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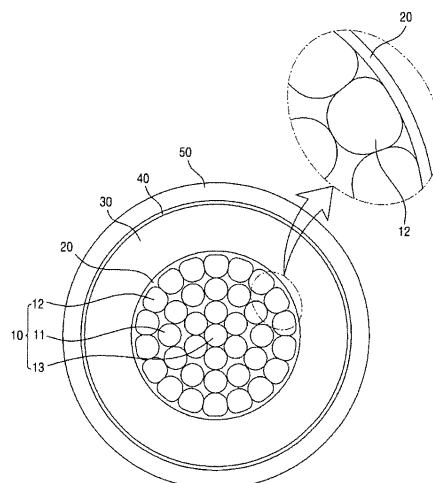
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(54) **POWER CABLE**

(57) Provided is a power cable. More particularly, the present invention relates to a power cable including an insulating layer formed of an insulating material which is eco-friendly and which has high heat resistance and mechanical strength while exhibiting high flexibility, bendability, impact resistance, cold resistance, installation property, workability, etc. which are in a tradeoff relationship with the heat resistance and the mechanical strength.

Fig. 3



Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a power cable. More particularly, the present invention relates to a power cable including an insulating layer formed of an insulating material which is eco-friendly and which has high heat resistance and mechanical strength while exhibiting high flexibility, bendability, impact resistance, cold resistance, installation property, workability, etc. which are in a tradeoff relationship with the heat resistance and the mechanical strength.

10 BACKGROUND ART

[0002] A general power cable includes a conductor and an insulating layer covering the conductor, and may further include an inner semiconducting layer between the conductor and the insulating layer, an outer semiconducting layer covering the insulating layer, and a sheath layer covering the outer semiconducting layer.

15 **[0003]** Recently, as power demand is increasing, a high-capacity cable is required to be developed. To this end, an insulating material is needed to manufacture an insulating layer having excellent mechanical and electrical characteristics.

[0004] Conventionally, a polyolefin-based polymer, such as polyethylene, an ethylene/propylene elastomeric copolymer (EPR), or an ethylene/propylene/diene copolymer (EPDM), is generally cross-linked and used as a base resin constituting the insulating material. This is because such a conventional cross-linked resin maintains high flexibility, satisfactory electrical and mechanical strength, etc. even at high temperatures.

20 **[0005]** However, the cross-linked polyethylene (XLPE) or the like used as the base resin of the insulating material is in a cross-linked form and thus is not eco-friendly, since it cannot be recycled and should be discarded by incineration when the lifespan of a cable having an insulating layer formed of the XLPE or the like comes to an end.

[0006] When used as a material of the sheath layer, polyvinyl chloride (PVC) is difficult to separate from the XLPE of the insulating material or the like, and is not eco-friendly since toxic chlorinated materials are generated during incineration.

25 **[0007]** In contrast, non-cross-linked high-density polyethylene (HDPE) or low-density polyethylene (LDPE) is eco-friendly since it is recyclable when the lifespan of a cable having an insulating layer formed thereof comes to an end, but is inferior to XLPE in terms of heat resistance. Thus, non-cross-linked HDPE or LDPE is only limited to certain purposes due to low operating temperatures thereof.

30 **[0008]** Thus, as disclosed in Korean Laid-Open Patent Publication Nos. 10-2014-0102408, 10-2014-0126993, and 10-2014-0128584, it may consider to use, as a base resin, a polypropylene resin which is an eco-friendly polymer having a melting point of 160 °C or higher and thus has high heat resistance without being cross-linked. However, since polypropylene resin has insufficient flexibility and bendability due to high rigidity thereof, the workability of installation of a cable having an insulating layer formed thereof is low and polypropylene resin is only limited to certain purposes.

35 **[0009]** FIGS. 1 and 2 schematically illustrate a cross section and a longitudinal section of a power cable of the related art to which an insulating layer including a polypropylene resin is applied.

[0010] As illustrated in FIGS. 1 and 2, the power cable of the related art as disclosed in Korean Laid-Open Patent Publication Nos. 10-2014-0102408, 10-2014-0126993, and 10-2014-0128584 includes a conductor 1, an inner insulating layer covering the conductor 1, an insulating layer 3 covering the inner semiconducting layer 2 and containing a non-cross-linked polypropylene resin as a base resin, an outer semiconducting layer 4 covering the insulating layer 3, a sheath layer 5 covering the outer semiconducting layer 4, etc.

40 **[0011]** Here, in order to achieve a compact cable having a reduced outer diameter, the conductor 1 may be a keystone conductor having a circular cross section, in which a plurality of wires each having a keystone-shaped cross section are arranged around a circular one wire in a circumferential direction of the cable to form a plurality of conductor layers as illustrated in FIGS. 1 and 2, or may be a circularly compressed conductor in which conductors of all layers are circularly compressed.

45 **[0012]** In addition, the conductor layers are alternately stranded, i.e., twisted, in an S-axis direction and a Z-axis direction in units of layers. Here, the circularly compressing of the conductors refers to compressing the conductors by passing them through a circular die smaller than outer diameters thereof outside the conductors when the conductors are stranded or by placing a concave semicircular roller or the like above and below the stranded conductors and applying pressure thereto from the outside. The conductors compressed circularly are referred to as circularly compressed conductors.

50 **[0013]** However, wires of the keystone conductor of the cable of the related art illustrated in FIGS. 1 and 2 or the circularly compressed conductor are arranged in extremely close contact with each other and thus gaps therebetween are minimized, thereby reducing the flexibility of the cable. Thus, the total flexibility of the cable deteriorates to a large extent due to the low flexibility of the conductor, in addition to the insulating layer formed of polypropylene resin having low flexibility. Accordingly, the workability of packaging, transportation, or installation of the cable is remarkably reduced.

55 **[0014]** In the cable of the related art illustrated in FIGS. 1 and 2, when an uncompressed common circular conductor

is used instead of the keystone conductor or the circularly compressed conductor, conductor layers are alternately twisted in the S-axis direction or the Z-axis direction in units of layers and thus total resistance of the conductor increases due to insufficient contact areas between the conductor layers. Thus, it is inevitable to increase a total outer diameter of the conductor so as to maintain the capacity of the cable.

[0015] Accordingly, a power cable which is eco-friendly, is inexpensive to manufacture, has high heat resistance and mechanical strength, and satisfies flexibility, bendability, impact resistance, cold resistance, installation property, workability, etc. which are in a tradeoff relationship with the high heat resistance and mechanical strength is in desperate need.

DETAILED DESCRIPTION OF THE INVENTION

TECHNICAL PROBLEM

[0016] The present invention is directed to an eco-friendly power cable.

[0017] The present invention is also directed to a power cable satisfying all of heat resistance and mechanical strength, and flexibility, bendability, impact resistance, cold resistance, installation property, workability, etc. which are in a tradeoff relationship with heat resistance and mechanical strength.

TECHNICAL SOLUTION

[0018] According to an aspect of the present invention, there is provided a power cable comprising: a stranded conductor including a plurality of wires; an inner semiconducting layer covering the stranded conductor; and an insulating layer covering the inner semiconducting layer, wherein the stranded conductor comprises a plurality of conductor layers formed by arranging a plurality of wires in a circumferential direction of a center wire, the plurality of conductor layers comprise: an outermost conductor layer; and at least one inner conductor layer inside the outermost conductor layer, and the inner conductor layer is not compressively deformed, and only the outermost conductor layer is circularly compressed as a whole.

[0019] According to an another aspect of the present invention, there is provided the power cable, wherein a space factor of the stranded conductor is 75 to 86%.

[0020] According to an another aspect of the present invention, there is provided the power cable, wherein a space factor of the outermost conductor layer is 90% or more.

[0021] According to an another aspect of the present invention, there is provided the power cable, wherein the plurality of wires included in the inner conductor layer have a circular cross section, and the plurality of wires included in the outermost conductor layer have a deformed circular or square cross section.

[0022] According to an another aspect of the present invention, there is provided the power cable, wherein the deformed circular shape comprises a curved trapezoidal shape, an oval shape, or a semicircular shape.

