisted into a cable core structure, wherein each wire core unit includes: an insulated wire core; a metal shielding layer cladded around the outside of the insulated wire core; a semiconductive adhesive layer cladded around the outside of the metal shielding layer, and the semiconductive adhesive layer is formed by curing a semiconductive adhesive, wherein, the medium-voltage cable is an airtight power cable with a rated voltage of 6kV to 30kV.

In the medium-voltage cable provided according to the present invention, the semiconductive adhesive consists of a first component and a second component, wherein, the first component comprises: methyl block room temperature vulcanized silicone rubber in 100 parts, ultrafine calcium carbonate in 30-45 parts, white carbon black in gas phase in 6-10 parts, titanium dioxide in 3-5 parts, graphene in 3-5 parts; and the second component comprises: ethyl orthosilicate in 4-8 parts, N-butyl borate in 2-4 parts, N-butyl titanate in 2-4 parts, octyltin dilaurate in trace amounts, and gamma aminopropyltriethoxysilane in trace amounts.

The medium-voltage cable provided according to the present invention further includes a plurality of fillers, the plurality of fillers are filled in the cable core structure and located between the plurality of wire core units, wherein, the fillers are non-mesh polypropylene ropes with flat films.

The medium-voltage cable provided according to the present invention further includes a wrapping tape layer, and the wrapping tape layer is cladded around the outside of the cable core structure.

The medium-voltage cable provided according to the present invention further includes an inner liner layer, the inner liner layer is cladded around the outside of the warping tape layer, and the inner liner layer is a low smoke halogen-free polyolefin inner liner layer.

The medium-voltage cable provided according to the present invention further includes an armoring layer cladded around the outside of the inner liner layer.

The medium-voltage cable provided according to the present invention further includes an outer sheath layer cladded around the outside of the armoring layer, and the outer sheath layer is a silane cross-linked low smoke halogen-free outer sheath layer.

In the medium-voltage cable provided according to the present invention, the insulated wire core includes: a conductor; a shielding layer cladded around the outside of the conductor; an insulation layer cladded around the outside of the shielding layer; an insulation shielding layer cladded around the outside of the insulation layer.

In the medium-voltage cable provided according to the present invention, the metal shielding layer is formed by weaving with tinned copper wire.

The present invention also provides a method for manufacturing the medium-voltage cable as described above, comprising: coating the semiconductive adhesive on the outside of the metal shielding layer to form the semiconductive adhesive layer, and wrapping the semiconductive adhesive layer with an aluminum-plastic composite tape while coating, wherein, the overlap rate of the aluminum-plastic composite tape is greater than or equal to 25%; removing the aluminum-plastic composite tape after the semiconductive adhesive layer is cured; twisting the plurality of wire core units into the cable core structure.

The medium-voltage cable provided by the present invention has the following beneficial effects compared to the prior art: by coating a semiconductive adhesive on the outside of the metal shielding layer, the present invention not only ensures electrical continuity of the metal shielding layer, but also prevents harmful gases from flowing along the weaving gap of the metal shielding layer, effectively preventing harmful gases from leaking outside the cable and posing a safety hazard to personnel. Thus the medium-voltage cable is widely applicable to the offshore Floating Production Storage and Offloading device, and the applicability of the medium-voltage cable is enhanced.

Description of Drawings

In order to explain the technical solutions in the present invention or in the prior art more clearly, hereunder the drawings required to be used in the description of examples or the prior art will be introduced briefly. Apparently, drawings in the following description are some examples of the present invention, and those of ordinary skills in the art may obtain other drawings based on these drawings without expending creative work.

Fig. 1 is a schematic diagram of the structure of a medium-voltage cable provided by the present invention;

Fig. 2 is a flowchart of a method for manufacturing the medium-voltage cable provided by the present invention;

Reference numerals:

10: Insulated wire core; 11: Conductor; 12: Shielding layer; 13: Insulation layer; 14: Insulation shielding layer; 20: Metal shielding layer; 30: Semiconductive adhesive layer; 40: Filler; 50: Wrapping tape layer; 60: Inner liner layer; 70: Armoring layer; 80: Outer sheath layer.

