(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 971 914 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
23.03.2022 Bulletin 2022/12

(21) Application number: **20823424.5**

(22) Date of filing: **12.06.2020**

(51) International Patent Classification (IPC):
H01B 7/17 (2006.01) ***H01B 7/42*** (2006.01)
H01B 7/00 (2006.01) ***H01B 9/00*** (2006.01)
H01B 1/02 (2006.01) ***H01B 3/18*** (2006.01)

(52) Cooperative Patent Classification (CPC):
H01B 1/02; H01B 3/18; H01B 7/00; H01B 7/17; H01B 7/42; H01B 9/00

(86) International application number:
PCT/KR2020/007632

(87) International publication number:
WO 2020/251296 (17.12.2020 Gazette 2020/51)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **14.06.2019 KR 20190070883**

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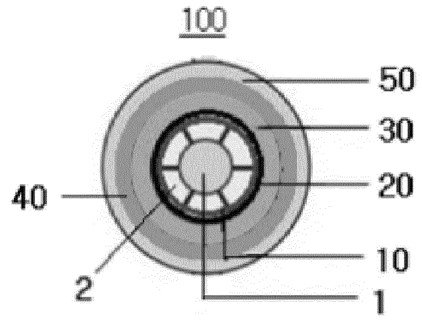
(54) **INCREASED CAPACITY OVERHEAD INSULATED WIRE**

(57) The present invention relates to an overhead insulated wire in which the surface of a conductor or between conductors has been insulated by using an insulator, the overhead insulated wire comprising: an electrical conductor layer (10) comprising an aluminum wire (2) surrounding a reinforcing wire (1); a semi conductive layer (20) containing carbon-based nanoparticles surrounding the electrical conductor layer (10); an insulation layer (30) containing carbon-based nanoparticles and inorganic nanoparticles surrounding the semi conductive layer (20); a heat conductive layer (40) containing carbon-based nanoparticles and inorganic nanoparticles surrounding the insulation layer (30); and a weather resistant covering layer (50) containing carbon-based nanoparticles and inorganic nanoparticles surrounding the heat conductive layer (40), thereby increasing the continuous use temperature of the overhead insulated wire to 150°C and improving an allowable current capacity by 50%, compared to an existing allowable current capacity to thereby cope with an increase in demand for transmission capacity of the overhead insulated wire without excessive investment costs and solve the increase in sag thereof.

FIG. 1



EP 3 971 914 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to an overhead insulated wire in which the surface of a conductor has been insulated by using an insulator, and more particularly, to an overhead insulated wire in which a covering layer of the overhead insulated wire is divided into a thermal conductive layer and a weather resistant covering layer so that the continuous use temperature and allowable current capacity of the overhead insulated wire can be increased.

BACKGROUND ART

[0002] In general, electricity produced in a power plant is supplied to each use place through a power transmission line composed of a steel transmission tower and an overhead transmission line after having been boosted in a boost substation. An aluminum conductor steel reinforced (ACSR) wire having an aluminum conductor or a steel core is used as the transmission line.

[0003] The power transmission line in the South Korean power system is operated at three kinds of transmission voltages of 765 kV, 345 kV, and 154 kV. A primary or secondary substation perform a voltage dropping operation in which a dropped voltage is applied to a power distribution line composed of an electric pole and an insulated wire from a power transmission line. For example, a voltage dropping operation is performed in which a dropped voltage is applied from a power transmission line of 154 kV to a power distribution line of 22 kV. The power transmission line is about 33,000 C-km in length, and the power distribution line is about 436,000 C-Km in length based on 2018 in South Korea.

[0004] In the construction of the power transmission and distribution lines, nowadays, social conflicts are caused by concerns about the risk of electromagnetic waves generated at high pressure and damage to the landscape. As a countermeasure to this problem, it is desirable to bury the power transmission and distribution line underground, but the construction cost thereof is greately increased compared to the overhead line, resulting in occurrence of a problem in that the huge costs are shifted to electricity consumers.

[0005] As a method of solving this problem, a high capacity overhead power transmission line has been developed in which the heat resistance of a conductor is improved in the power transmission line to allow the normal use temperature to be raised from 90°C to 150 to 230°C, and the thermal expansion of the reinforcing wire at a use temperature is suppressed by using an Invar wire having a low coefficient of thermal expansion to allow the allowable current capacity of an overhead power transmission line to be increased by 50 to 100%. Consequently, only an overhead power transmission line that has been installed previously is replaced with a high capacity overhead power transmission line having the same size as that of the previously installed overhead power transmission line by using facility such as an existing steel transmission tower or the like so that it is possible to cope with the increase in demand of transmission capacity without civil complaints or excessive investment costs.