[0023] According to an another aspect of the present invention, there is provided the power cable, wherein the plurality of wires included in each of the plurality of conductor layers are united or stranded by being twisted in the same direction.

[0024] According to an another aspect of the present invention, there is provided the power cable, wherein, if the stranded conductor is an aluminum 1000 series conductor with a nominal cross sectional area of 185 SQ, a maximum load measured when the power cable is bent according to clause 2.4.24 of the standard HD 605 S2 is 1,500 N or less.

[0025] According to an another aspect of the present invention, there is provided the power cable, wherein the insulating layer comprises polypropylene as a base resin.

[0026] According to an another aspect of the present invention, there is provided the power cable, wherein the insulating layer comprises a non-cross-linked thermoplastic resin in which a polypropylene resin A and a heterophasic resin B are blended at a weight ratio (A:B) of 3:7 or 6:4, wherein, in the heterophasic resin B, a propylene copolymer is dispersed in a polypropylene matrix.

[0027] According to an another aspect of the present invention, there is provided the power cable, wherein the polypropylene resin A satisfies all of the following conditions a) to i):

- a) a density of 0.87 to 0.92 g/cm³, measured according to ISO 11883;
- b) a melting flow rate (MFR) of 1.7 to 1.9 g/10 min, measured under a load of 2.16 kg and at 230 °C according to ISO 1133;
- c) a tensile modulus of 930 to 980 MPa, measured at a tensile rate of 1 mm/min;
- d) a tensile stress at yield of 22 to 27 MPa, measured at a tensile rate of 50 mm/min;
- e) a tensile strain at yield of 13 to 15%, measured at a tensile rate of 50 mm/min;
- f) a charpy impact strength of 1.8 to 2.1 kJ/m² at 0 °C and of 5.5 to 6.5 kJ/m² at 23 °C;
- g) heat distortion temperature of 68 to 72 °C, measured under 0.45 MPa;
- h) a Vicat softening point of 131 to 136 °C, measured at 50 °C/h and 10 N according to the standard A50; and

i) Shore D hardness of 63 to 70, measured according to ISO 868.

[0028] According to another aspect of the present invention, there is provided the power cable, wherein the heterophasic resin B satisfies all of the following conditions a) to j):

- a) a density of 0.86 to 0.90 g/cm³, measured according to ISO 11883;
- b) a melting flow rate (MFR) of 0.1 to 1.0 g/10 min, measured under a load of 2.16 kg and at 230 °C according to ISO 1133;
- c) a tensile stress at break of 10 MPa or more, measured at a tensile rate of 50 mm/min;
- d) a tensile strain at break of 13 to 15%, measured at a tensile rate of 50 mm/min;
- e) bending strength of 95 to 105 MPa;
- f) notched izod impact strength of 68 to 72 kJ/m² at -40 °C;
- g) heat distortion temperature of 38 to 42 °C, measured under 0.45 MPa;
- h) a Vicat softening point of 55 to 59 °C, measured at 50 °C/h and 10 N according to the standard A50;
- i) Shore D hardness of 25 to 31, measured according to ISO 868; and
- j) a melting point of 155 to 170 °C.

[0029] According to another aspect of the present invention, there is provided the power cable, wherein the polypropylene resin A is a random propylene-ethylene copolymer containing an ethylene monomer in an amount of 1 to 5% by weight, based on the total weight of monomers, and the polypropylene matrix included in the heterophasic resin B is a propylene homopolymer.

[0030] According to another aspect of the present invention, there is provided the power cable, wherein the propylene copolymer included in the heterophasic resin B is a propylene-ethylene rubber (PER) particle containing an ethylene monomer in an amount of 20 to 50% by weight, based on the total weight of monomers, and having a particle size of 1 μm or less.

[0031] According to another aspect of the present invention, there is provided the power cable, wherein the content of the propylene copolymer is 60 to 80% by weight, based on the total weight of the heterophasic resin B.

[0032] According to another aspect of the present invention, there is provided the power cable, wherein the heterophasic resin B has a melting enthalpy of 25 to 40 J/g, measured by a differential scanning calorimetry (DSC).

[0033] According to another aspect of the present invention, there is provided the power cable, wherein the insulating layer further comprises a nucleating agent in an amount of 0.1 to 0.5 parts by weight, based on 100 parts by weight of the non-cross-linked thermoplastic resin, and the polypropylene resin A has a crystal size of 1 to 10 μm.

[0034] According to another aspect of the present invention, there is provided the power cable, wherein the insulating layer further comprises an insulating oil in an amount of 1 to 10 parts by weight, based on 100 parts by weight of the non-cross-linked thermoplastic resin.

[0035] According to another aspect of the present invention, there is provided the power cable, wherein the insulating layer further comprises one or more other additives selected from the group consisting of antioxidants, impact aids, heat stabilizers, nucleating agents and acid scavengers, the other additives being added in an amount of 0.001 to 10% by weight, based on the total weight of the insulating layer.

[0036] According to another aspect of the present invention, there is provided the power cable, wherein the non-cross-linked thermoplastic resin has a melting point T_m of 150 to 160 °C and a melting enthalpy of 30 to 80 J/g, the melting point T_m and the melting enthalpy being measured by a differential scanning calorimeter (DSC).

[0037] According to another aspect of the present invention, there is provided a power cable comprising a stranded conductor including a plurality of wires; an inner semiconducting layer covering the stranded conductor; and an insulating layer covering the inner semiconducting layer, wherein the stranded conductor comprises a plurality of conductor layers formed by arranging a plurality of wires in a circumferential direction of a center wire, the plurality of conductor layers comprise: an outermost conductor layer; and at least one inner conductor layer inside the outermost conductor layer, and the outermost conductor layer is circularly compressed as a whole, and at least one of the at least one inner conductor layer is not circularly compressed.

[0038] According to another aspect of the present invention, there is provided the power cable, wherein the insulating layer comprises polypropylene as a base resin.

ADVANTAGEOUS EFFECTS

[0039] A non-cross-linked propylene polymer is employed as a material of an insulating layer in a power cable according to the present invention, and thus, the power cable is eco-friendly and exhibits high heat resistance and mechanical strength.

[0040] In addition, the power cable according to the present invention exhibits excellent effects of satisfying all flexibility,

bendability, impact resistance, cold resistance, installation property, workability, etc., although an insulation layer formed of a propylene polymer having high rigidity is applied thereto due to a new design of a conductor structure.

DESCRIPTION OF THE DRAWINGS

[0041]

FIG. 1 is a schematic view of a cross section of an example of a power cable according to the related art.

FIG. 2 is a schematic view of a longitudinal section of the power cable according to the related art of FIG. 1.

FIG. 3 is a schematic view of a cross section of a power cable according to an embodiment of the present invention.

FIG. 4 is a schematic view of a longitudinal section of the power cable of FIG. 3.

FIG. 5 is a schematic view of a cross section of a power cable according to another embodiment of the present invention.

FIG. 6 is a diagram schematically illustrating a condition for calculation of a space factor of a conductor of a power cable according to the present invention.

FIG. 7 is a diagram schematically illustrating a condition for calculation of a space factor of an outermost side of a conductor of a power cable according to the present invention.

FIG. 8 is a schematic view of a cross section of an inner semiconducting layer in a stranded conductor formed by uniting conductor wires having a circular cross section.

FIG. 9 is a graph showing a result of conducting a bending test on cable specimens of embodiments of the present invention, according to clause 2.4.24 of the standard HD 605 S2.

MODE OF THE INVENTION

[0042] Hereinafter, exemplary embodiments of the present invention will be described in detail. The present invention is, however, not limited thereto and may be embodied in many different forms. Rather, the embodiments set forth herein are provided so that this disclosure will be thorough and complete, and fully convey the scope of the invention to those skilled in the art. Throughout the specification, the same reference numbers represent the same elements.

[0043] FIGS. 3 and 4 illustrate a cross section and a longitudinal section of a power cable according to an embodiment of the present invention.