Embodiments

In order to make the objects, technical solutions and advantages of the present invention clearer, hereunder technical solutions in the present invention will be clearly and fully described in conjunction with drawings in the present invention. Apparently, the described examples are some examples of the present invention, not all examples. All other examples obtained by those of ordinary skills in the art without expending any creative work based on examples of the present invention fall into the protection scope of the present invention.

In the description and claims of the present invention, terms such as “first” feature, “second” feature may explicitly or implicitly include one or more said features. In the description of the present invention, unless otherwise specified, the meaning of “more” is two or more than two.

In the description of the present invention, it should be understood that directional or positional relationships indicated by terms such as “center”, “longitudinal”, “transverse”, “length”, “width”, “thickness”, “up”, “down”, “front”, “back”, “left”, “right”, “vertical”, “horizontal”, “top”, “bottom”, “inside”, “outside” are based on the directional or positional relationships shown in the accompanying drawings, and they are used only for easy description of the present invention and simplified description and do not indicate or imply that the referred device or element must have a specific orientation, be constructed and operated in a specific orientation, and therefore they cannot be understood as a limitation of the present invention.

In the description of the present invention, it should be noted that unless otherwise specified and defined, the terms such as “set”, “install”, “interconnect”, and “connect” should be broadly understood, for example, it may be a fixed connection, or a detachable connection, or an integral connection; it may be a mechanical connection or an electrical connection; it may be a direct interconnection, or an indirect interconnection through an intermediate medium, or an internal communication between two elements. For those of ordinary skills in the art, the specific meaning of the above terms in the present invention can be understood according to specific situations.

Hereunder the medium-voltage cable and the method for manufacturing the medium-voltage cable in the present invention will be described with reference to Figs. 1-2.

As shown in Fig. 1, in an example of the present invention, the medium-voltage cable comprises a plurality of wire core units, the plurality of wire core units are twisted into a cable core structure, wherein each wire core unit includes: an insulated wire core 10, a metal shielding layer 20 and a semiconductive adhesive layer 30. The metal shielding layer 20 is cladded around the outside of the insulated wire core 10, the semiconductive adhesive layer 30 is cladded around the outside of the metal shielding layer 20, and the semiconductive adhesive layer 30 is formed by curing a semiconductive adhesive.

It should be noted that the medium-voltage cable in the present invention refers to an airtight power cable with a rated voltage of 6kV to 30kV.

Specifically, the metal shielding layer 20 is formed by weaving with tinned copper wires with a nominal diameter of 0.2mm, and the weaving density is not less than 80%. The metal shielding layer 20 is formed after the weaving is finished. A semiconductive adhesive is coated on the outside of the metal shielding layer 20 and the semiconductive adhesive layer 30 is formed after the semiconductive adhesive is cured. The semiconductive adhesive layer 30 has conductive properties and can ensure electrical continuity of the metal shielding layer 20. At the same time, the semiconductive adhesive layer can fill the gaps formed by weaving, avoiding harmful gases from spreading through the gaps formed by weaving and posing a safety hazard to personnel.

By coating semiconductive adhesive on the outside of the metal shielding layer, the medium-voltage cable provided in the example of the present invention ensures electrical continuity of the metal shielding layer and prevents harmful gases from flowing along the weaving gaps of the metal shielding layer, as well as effectively preventing harmful gases from leaking out of the cable and posing a safety hazard to personnel, so the medium-voltage cable can be widely used in offshore Floating Production Storage and Offloading device, enhancing the applicability of the medium-voltage cable.