[0006] However, a conventional insulated wire used in an overhead power distribution line has a concentric structure consisting of a reinforcing wire, a conductor layer, a semi-conductive layer, an insulation layer, and a covering layer, and is used at a continuous use temperature of 90°C according to Technical Standard of KEPCO, "ES 6145-0021", making it difficult to increase the allowable current capacity.

[0007] In this case, the insulated wire entails a problem in that if the continuous use temperature of the insulated wire exceeds 90°C, the deterioration in the insulation breakdown voltage and the mechanical properties of crosslinked polyethylene used as a material of the insulating layer are accelerated, resulting in an accident of the overhead power distribution line. For this reason, the conventional insulated wire makes it difficult to apply to an overhead insulated wire using an existing technology of increasing the capacity of the overhead power transmission line.

[0008] In an attempt to solve the above problem, Korean Patent Laid-Open Publication No. 10-2011-0020126 discloses that the continuous use temperature of the insulation layer is 120°C or higher and the allowable current capacity thereof is increased by 33% compared to a conventional overhead insulated wire through improvement of a resin composition of the insulation layer. However, it is difficult to solve a problem with a deterioration in the conductor layer, caused when the continuous use allowable temperature of the overhead insulated wire is raised to 120°C or higher, and a problem with an increase in sag of a steel core due to thermal expansion.

[0009] In the meantime, Korean Patent Laid-Open Publication No. 10-2011-0098548 discloses that the continuous use temperature of an insulated wire is 125°C or higher and the allowable current capacity thereof is increased by 37% compared to the conventional overhead insulated wire by adopting a heat-resistant aluminum alloy containing zirconium as a material for a conductor layer and improving a crosslinked polyethylene resin composition of an insulating layer. However, the insulated wire involves a problem with an increase in sag of a reinforcing wire due to thermal expansion.

[0010] In addition, the above Korean patents discloses that the continuous use allowable temperature of the overhead insulated wire is limited to 120 to 125°C, and the allowable current capacity thereof is increased by 33 to 37% compared to the conventional overhead insulated wire. However, the above patents still encounters a problem in that they do not attain an increasing effect of the allowable current capacity of the overhead insulated wire by more than 50%, which can effectively cope with an increase in demand capacity of the overhead power distribution line and provide excellent economic efficiency compared to new cost investment.

[Prior Art Literature]

[Patent Documents]

[0011]

Patent Document 1: Korean Patent Laid-Open Publication No. 10-2011-0020126A (laid open on 02.03.2011)
Patent Document 2: Korean Patent Laid-Open Publication No. 10-2011-0098548A (laid open on 01.09.2011)
Patent Document 3: Korean Patent Laid-Open Publication No. 10-2019-0000063A (laid open on 02.01.2011)
Patent Document 4: Korean Patent No. 10-0747932B1 (issued on 02.08.2007)

DISCLOSURE OF INVENTION

TECHNICAL PROBLEM

[0012] Accordingly, the present invention has been made to solve the above-mentioned problems occurring in the prior art, and it is an object of the present invention to provide an overhead insulated wire in which a covering layer of the overhead insulated wire is divided into a thermal conductive layer and a weather resistant covering layer so that the continuous use temperature and allowable current capacity of the overhead insulated wire can be increased.

TECHNICAL SOLUTION

[0013] To achieve the above object, the present invention provides a high capacity overhead insulated wire of the present invention includes: a reinforcing wire; a conductor layer comprising an aluminum wire surrounding the reinforcing wire; a semi-conductive layer containing carbon-based nanoparticles, which surrounds the conductor layer; an insulation layer containing carbon-based nanoparticles and inorganic nanoparticles, which surrounds the semi-conductor layer; a thermal conductive layer containing carbon-based nanoparticles and inorganic nanoparticles, which surrounds the insulation layer; and a weather resistant covering layer containing carbon-based nanoparticles and inorganic nanoparticles, which surrounds the thermal conductive layer.

ADVANTAGEOUS EFFECTS

[0014] The high capacity overhead insulated wire according to the present invention has the following advantageous effects.

[0015] A covering layer of the overhead insulated wire is divided into a thermal conductive layer and a weather resistant covering layer, and a polymer matrix composition is applied to the overhead insulated wire so that the continuous use temperature of the overhead insulated wire can be increased to 150°C and the allowable current capacity can be improved by 50%, compared to an existing allowable current capacity to thereby cope with an increase in demand for transmission capacity of the overhead insulated wire without excessive investment costs and solve a problem with an increase in sag thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. 1 is a cross-sectional view illustrating an example of an overhead insulated wire according to the present invention.