[0044] As illustrated in FIGS. 3 and 4, the power cable according to the present invention includes a conductor 10 formed of a conductive material such as copper or aluminum, an insulating layer 30 formed of an insulating polymer or the like, an inner conducting layer 20 covering the conductor 10, removing an air layer between the conductor 10 and the insulating layer 30, and reducing local field concentration, an outer semiconducting layer 40 shielding cable and allowing an equal electric field to be applied to the insulating layer 30, a sheath layer 50 protecting the cable, etc.

[0045] The dimensions of the conductor 10, the insulating layer 30, the semiconductor layers 20 and 40, the sheath layer 50, etc. may vary according to use of the cable, a transmission voltage, or the like.

[0046] The conductor 10 may be a conductor formed by twisting a plurality of wires to improve the flexibility, bendability, installation property, workability, etc. of the power cable, and particularly includes a plurality of conductor layers formed by arranging a plurality of wires around a center wire in a circumferential direction of the center wire. In detail, the plurality of conductor layers may include an outermost conductor layer 12 and at least one inner conductor layer 11 inside the outermost conductor layer 12.

[0047] Here, one or more layers among the at least one inner conductor layer 11 are not circularly compressed and thus wires included therein have a circular cross section. In contrast, some conductor layers, including the outermost conductor layer 12, are circularly compressed and thus cross sections of wires included therein are changed into a deformed circular or square shape, e.g., a curved trapezoidal shape, an oval shape, a semicircular shape, a polygonal shape, or the like. Here, the curved trapezoidal shape refers to a fan-like shape into which a trapezoidal shape is bent such that wires are united or twisted in a circular shape as illustrated in FIG. 5.

[0048] When some conductor layers, including the outermost conductor layer 12, are compressed into the circular shape, a compressive force is applied to wires included in the uncompressed layers inside the compressed layers. Since

most of the compressive force is applied to the compressed layers and the remaining force is transmitted to the uncompressed layers through the compressed layers. Accordingly, the force is weakened and thus the wires of the uncompressed layers are slightly deformed and thus are maintained in an almost circular shape. Here, the circular shape is not a mathematically perfect circular shape and should be understood to mean a circular shape when viewed in its entirety at a glance. In the present invention, the term "circular shape" may be understood to include the former and the latter.

[0049] Since the wires of the uncompressed layers among the at least one inner conductor layer 11 have the circular cross sections, there are gaps between the wires and thus a space factor of the conductor 10 may be 75 to 86%, and preferably, 80 to 86%. Thus, deterioration of the flexibility, bendability, installation property, workability, etc. of the power cable due to the rigidity of the propylene polymer used to form the insulating layer of the power cable may be compensated for. Here, as illustrated in FIG. 6, the space factor of the conductor 10 refers to a ratio $(B/A \times 100)$ of the sum of cross-sectional areas of the wires of the stranded conductor 10 (an area B of a hatched region of the stranded conductor 10 which is a right diagram illustrated in FIG. 6) to a cross-sectional area of a single-wire conductor 10' (an area A of a hatched region of a left single-wire conductor 10' illustrated in FIG. 6) having an outer diameter D which is the same as an average outer diameter of the stranded conductor 10 formed of wires. Here, the average outer diameter of the stranded conductor 10 refers to an arithmetic mean diameter of a largest outer diameter and a smallest outer diameter of the stranded conductor 10.

[0050] When the space factor of the stranded conductor 10 is reduced as described above, the total outer diameter of the cable increases and thus the flexibility, etc. of the cable may deteriorate to some extent. The present invention has been completed by first improving that a degree of increase in the flexibility due to the gaps between the wires of the uncompressed layers is greater than a degree of decrease in the flexibility due to the reduction in the space factor. This is a new approach totally different from the power cable of the related art, in which a material of layers of the cable is replaced with a more flexible material or the thickness of a conductor or layers stacked on the conductor is reduced to improve flexibility.

[0051] Specifically, although an insulating layer of the power cable according to the present invention is formed of a composition including a polypropylene resin as a base resin due to the design of a conductor as described above, the flexibility of the power cable (a maximum load required when bent) was high, i.e., about 1,500 N or less, when measured in accordance with clause 2.4.24 of the standard HD 605 S2 with respect to a 12/20 kV cable with aluminum 1000 series conductors having a nominal cross-sectional area of 185 SQ.

[0052] The wires of the outermost conductor layer 12 are compressed into the circular shape as a whole and thus the cross sections of outermost wires are deformed, thereby reducing gaps between the wires. Thus, even when the inner semiconducting layer 20 is formed to a thin thickness on an outer surface of the outermost conductor layer 12 as illustrated in FIG. 3, the inner semiconducting layer 20 is formed into a circular shape having no curvature as a whole, so that a non-uniform electric field and local electric field concentration may be prevented when the power cable is bent. Here, the space factor of the outermost conductor layer 12 may be 90% or more, and preferably 93% or more. As illustrated in FIG. 7, the space factor of the outermost conductor layer 12 is defined as a ratio $(B'/A' \times 100)$ of the sum of cross-sectional areas of the wires of the outermost conductor layer 12 (an area B' of a hatched region of a right stranded conductor 10 illustrated in FIG. 7) to a cross-sectional area A' of a donut-shaped imaginary band having an outer diameter D and an inner diameter d which are respectively the same as the average outer diameter and the average inner diameter of the outermost conductor layer 12. Here, the average outer diameter of the outermost conductor layer 12 refers to an arithmetic mean outer diameter of a largest outer diameter and a smallest outer diameter of the outermost conductor layer 12, and the average inner diameter of the outermost conductor layer 12 refers to an arithmetic mean inner diameter of a largest inner diameter and a smallest inner diameter of the outermost conductor layer 12.

[0053] As illustrated in FIG. 8, when wires included in an outermost conductor layer 120 are not circularly compressed and thus have circular cross sections like those of wires included in an inner conductor layer 110, gaps between the wires are large. Thus, when the inner semiconducting layer 200 is extruded on an outer surface of the outermost conductor layer 120, the inner semiconducting layer 200 is formed filling the gaps between the wires and thus cannot be formed in a circular shape as a whole. Therefore, a non-uniform electric field and local electric field concentration are not sufficiently reduced by the inner semiconducting layer 200, and a thickness of the inner semiconducting layer 200 should be increased to form the inner semiconducting layer 200 in a circular shape as a whole. However, in this case, an outer diameter of the power cable unnecessarily increases. Here, when the space factor of the outermost conductor layer 120 is less than 90%, the outermost conductor layer 120 may not be exactly circularly compressed and thus cannot sufficiently reduce the electric field concentration.

[0054] Furthermore, as described above, when gaps between wires of a stranded conductor increase and thus a total space factor of the stranded conductor decreases, a contact area between the wires of the conductor is small and the total resistance of the conductor of the cable may increase.

[0055] To improve the problem, the plurality of conductor layers included in the stranded conductor 10 may be formed by stranding (twisting) them in the same direction, i.e., the S-axis direction or the Z-axis direction.

[0056] Even if only the conductors of an outermost layer are circularly compressed and wires of an inner layer are maintained in the original shape without being circularly compressed, a contact area between wires of interlayer conductors reduces and the resistance of the conductor relatively increases when conductor layers are alternately twisted in the S-axis direction and the Z-axis direction in units of layers as in the related art illustrated in FIG. 2. In the present invention, since directions in which conductor layers are stranded are the same and thus wires of interlayer conductors may be stranded in continuous contact with each other, a contact area between the wires of the conductor of each conductor layer increases and thus an increase in resistance of the inner conductor layer 12 due to a low space factor thereof may be compensated for. Here, if the space factor of the conductor 10 is 86% or more, the flexibility of the cable cannot be secured. If when the space factor of the conductor 10 is 75% or less, a resistance of the conductor 10 increases and thus a satisfactory resistance of the conductor 10 cannot be secured even when the conductor layers are stranded in the same direction as described above. Thus, in order to reduce the resistance to an appropriate level, the size of the conductor 10 need to be increased but the flexibility thereof deteriorates and thus the cable is difficult to handle in terms of insulation, transport, etc., when the size of the conductor 10 is large.

[0057] The insulating layer 30 of the power cable according to the present invention may include a non-cross-linked thermoplastic resin in which (A) a polypropylene resin and (B) a heterophasic resin in which a propylene copolymer is dispersed in a polypropylene matrix are blended.