Furthermore, in the example of the present invention, the semiconductive adhesive consists of a first component and a second component, wherein, the first component comprises: methyl block room temperature vulcanized silicone rubber in 100 parts, ultrafine calcium carbonate in 30-45 parts, white carbon black in gas phase in 6-10 parts, titanium dioxide in 3-5 parts, graphene in 3-5 parts;

and the second component comprises: ethyl orthosilicate in 4-8 parts, N-butyl borate in 2-4 parts, N-butyl titanate in 2-4 parts, octyltin dilaurate in trace amounts, and gamma aminopropyltriethoxysilane in trace amounts.

Specifically, the semiconductive adhesive consists of the first component and the second component. When in use, the first component and the second component are mixed and stirred evenly before being coated on the metal shielding layer 20. The semiconductive adhesive can weld the gaps formed by the weaving of the metal shielding layer 20 to prevent harmful gases from leaking out and also have conductive properties.

In the medium-voltage cable provided in the example of the present invention, by providing the semiconductive adhesive with the above components, the semiconductive adhesive not only has good conductivity and also has high temperature resistance level and can bear 90°C for a long time, thus the use performance of the medium-voltage cable is enhanced and the service life of the medium-voltage cable is extended.

As shown in Fig. 1, in the example of the present invention, the medium-voltage cable further includes a plurality of fillers 40. The plurality of fillers 40 are filled into the cable core structure and located between the plurality of wire core units, wherein, the fillers 40 are non-mesh polypropylene ropes with flat films.

Specifically, in the prior art, the fillers 40 mostly adopt structurally fluffy materials, which are filled into the cable core structure. Due to the small gaps existed in the structurally fluffy materials, harmful gases can still freely move along the axial direction of cable in the cable core structure, thereby posing a safety hazard to personnel. In this example, the fillers 40 are non-mesh ultrathin polypropylene ropes with flat films. Using the polypropylene ropes to tightly fill the cable core structure can ensure the longitudinal airtightness of the cable core structure of the medium-voltage cable and prevent harmful gases from spreading along the axial direction of the medium-voltage cable to the safe area.

In the medium-voltage cable provided in the example of the present invention, by providing the fillers as non-mesh polypropylene ropes with flat films, the cable core structure is tightly filled after the fillers are filled into the cable core structure, so as to ensure the longitudinal airtightness of the cable core structure and prevent harmful gases from flowing along the axial direction of the medium-voltage cable, thereby preventing harmful gases from leaking into safe areas and posing a safety hazard to personnel.

As shown in Fig. 1, in the example of the present invention, the medium-voltage cable further includes a wrapping tape layer 50, which is cladded around the outside the cable core structure.

Specifically, a plurality of wire core units are twisted into a cable core structure, the gaps formed during twisting are filled with non-mesh ultrathin polypropylene ropes with flat films, and a layer of non-woven fabric with a nominal thickness of 0.2mm is wrapped around the cable core structure to form the wrapping tape layer 50. Furthermore, in the example of the present invention, the overlap rate of the wrapping tape layer 50 is 15% to 20%, such as for cable of 18/30kV 3x95 specification, the diameter after the wrapping tape layer 50 is wound is 70.6mm.

As shown in Fig. 1, in the example of the present invention, the medium-voltage cable further includes an inner liner layer 60, which is cladded around the outside of the wrapping tape layer 50, wherein, the inner liner layer 60 is a low smoke halogen-free polyolefin inner liner layer.

Specifically, the inner liner layer 60 is made of low smoke halogen-free polyolefin material, such as for cable of 18/30kV 3 × 95 specification, the nominal thickness of the inner liner layer 60 is 1.8mm, and the outer diameter of the cable after extrusion is 74.2mm.

As shown in Fig. 1, in the example of the present invention, the medium-voltage cable further includes an armoring layer 70, and the armoring layer 70 is cladded around the outside of the inner liner layer 60.

Specifically, the armoring layer 70 is formed by weaving with tinned copper wires having a single wire diameter of 0.4mm in a weaving density of not less than 80, such as for cable of 18/30kV 3 × 95 specification, the outer diameter of the cable after weaving is 75.8mm.