[0058] The polypropylene resin A may include a propylene homopolymer and/or a propylene copolymer, and preferably, the propylene copolymer alone. The propylene homopolymer refers to polypropylene formed by polymerization of propylene contained in an amount of 99% by weight or more, and preferably, 99.5% by weight or more, based on the total weight of monomers.

[0059] The propylene copolymer may include propylene with ethylene or α -olefin having 4 to 12 carbon atoms, e.g., a comonomer selected from among 1-butene, 1-pentene, 4-methyl-1-pentene, 1-hexene, 1-octene, 1-decene, 1-dodecene, and a combination thereof, and preferably, a copolymer with ethylene. When propylene and ethylene are copolymerized, a hard and flexible property is exhibited.

[0060] The propylene copolymer may include a random propylene copolymer and/or a block propylene copolymer, preferably, the random propylene copolymer, and more preferably, the random propylene copolymer only. The random propylene copolymer refers to a propylene copolymer formed by alternately arranging a propylene monomer and another olefin monomer. The random propylene copolymer is preferably a random propylene copolymer including an ethylene monomer in an amount of 1 to 10% by weight, preferably, 1 to 5% by weight, and more preferably, 3 to 4% by weight, based on the total weight of the monomers.

[0061] The random propylene copolymer preferably has a density of 0.87 to 0.92 g/cm³ (measured according to ISO 11883), a melting flow rate (MFR) of 1.7 to 1.9 g/10 min (measured under a load of 2.16 kg at 230 °C according to ISO 1133), a tensile modulus of 930 to 980 MPa (measured at a tensile rate of 1 mm/min), a tensile stress of 22 to 27 MPa (measured at a tensile rate of 50 mm/min), a tensile strain of 13 to 15% (measured at a tensile rate of 50 mm/min), a Charpy impact strength of 1.8 to 2.1 kJ/m² at 0 °C, a Charpy impact strength of 5.5 to 6.5 kJ/m² at 23 °C, a thermal deformation temperature of 68 to 72 °C (measured under 0.45 MPa), a Vicat softening point of 131 to 136 °C (measured at 50 °C/h and 10 N according to standard A50), and Shore D hardness of 63 to 70 (measured according to ISO 868).

[0062] The random propylene copolymer may improve the mechanical strength, such as the tensile strength, of the insulating layer 30 to be formed, is suitable for a transparent molded product due to high transparency thereof, has a relatively high crystallization temperature T_c and thus shorten a cooling time after the extrusion of the insulating layer 30, thereby improving the yield of the cable and minimizing the shrinkage and thermal deformability of the insulating layer 30, and is relatively cheap and thus reduces manufacturing costs of the cable.

[0063] The polypropylene resin A may have a weight average molecular weight (M_w) of 200,000 to 450,000. Furthermore, the polypropylene resin A may have a melting point T_m of 140 to 175 °C (measured by a differential scanning calorimeter (DSC)), a melting enthalpy of 50 to 100 J/g (measured by the DSC), and bending strength of 30 to 1,000 MPa, and preferably, 60 to 1,000 MPa at room temperature (measured according to ASTM D790).

[0064] The polypropylene resin A may be polymerized under general stereospecific Ziegler-Natta catalyst, metallocene catalyst, constraining geometry catalyst, other organometallic or coordination catalysts, and preferably, Ziegler-Natta catalyst or metallocenes catalyst. Here, metallocene is a generic name of a bis(cyclopentadienyl) metal which is a novel organometallic compound in which cyclopentadiene and a transition metal are bonded in a sandwich structure. A general formula of a simplest structure thereof is M(C₅H₅)₂ (here, M represents Ti, V, Cr, Fe, Co, Ni, Ru, Zr, Hf, or the like). Polypropylene polymerized under the metallocene catalyst has a low residual catalyst amount of about 200 to 700 ppm and thus the deterioration of the electrical characteristics of an insulating composition containing polypropylene may be suppressed or minimized due to the low residual catalyst amount.

[0065] Although the polypropylene resin A is in a non-cross-linked form, the polypropylene resin A exhibits sufficient heat resistance due to a high melting point thereof and thus a power cable having an improved continuous use temperature may be provided. Furthermore, since the polypropylene resin A is in the non-cross-linked form, it is recyclable and thus is eco-friendly. In contrast, a conventional cross-linked resin is difficult to recycle and thus is not eco-friendly, and does

not exhibit uniform production capability and thus may cause deterioration of long-term extrudability when crosslinking or scorch occurs early during the formation of the insulating layer 30.

[0066] In the heterophasic resin B in which the propylene copolymer is dispersed in the polypropylene matrix, the polypropylene matrix may be the same as or different from the polypropylene resin A, and may preferably include a propylene homopolymer, and more preferably, the propylene homopolymer alone.

[0067] In the heterophasic resin B, the propylene copolymer dispersed in the polypropylene matrix (hereinafter referred to as 'dispersed propylene copolymer') is substantially amorphous. Here, the amorphous propylene copolymer means that the propylene copolymer has a residual crystallinity with a melting enthalpy of less than 10 J/g. The dispersed propylene copolymer may include at least one comonomer selected from the group consisting of ethylene and C₄₋₈ α -olefin such as 1-butene, 1-pentene, 4-methyl-1-pentene, 1-hexene, 1-heptene, or 1-octene.

[0068] The content of the dispersed propylene copolymer may be 60 to 90% by weight, and preferably, 65 to 80% by weight, based on the total weight of the heterophasic resin B. Here, the flexibility, bendability, impact resistance, cold resistance, etc. of the insulating layer 30 formed may be insufficient when the content of the dispersed propylene copolymer is less than 60% by weight, whereas the heat resistance, mechanical strength, etc. of the insulating layer 30 may be insufficient when the content of the dispersed propylene copolymer is greater than 90% by weight.

[0069] The dispersed propylene copolymer may be propylene-ethylene rubber (PER) or propylene-ethylene diene rubber (EPDM) containing an ethylene monomer in an amount of 20 to 50% by weight, and preferably, 30 to 40% by weight, based on the total weight of the monomers. The flexibility, bendability, and impact resistance of the insulating layer 30 may be high but the cold resistance thereof may be insufficient when the content of the ethylene monomer is less than 20% by weight, whereas the cold resistance, heat resistance, and mechanical strength of the insulating layer 30 may be high but the flexibility thereof may deteriorate when the content of the ethylene monomer is greater than 50% by weight.

[0070] In the present invention, the dispersed propylene copolymer may have a particle size of 1 μ m or less, preferably, 0.9 μ m or less, and more preferably, 0.8 μ m or less. Due to the particle size of the dispersed propylene copolymer, uniform dispersion of the dispersed propylene copolymer in the polypropylene matrix may be ensured and the impact strength of the insulating layer 30 including the dispersed propylene copolymer may be improved. In addition, due to the particle size, the likelihood of stopping already formed cracks or cracks may be increased while reducing the risk of cracks caused by the particles.

[0071] The heterophasic resin B may have a melting flow rate (MFR) of 0.2 to 1.0 g/10 min, and preferably, 0.8 g/10 min (measured under a load of 2.16 kg and at 230 °C according to ISO 1133); a tensile stress at break of 10 MPa or more; a tensile strain at break of 490% or more, a bending strength of 95 to 105 MPa, a notched izod impact strength of 68 to 72 kJ/m² when measured at -40 °C, thermal deformation temperature of 38 to 42 °C (measured under 0.45 MPa), a Vicat softening point of 55 to 59 °C (measured at 50 °C/h and 10 N according to A50), Shore D hardness of 25 to 31 (measured according to ISO 868), a melting point T_m of 155 to 170 °C (measured by the DSC), and a melting enthalpy of 25 to 40 J/g (measured by the DSC).

[0072] The density of the heterophasic resin B may be 0.86 to 0.90 g/cm³, and preferably, 0.88 g/cm³, when measured according to the ISO 11883. The characteristics, e.g., impact strength and a shrinkage property, of the insulating layer 30 are influenced by the density of the heterophasic resin B.

[0073] The heterophasic resin B contains non-cross-linked polypropylene and thus is recyclable and eco-friendly, may improve the heat resistance of the insulating layer 30 formed of the polypropylene matrix having high heat resistance, and may improve the flexibility, bending property, impact resistance, cold resistance, installation property, workability, etc. of the insulating layer 30 which deteriorate due to the rigidity of the polypropylene resin A.

[0074] The weight ratio (A: B) between the polypropylene resin A and the heterophasic resin B may be 3:7 to 6:4, and preferably, 5:5. When the weight ratio is less than 3:7, the mechanical strength, e.g., tensile strength, of the insulating layer 30 may be insufficient. When the weight ratio is greater than 6:4, the flexibility, bendability, impact resistance, cold resistance, etc. of the insulating layer 30 may be insufficient.

[0075] Due to a combination of the polypropylene resin A exhibiting high heat resistance and mechanical strength and the heterophasic resin B exhibiting high heat resistance, flexibility, bendability, impact resistance, cold resistance, installation property, workability, etc. and the compatibility thereof, the non-cross-linked thermoplastic resin contained in the insulating layer 30 of the power cable according to the present invention has an excellent effect of achieving all the above-described features which are in a tradeoff relationship with each other, i.e., heat resistance and mechanical strength and flexibility, bendability, impact resistance, cold resistance, installation property, workability, etc.

[0076] Here, the non-cross-linked thermoplastic resin may have a melting point T_m of 150 to 160 °C (measured by the DSC) and a melting enthalpy of 30 to 80 J/g (measured by the DSC).

[0077] When the melting enthalpy of the non-cross-linked thermoplastic resin is less than 30 J/g, it means that the non-cross-linked thermoplastic resin has a small crystal size and low crystallinity and the heat resistance and mechanical strength of the cable are low. When the melting enthalpy exceeds 80 J/g, it means that the non-cross-linked thermoplastic resin has a large crystal size and high crystallinity and the electrical characteristics of the insulating layer 30 may

deteriorate.

[0078] In the present invention, the insulating layer 30 may further include a nucleating agent, as well as the non-cross-linked thermoplastic resin. The nucleating agent may be a sorbitol-based nucleating agent. That is, the nucleating agent is a sorbitol-based nucleating agent, such as 1,3: 2,4-bis(3,4-dimethyldibenzylidene) sorbitol, bis(p-methyldibenzylidene) sorbitol, substituted dibenzylidene sorbitol, or a mixture thereof.

[0079] The nucleating agent may accelerate the curing of the non-cross-linked thermoplastic resin even when not quenched during a cable extrusion process, thereby improving the productivity of a cable, electrical characteristics of an insulating layer may be improved by limiting a size of crystals generated during the curing of the non-cross-linked thermoplastic resin to 1 to 10 μm , and crystallinity may be increased by forming a plurality of crystallization sites at which crystals are formed, thereby improving all the heat resistance, mechanical strength, etc. of the insulating layer.

[0080] Since the nucleating agent has a high melting temperature, injection and extrusion processing should be performed at a high temperature of about 230 °C and two or more sorbitol-based nucleating agents are preferably used in combination. When two or more different sorbitol-based nucleating agents are used in combination, the expression of the nucleating agents may be enhanced even at a low temperature.

[0081] The nucleating agent may be contained in an amount of 0.1 to 0.5 parts by weight, based on 100 parts by weight of the non-cross-linked thermoplastic resin. When the content of the nucleating agent is less than 0.1 part by weight, the heat resistance and electrical/mechanical strength of the non-cross-linked thermoplastic resin and the insulating layer containing the same may deteriorate due to a large crystal size, e.g., a crystal size greater than 10 μm and a non-uniform distribution of crystals. In contrast, when the content of the nucleating agent is greater than 0.5 part by weight, a surface interface area between a crystal and an amorphous portion of the resin increases due to an extremely small crystal size, e.g., a crystal size of less than 1 μm , and thus AC dielectric breakdown (ACBD) characteristics, impulse characteristics, etc. of the non-cross-linked thermoplastic resin and the insulating layer containing the same may deteriorate.

[0082] In the present invention, the insulating layer 30 may further include insulating oil.

[0083] The insulating oil may be mineral oil, synthetic oil, or the like. In particular, the insulating oil may be an aromatic oil including an aromatic hydrocarbon compound, such as dibenzyltoluene, alkylbenzene, or alkyldiphenylethane, a paraffinic oil including a paraffinic hydrocarbon compound, a naphthenic oil including a naphthenic hydrocarbon compound, silicon oil, or the like.

[0084] The content of the insulating oil may be 1 to 10 parts by weight, and preferably, 1 to 7.5 parts by weight, based on 100 parts by weight of the non-cross-linked thermoplastic resin. When the content of the insulating oil is greater than 10 parts by weight, the insulating oil may be eluted during the extrusion process of forming the insulating layer 30 on the conductor 10, thus making it difficult to process the cable.

[0085] As described above, the insulating oil may additionally improve the flexibility, bendability, etc. of the insulating layer 30 formed of, as a base resin, a polypropylene resin having high rigidity and slightly low flexibility, thereby facilitating the installation of a cable, and at the same time exhibits an excellent effect of maintaining or improving the high heat resistance and intrinsic mechanical and electrical properties of the polypropylene resin. In particular, the insulating oil exhibits an excellent effect of supplementing deterioration of processability due to a narrow molecular weight distribution when the polypropylene resin is polymerized under the metallocene catalyst.

[0086] In the present invention, the insulating layer 30 may further include other additives such as an antioxidant, a shock absorber, a heat stabilizer, a nucleating agent, and acid scavengers. The other additives may be added in an amount of 0.001 to 10% by weight, based on the total weight of the insulating layer 30, according to the type thereof.

[0087] The inner semiconducting layer 20 may include, as a base resin, a blending resin of the heterophasic resin B in which a propylene copolymer is dispersed in the polypropylene matrix and another heterophasic resin B'. Here, similarly, the heterophasic resin B' is a heterophasic resin in which a propylene copolymer is dispersed in a polypropylene matrix but the polypropylene matrix includes a propylene random copolymer. Thus, the heterophasic resin B' has a lower melting point and a higher melting flow rate (MFR) than those of the heterophasic resin B. For example, the melting point of the heterophasic resin B' may be 140 to 150 °C, and the higher melting flow rate (MFR) thereof measured under a load of 2.16 kg and at 230 °Cm according to the ISO 1133 may be 6 and 8 g/10 min.

[0088] The content of the heterophasic resin B may be 50 to 80 parts by weight and the content of the heterophasic resin B' may be 20 to 50 parts by weight, based on 100 parts by weight of the base resin. Carbon black may be further provided in an amount of 35 to 70 parts by weight, and an antioxidant may be further provided in an amount of 0.2 to 3 parts by weight.

[0089] When the content of the heterophasic resin B is less than 50 parts by weight and the content of the heterophasic resin B' is greater than 50 parts by weight, the heat resistance and elongation of the inner semiconducting layer 20 may deteriorate to a large extent. When the content of the heterophasic resin B is greater than 80 parts by weight and the content of the heterophasic resin B' is less than 20 parts by weight, the viscosity of the composition of the inner semiconducting layer 20 increases and thus a screw load may increase when extruded, thereby greatly reducing workability.

[0090] When the content of the carbon black is less than 35 parts by weight, the semiconducting property of the inner

semiconducting layer 20 may not be realized, whereas when the content of the carbon black is greater than 70 parts by weight, the viscosity of the inner semiconducting layer 20 increases and thus the screw load may increase when extruded, thereby greatly reducing workability.

[0091] When the content of the antioxidant is less than 0.2 parts by weight, it may be difficult to secure long-term heat resistance of the power cable in a high-temperature environment. In contrast, when the content of the antioxidant is greater than 3 parts by weight, a blooming phenomenon that the antioxidant is eluted to a surface of the inner semiconducting layer 20 in white may occur and thus the semiconducting properties may deteriorate.