As shown in Fig. 1, in the example of the present invention, the medium-voltage cable further includes an outer sheath layer 80, which is cladded around the outside of the armoring layer 70. The outer sheath layer 80 is a silane cross-linked low smoke halogen-free outer sheath layer.

Specifically, after the medium-voltage cable is applied to offshore Floating Production Storage and Offloading device, the medium-voltage cable will work in an oily environment for a long time, and the outer sheath will be slowly corroded by the oil contamination, thereby reducing the service life of the medium-voltage cable. Conventional oil resistant cables usually use irradiation crosslinking technology to achieve oil resistance requirements, but irradiation crosslinking is limited by the outer diameter of the cable, that is, if the outer diameter of the cable is larger than 80mm, it is hard to proceed with the processing, making the outer sheath layer of the cable with thicker diameter have no oil resistance.

In this example, the outer sheath layer 80 is formed by extruding silane cross-linked low smoke halogen-free sheath material. For cables with a diameter greater than 80mm, cross-linking can be completed after lasting for 24 hours in steam, making the outer sheath layer 80 of the cable with a larger diameter also has oil resistance.

In the medium-voltage cable provided in the example of the present invention, by providing the outer sheath layer as silane cross-linked low smoke halogen-free outer sheath layer, the outer sheath layer of the cable with a larger diameter also has oil resistance and the service life of the medium-voltage cable is prolonged.

As shown in Fig. 1, in the example of the present invention, the insulated wire core 10 includes: a conductor 11, a shielding layer 12, an insulation layer 13, and an insulation shielding layer 14. The shielding layer 12 is cladded around the outside of the conductor 11, the insulation layer 13 is cladded around the outside of the shielding layer 11, and the insulation shielding layer 14 is cladded around the outside of the insulation layer 13.

Specifically, in this example, the conductor 11 is tinned conductor, and a plurality of tinned conductor monofilaments are twisted to form the conductor 11. For example, for the conductor 11 with a cross-sectional area of 95mm², it is formed by twisting in a 1+6+12 structure with 19 tinned conductor monofilaments having an outer diameter of 2.52mm, and the outer diameter of the conductor 11 after twisting is 12.5mm. Continuous vulcanization production lines is used for co-extruding three layers (150+100+60) in the outside of the conductor 11 in sequence to simultaneously extrude the shielding layer 12, the insulation layer 13, and the insulation shielding layer 14, so as to form the insulated wire core 10. Furthermore, for example, for the 18/30kV 3 × 95 specification, the nominal thickness of the shielding layer 12 is 0.8mm, the nominal thickness of the insulation layer 13 is 8.0mm, the nominal thickness of the insulation shielding layer 14 is 0.8mm, and the outer diameter of the insulated wire core 10 is 31.7mm.

Furthermore, in the example of the present invention, the material of the shielding layer 12 may be a semiconductive shielding material, the material of the insulation layer 13 may be medium-voltage ethylene propylene rubber, and the material of the insulation shielding layer 14 may be a semiconductive material.

As shown in Fig. 2, an example of the present invention also provides a method for manufacturing the medium-voltage cable, which specifically includes the following steps:

Step 01: Coating the semiconductive adhesive on the outside of the metal shielding layer 20 to form the semiconductive adhesive layer 30, and wrapping the semiconductive adhesive layer 30 with an aluminum-plastic composite tape while coating, wherein, the overlap rate of the aluminum-plastic composite tape is greater than 25% or equal to 25%; Step 02: Removing the aluminum-plastic composite tape after the semiconductive adhesive layer 30 is cured; Step 03: Twisting the plurality of wire core units into the cable core structure.