[0092] The outer semiconducting layer 40 may include a blending resin of the heterophasic resin B and an ethylene copolymer resin as a base resin. The ethylene copolymer resin may include, for example, ethylene butyl acrylate (EBA), ethylene vinyl acetate (EVA), ethylene ethyl acrylate (EEA), ethylene methyl acrylate (EMA), or a combination thereof.

[0093] Here, the content of the heterophasic resin B may be 10 to 40 parts by weight and the content of the ethylene copolymer resin may be 60 to 90 parts by weight, based on 100 parts by weight of the base resin, and 35 to 70 parts by weight of carbon black, 0.2 to 3 parts by weight of an antioxidant, and the like may be further provided.

[0094] Here, when the content of the heterophasic resin B is less than 10 parts by weight and the content of the ethylene copolymer resin is greater than 90 parts by weight, it may be difficult to secure the heat resistance of the power cable in a high-temperature environment and the adhesion of the outer semiconducting layer 40 to the insulating layer 30 may be greatly reduced. When the content of the heterophasic resin B is less than 40 parts by weight and the content of the ethylene copolymer resin is less than 60 parts by weight, the ease of peeling the outer semiconducting layer 40 from the insulating layer 30 may be greatly reduced.

[0095] When the content of the carbon black is less than 35 parts by weight, the semiconducting property of the outer semiconducting layer 20 may not be realized. When the content of the carbon black is greater than 70 parts by weight, the viscosity of the composition of the outer semiconducting layer 20 increases and thus the screw load increases when extruded, thereby greatly reducing workability.

[0096] When the content of the antioxidant is less than 0.2 parts by weight, the long-term heat resistance of the power cable may be difficult to secure in a high-temperature environment. When the content of the antioxidant is greater than 3 parts by weight, the blooming phenomenon that the antioxidant is eluted to a surface of the inner semiconducting layer 20 in white may occur and thus the semiconducting properties may deteriorate.

[Examples]

[0097] Power cable specimens shown in Table 1 below were prepared, the flexibility thereof was evaluated by measuring a maximum magnitude of force required when bent according to clause 2.4.24 of the HD 605 S2 standard, and a conductor resistance was measured by a mellowing method of applying a uniform current to wires of a conductor of each of the specimens. A load required according to a sag length indicating a degree to which each of the power cable specimens sagged due to load when the power cable specimens were bent for the evaluation of flexibility is as illustrated in FIG. 9.

[Table 1]

		Example	Comparative example
Conductor structure	aluminum	Aluminum 1000 series	Aluminum 1000 series
	Circular compression	Only outermost layer was circularly compressed	All layers were circularly compressed
	Space factor of outermost layer	94%	94%
	Total space factor	80%	94%
Conductor outer diameter (mm)		15.81	15.89
Diameter of wire (mm) first layer/second layer/outermost layer		2.46/2.35/2.42	2.68/2.52/2.32
Weight (g/m)		475.6	491.6
Pitch direction First layer/second layer/outermost layer		S/S/S	S/Z/S
Pitch (mm) First layer/second layer/outermost layer		194.8/194.4/195.4	156/206.5/207.2

(continued)

	Example	Comparative example
Material of insulating layer	polypropylene	polypropylene
Flexibility (maximum magnitude of force)	about 1,200 N	about 2,100 N
Conductor resistance (Ω/km)	0.16164	0.16075
*Since the conductor resistances of the example and the comparative example were 0.164 or less, nominal cross-sectional areas thereof are the same, i.e., 185 SQ (the nominal cross-sectional areas are in accordance with the IEC 60228 standard).		

[0098] As illustrated in Table 1 above and FIG. 9, in the power cable of the example of the present invention specifically designed in units of layers of a stranded conductor including a plurality of conductor layers, although an insulating layer was formed of a polypropylene resin that is stiff and inflexible, the flexibility of the power cable was high and an increase in resistance was minimized by applying the same pitch direction in which conductor layers were twisted in conductor layers. In contrast, the flexibility of the power cable of the comparative example was very low since a whole stranded conductor was simply circularly compressed.

[0099] While the present invention has been described above with respect to exemplary embodiments thereof, it would be understood by those skilled in the art that various changes and modifications may be made without departing from the technical conception and scope of the present invention defined in the following claims. Thus, it is clear that all modifications are included in the technical scope of the present invention as long as they include the components as claimed in the claims of the present invention.

Claims

1. A power cable comprising:

a stranded conductor including a plurality of wires;
 an inner semiconducting layer covering the stranded conductor;
 and
 an insulating layer covering the inner semiconducting layer,
 wherein the stranded conductor comprises a plurality of conductor layers formed by arranging a plurality of
 wires in a circumferential direction of a center wire,
 the plurality of conductor layers comprise:

an outermost conductor layer; and
 at least one inner conductor layer inside the outermost conductor layer, and
 the inner conductor layer is not compressively deformed, and
 only the outermost conductor layer is circularly compressed as a whole.

2. The power cable of claim 1, wherein a space factor of the stranded conductor is 75 to 86%.

3. The power cable of claim 2, wherein a space factor of the outermost conductor layer is 90% or more.

4. The power cable of claim 3, wherein the plurality of wires included in the inner conductor layer have a circular cross section, and
 the plurality of wires included in the outermost conductor layer have a deformed circular or square cross section.

5. The power cable of claim 4, wherein the deformed circular shape comprises a curved trapezoidal shape, an oval shape, or a semicircular shape.

6. The power cable of any one of claims 1 to 5, wherein the plurality of wires included in each of the plurality of conductor layers are united or stranded by being twisted in the same direction.

7. The power cable of any one of claims 1 to 5, wherein, if the stranded conductor is an aluminum 1000 series conductor with a nominal cross sectional area of 185 SQ, a maximum load measured when the power cable is bent according

to clause 2.4.24 of the standard HD 605 S2 is 1,500 N or less.

8. The power cable of any one of claims 1 to 5, wherein the insulating layer comprises polypropylene as a base resin.

9. The power cable of claim 8, wherein the insulating layer comprises a non-cross-linked thermoplastic resin in which a polypropylene resin A and a heterophasic resin B are blended at a weight ratio (A:B) of 3:7 or 6:4, wherein, in the heterophasic resin B, a propylene copolymer is dispersed in a polypropylene matrix.

10. The power cable of claim 9, wherein the polypropylene resin A satisfies all of the following conditions a) to i):

- a) a density of 0.87 to 0.92 g/cm³, measured according to ISO 11883;
- b) a melting flow rate (MFR) of 1.7 to 1.9 g/10 min, measured under a load of 2.16 kg and at 230 °C according to ISO 1133;
- c) a tensile modulus of 930 to 980 MPa, measured at a tensile rate of 1 mm/min;
- d) a tensile stress at yield of 22 to 27 MPa, measured at a tensile rate of 50 mm/min;
- e) a tensile strain at yield of 13 to 15%, measured at a tensile rate of 50 mm/min;
- f) a charpy impact strength of 1.8 to 2.1 kJ/m² at 0 °C and of 5.5 to 6.5 kJ/m² at 23 °C;
- g) heat distortion temperature of 68 to 72 °C, measured under 0.45 MPa;
- h) a Vicat softening point of 131 to 136 °C, measured at 50 °C/h and 10 N according to the standard A50; and
- i) Shore D hardness of 63 to 70, measured according to ISO 868.

11. The power cable of claim 9, wherein the heterophasic resin B satisfies all of the following conditions a) to j):

- a) a density of 0.86 to 0.90 g/cm³, measured according to ISO 11883;
- b) a melting flow rate (MFR) of 0.1 to 1.0 g/10 min, measured under a load of 2.16 kg and at 230 °C according to ISO 1133;
- c) a tensile stress at break of 10 MPa or more, measured at a tensile rate of 50 mm/min;
- d) a tensile strain at break of 13 to 15%, measured at a tensile rate of 50 mm/min;
- e) bending strength of 95 to 105 MPa;
- f) notched izod impact strength of 68 to 72 kJ/m² at -40 °C;
- g) heat distortion temperature of 38 to 42 °C, measured under 0.45 MPa;
- h) a Vicat softening point of 55 to 59 °C, measured at 50 °C/h and 10 N according to the standard A50;
- i) Shore D hardness of 25 to 31, measured according to ISO 868; and
- j) a melting point of 155 to 170 °C.

12. The power cable of claim 9, wherein the polypropylene resin A is a random propylene-ethylene copolymer containing an ethylene monomer in an amount of 1 to 5% by weight, based on the total weight of monomers, and the polypropylene matrix included in the heterophasic resin B is a propylene homopolymer.

13. The power cable of claim 9, wherein the propylene copolymer included in the heterophasic resin B is a propylene-ethylene rubber (PER) particle containing an ethylene monomer in an amount of 20 to 50% by weight, based on the total weight of monomers, and having a particle size of 1 µm or less.

14. The power cable of claim 13, wherein the content of the propylene copolymer is 60 to 80% by weight, based on the total weight of the heterophasic resin B.

15. The power cable of claim 9, wherein the heterophasic resin B has a melting enthalpy of 25 to 40 J/g, measured by a differential scanning calorimetry (DSC).

16. The power cable of claim 9, wherein the insulating layer further comprises a nucleating agent in an amount of 0.1 to 0.5 parts by weight, based on 100 parts by weight of the non-cross-linked thermoplastic resin, and the polypropylene resin A has a crystal size of 1 to 10 µm.

17. The power cable of claim 9, wherein the insulating layer further comprises an insulating oil in an amount of 1 to 10 parts by weight, based on 100 parts by weight of the non-cross-linked thermoplastic resin.

18. The power cable of claim 9, wherein the insulating layer further comprises one or more other additives selected from the group consisting of antioxidants, impact aids, heat stabilizers, nucleating agents and acid scavengers, the

other additives being added in an amount of 0.001 to 10% by weight, based on the total weight of the insulating layer.

5 19. The power cable of claim 9, wherein the non-cross-linked thermoplastic resin has a melting point T_m of 150 to 160 °C and a melting enthalpy of 30 to 80 J/g, the melting point T_m and the melting enthalpy being measured by a differential scanning calorimeter (DSC).

10 20. A power cable comprising
a stranded conductor including a plurality of wires;
an inner semiconducting layer covering the stranded conductor; and
an insulating layer covering the inner semiconducting layer, wherein the stranded conductor comprises a plurality
of conductor layers formed by arranging a plurality of wires in a circumferential direction of a center wire,
the plurality of conductor layers comprise:

15 an outermost conductor layer; and
at least one inner conductor layer inside the outermost conductor layer, and
the outermost conductor layer is circularly compressed as a whole, and at least one of the at least one inner
conductor layer is not circularly compressed.

20 21. The power cable of claim 20, wherein the insulating layer comprises polypropylene as a base resin.