Specifically, the metal shielding layer 20 is formed outside the insulated wire core 10 by weaving tinned copper wires with a nominal diameter of 0.2mm in a weaving density of not less than 80%. The semiconductive adhesive is coated on the outside of the metal shielding layer 20 and the aluminum-plastic composite tape is wrapped around the semiconductive adhesive while coating, wherein the overlap rate of the aluminum-plastic composite tape is not less than 25%. The coated semiconductive adhesive is cured about 6 hours after coating, and then the aluminum-plastic composite tape is removed. At this time, for example, for the cable of 18/30kV 3×95 specification, the outer diameter of the wire core unit is 32.5mm. The plurality of wire core units are twisted to form the cable core structure.

Furthermore, in this example, the semiconductive adhesive layer 30 has conductive properties, which can ensure electrical continuity of the metal shielding layer 20. At the same time, the semiconductive adhesive layer can fill the gaps formed by weaving, avoiding the diffusion of harmful gases along the gaps formed by weaving which will pose a hidden danger to personnel safety.

By coating the semiconductive adhesive on the outside of the metal shielding layer, the method for manufacturing the medium-voltage cable provided in the example of the present invention ensures electrical continuity of the metal shielding layer and prevents harmful gases from flowing along the weaving gaps of the metal shielding layer, so effectively prevents harmful gases from leaking outside the cable and posing a hidden danger to personnel, thus the medium-voltage cable can be widely used in offshore Floating Production Storage and Offloading device, and the applicability of the medium-voltage cable is enhanced.

Hereunder the method for manufacturing the medium-voltage cable provided in the example of the present invention will be described in details:

A plurality of tinned conductor monofilaments are twisted to form the conductor 11 and continuous vulcanization production lines for co-extrusion of three layers (150+100+60) in sequence is used to simultaneously extrude the shielding layer 12, the insulation layer 13, and the insulation shielding layer 14 outside the conductor 11, so as to form the insulated wire core 10. The metal shielding layer 20 is formed by weaving with tinned copper wires having a nominal diameter of 0.2mm in a weaving density of not less than 80%. The metal shielding layer 20 is cladded around the outside of the insulated wire core 10, the semiconductive adhesive is coated on the outside of the metal shielding layer 20, and the aluminum-plastic composite tape is wrapped around the semiconductive adhesive while coating, wherein the overlap rate is not less than 25%. The coated semiconductive adhesive is cured about 6 hours after coating, and then the aluminum-plastic composite tape is removed. The plurality of wire core units are twisted to form the cable core structure.

The gaps in the cable core structure is filled with fillers 40, and the fillers 40 are non-mesh ultrathin polypropylene ropes with flat films, which can tightly fill the cable core structure, ensure the longitudinal airtightness of the cable core structure of the medium-voltage cable and prevent harmful gases from spreading along the axial direction of the medium-voltage cable to the safe area. A layer of non-woven fabric with a nominal thickness of 0.2mm is wrapped around the cable core structure to form the wrapping tape layer 50. The inner liner layer 60 formed by extruding low smoke halogen-free material is arranged outside the wrapping tape layer 50. The armoring layer 70 formed by weaving with tinned copper wires having a diameter of 0.4mm is arranged outside the

inner liner layer 60. The outer sheath layer 80 formed by extruding silane cross-linked low smoke halogen-free sheath material is arranged outside the armoring layer 70.

Furthermore, the processing requirements for producing the outer sheath layer 80 with silane crosslinking technology are extremely high. Pre-crosslinked scorched particles will be generated during the production process, and if the scorched particles remain in the screw or machine head and cannot be discharged in time, the scorched particles will gradually accumulate and eventually form large particles to be discharged together, which will form large particles on the surface of the sheath and even cause holes. After research, the main reason for occurrence of pre-crosslinking during the extrusion is the high extrusion temperature. Therefore, it is a difficult point for silane crosslinking to determine the minimum extrusion temperature at which the material can be fully plasticized. After several experiments and repeated adjustments to the process temperature, the optimal extrusion temperature is finally determined to be 145°C, 155°C, 160°C, 160°C, 165°C, 165°C, 165°C, 165°C, 165°C, 165°C. In order to avoid the accumulation of pre-crosslinked small particles in the screw and machine head, large machines are used for high-speed production. During the production process, the screw rotation speed is increased at intervals to push out the accumulated scorched particles in dead corners, thereby avoiding the generation of large scorched particles and broken holes.

Finally, it should be noted that the above examples are only used to illustrate the technical solutions of the present invention, and not to limit them; Although the present invention has been described in detail with reference to the aforementioned examples, those of ordinary skills in the art should understand that they can still modify the technical solutions described in the aforementioned examples, or equivalently replace some of the technical features; however, these modifications or replacements do not make the essence of the corresponding technical solutions deviate from the spirit and scope of technical solutions of the examples of the present invention.

Claims

1. A medium-voltage cable, characterized in that the medium-voltage cable comprises a plurality of wire core units, the plurality of wire core units are twisted into a cable core structure, each wire core unit includes:
an insulated wire core;
a metal shielding layer cladded around the outside of the insulated wire core;
a semiconductive adhesive layer cladded around the outside of the metal shielding layer, and the semiconductive adhesive layer is formed by curing semiconductive adhesive;
wherein, the medium-voltage cable is an airtight power cable with a rated voltage of 6kV to 30kV.
2. The medium-voltage cable according to claim 1, characterized in that the semiconductive adhesive consists of a first component and a second component, wherein, the first component comprises: methyl block room temperature vulcanized silicone rubber in 100 parts, ultrafine calcium carbonate in 30-45 parts, white carbon black in gas phase in 6-10 parts, titanium dioxide in 3-5 parts, graphene in 3-5 parts; and
the second component comprises: ethyl orthosilicate in 4-8 parts, N-butyl borate in 2-4 parts, N-butyl titanate in 2-4 parts, octyltin dilaurate in trace amounts, and gamma aminopropyltriethoxysilane in trace amounts.
3. The medium-voltage cable according to claim 1, characterized in that the medium-voltage cable further includes a plurality of fillers, the plurality of fillers are filled in the cable core structure and located between the plurality of wire core units, wherein, the fillers are non-mesh polypropylene ropes with flat film.
4. The medium-voltage cable according to claim 3, characterized in that the medium-voltage cable further includes a wrapping tape layer, the wrapping tape layer is cladded around the outside of the cable core structure.
5. The medium-voltage cable according to claim 4, characterized in that the medium-voltage cable further includes an inner liner layer, the inner liner layer is cladded around the outside of the wrapping tape layer, and the inner liner layer is a low smoke halogen-free polyolefin inner liner layer.
6. The medium-voltage cable according to claim 5, characterized in that the medium-voltage cable further includes an armoring layer cladded around the outside of the inner liner layer.
7. The medium-voltage cable according to claim 6, characterized in that the medium-voltage cable further includes an outer sheath layer cladded around the outside of the armoring layer, and the outer sheath layer is a silane cross-linked low smoke halogen-free outer sheath layer.
8. The medium-voltage cable according to claim 1, characterized in that the insulated wire core includes:
a conductor;
a shielding layer cladded around the outside of the conductor;
an insulation layer cladded around the outside of the shielding layer;
an insulation shielding layer cladded around the outside of the insulation layer.
9. The medium-voltage cable according to claim 1, characterized in that the metal shielding layer is formed by weaving with tinned copper wire.

10. A method for manufacturing the medium-voltage cable of claim 1, comprising:

coating semiconductive adhesive on the outside of the metal shielding layer to form a semiconductive adhesive layer, and wrapping the semiconductive adhesive layer with an aluminum-plastic composite tape while coating, wherein, the overlap rate of the aluminum-plastic composite tape is greater than 25% or equal to 25%;

removing the aluminum-plastic composite tape after the semiconductive adhesive layer is cured;

twisting the plurality of wire core units into the cable core structure.