Fig. 1

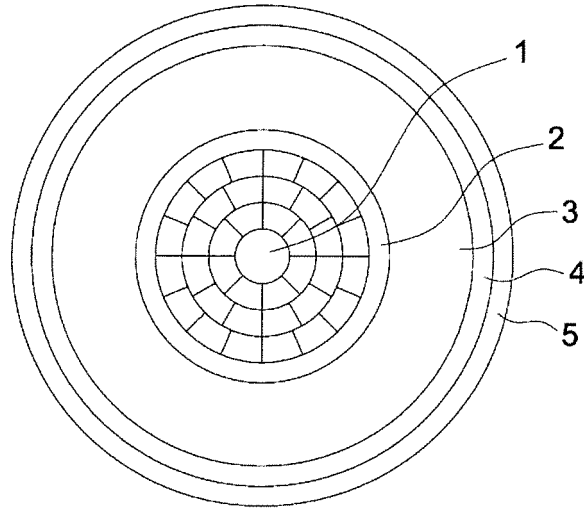


Fig. 2

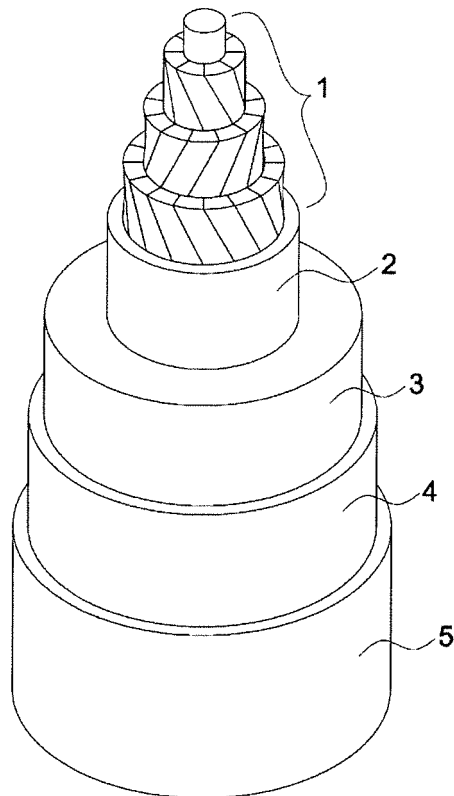


Fig. 3

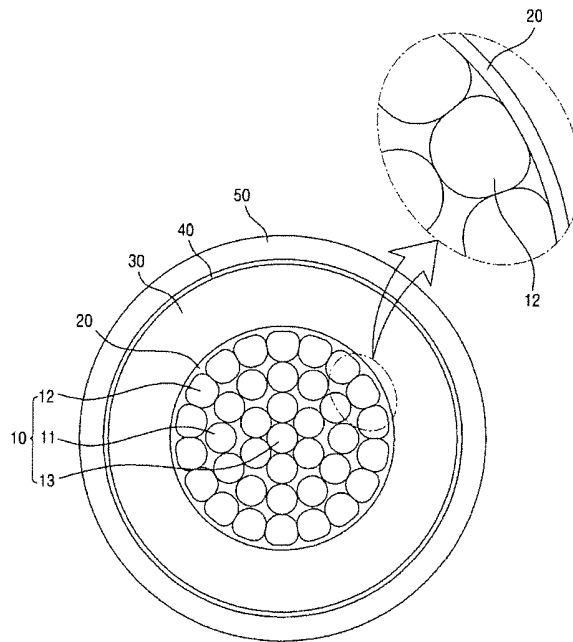


Fig. 4

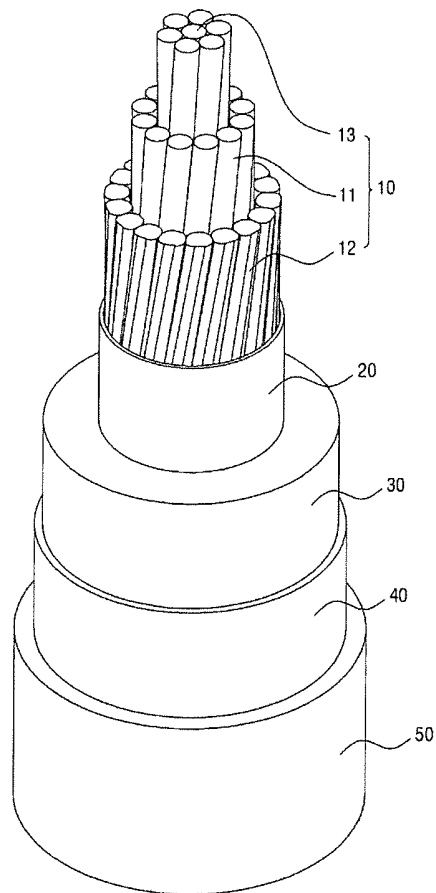


Fig. 5

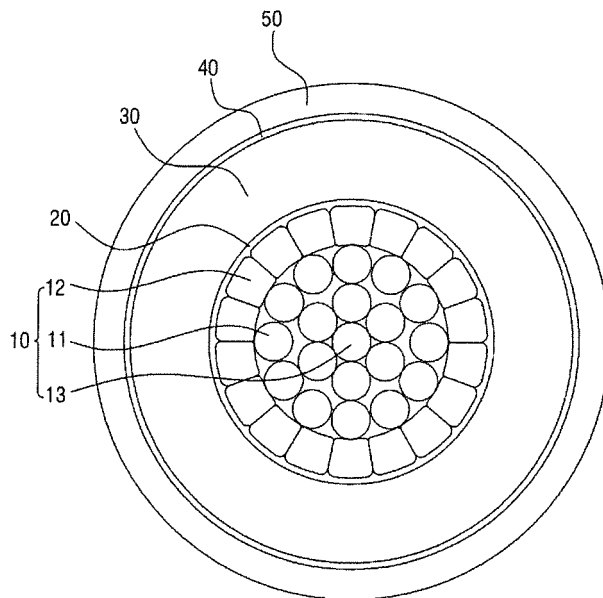


Fig. 6

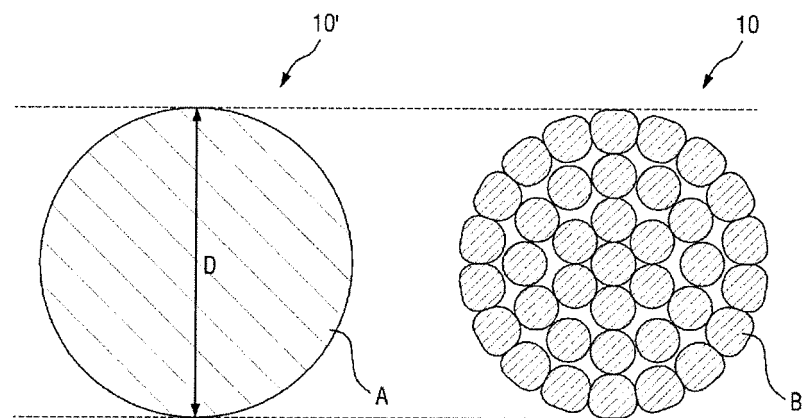


Fig. 7

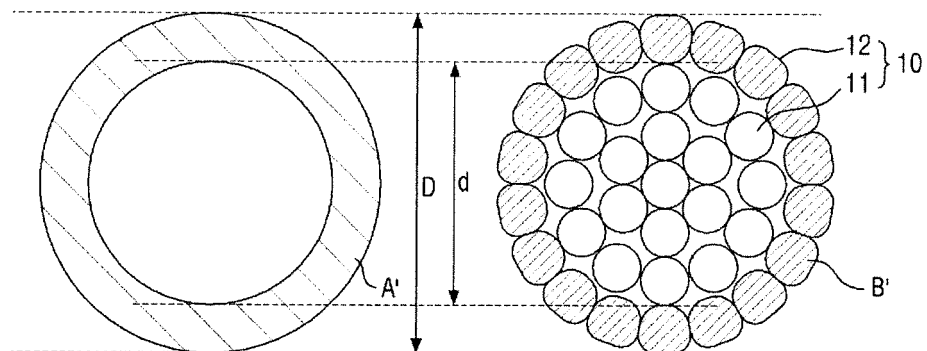


Fig. 8

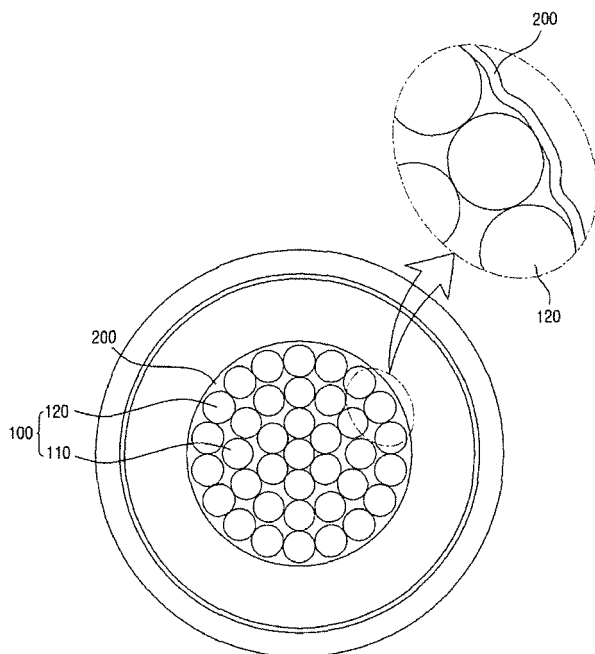
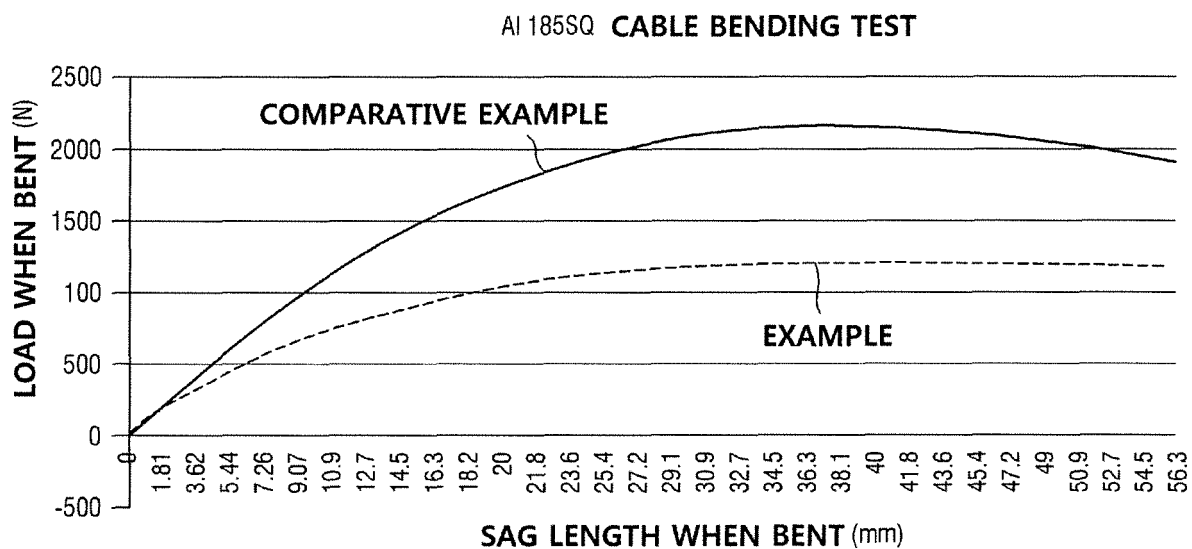


Fig. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2017/006685

A. CLASSIFICATION OF SUBJECT MATTER

H01B 9/00(2006.01)i, H01B 7/00(2006.01)i, H01B 13/00(2006.01)i, H01B 3/30(2006.01)i, H01B 13/02(2006.01)i,
H01B 7/295(2006.01)i, H01B 7/29(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01B 9/00; H01B 5/08; B21F 19/00; D07B 1/12; H01B 5/02; H01B 13/00; H01B 7/00; H01B 3/30; H01B 13/02; H01B 7/295

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Utility models and applications for Utility models: IPC as above

Japanese Utility models and applications for Utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS (KIPO internal) & Keywords: power cable, compression, conductor, strand

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR 10-2013-0102773 A (LS CABLE & SYSTEM LTD.) 23 September 2013 See paragraph [55], claims 1, 4 and figures 2-5.	1-21
Y	KR 10-2014-0134836 A (LS CABLE & SYSTEM LTD.) 25 November 2014 See claims 1-11 and figures 1, 2.	1-21
Y	KR 10-2013-0118097 A (LS CABLE & SYSTEM LTD.) 29 October 2013 See claim 1 and figures 1-4.	2-5
A	JP 2009-158331 A (SANSHU DENSEN K.K.) 16 July 2009 See paragraphs [77]-[92] and figures 7, 8.	1-21
A	JP 2008-262812 A (YAZAKI CORP.) 30 October 2008 See claim 1 and figure 1.	1-21

☐ Further documents are listed in the continuation of Box C.
 ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

07 SEPTEMBER 2017 (07.09.2017)

Date of mailing of the international search report

08 SEPTEMBER 2017 (08.09.2017)

Name and mailing address of the ISA/KR



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Authorized officer

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2017/006685

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REFERENCES CITED IN THE DESCRIPTION

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- KR 1020140126993 [0008] [0010]
- KR 1020140128584 [0008] [0010]