[0017] * Explanation on reference numerals of main elements in the drawings *

100:	overhead insulated wire	1:	reinforcing wire
2:	aluminum wire	10:	conductor layer
20:	semi-conductive layer	30:	insulation layer
40:	thermal conductive layer	50:	weather resistant covering layer

BEST MODE FOR CARRYING OUT THE INVENTION

[0018] Now, a preferred embodiment of a high capacity overhead insulated wire according to the present invention will be described hereinafter in detail with reference to the accompanying drawings.

[0019] As shown in FIG. 1, a high capacity overhead insulated wire of the present invention includes: a reinforcing wire 1; a conductor layer 10 comprising an aluminum wire 2 surrounding the reinforcing wire 1; a semi-conductive layer 20 containing carbon-based nanoparticles, which surrounds the conductor layer 10; an insulation layer 30 containing carbon-based nanoparticles and inorganic nanoparticles, which surrounds the semi-conductor layer 20; a thermal conductive layer 40 containing carbon-based nanoparticles and inorganic nanoparticles, which surrounds the insulation layer 30; and a weather resistant covering layer 50 containing carbon-based nanoparticles and inorganic nanoparticles, which surrounds the thermal conductive layer 40.

[0020] First, in order to increase the allowable current capacity of an overhead power transmission line using an existing overhead power transmission line, the overhead power transmission line and the existing overhead power transmission line are required to be identical to each other in terms of the length of the line, the allowable sag, and the wire installation tension. In addition, the same electrical connection fittings are required to be used in the overhead power transmission line and the existing overhead power transmission line. When the allowable current capacity of the overhead insulated wire is increased under the above conditions, the temperature of the conductor is increased by Joule heating. The maximum continuous use temperature of a conventional overhead insulated wire conductor which is currently being used is 90°C. When the maximum allowable current capacity of the overhead insulated wire is increased by 50%, the maximum continuous use temperature of the conductor becomes 150°C. At this time, there occurs a problem in that an increase in the thermal expansion amount of the reinforcing wire and the conductor leads to an increase in sag of the overhead insulated wire.

[0021] In addition, since deterioration (or thermal aging) of the conductor due to heat is more accelerated at a continuous use temperature of 150°C than at a continuous use temperature of 90°C, a hard drawn aluminum wire used as a wire of a conductive layer and a reinforcing wire having a tensile strength of 200 kgf/mm^2 or less used as a steel wire in a conventional overhead insulation wire cannot be used for an overhead insulated wire with a high capacity of 50%.

[0022] Thus, the high capacity overhead insulated wire of the present invention is characterized in that an ultra-high strength reinforcing wire and a softened and heat-treated aluminum wire are used to increase the maximum continuous use temperature of the overhead insulated wire to 150°C to increase the maximum allowable current capacity of the overhead insulated wire by 50%.

[0023] Meanwhile, another technical problem to be solved when the maximum allowable current capacity of the overhead insulated wire is increased is a degradation of the mechanical and physical properties and the insulation breakdown voltage due to thermal aging of a polymeric material of the insulation layer.

[0024] Therefore, the high capacity overhead insulated wire of the present invention is characterized in that it includes a thermal conductive layer that surrounds the insulation layer to minimize a deterioration in the mechanical and physical properties and the insulation breakdown voltage due to thermal aging of the insulator to increase the maximum allowable current capacity of the overhead insulated wire by 50%.

[0025] In this case, the allowable current capacity of the overhead insulated wire is determined depending on the maximum temperature at which the insulator can endure without thermal aging. This temperature is generally set to 90° C. The highest temperature of the insulator is generated at the interface between the insulator and the conductor, so that an allowable current capacity is determined by the temperature of the conductor.

[0026] The high capacity overhead insulated wire of the present invention is characterized in that the maximum allowable current capacity of the overhead insulated wire is increased by reducing the thermal resistance or increasing the thermal conductivity of a semi-conductive layer, an insulation layer, and a covering layer of a conventional overhead insulated wire. The high capacity overhead insulated wire of the present invention includes the thermal conductive layer 40 having a significantly higher thermal conductivity than an existing covering layer between the insulating layer 30 and the weather resistant covering layer 50 to further increase the maximum allowable current capacity of the overhead insulated wire.

[0027] Hereinafter, the constituent elements of the overhead insulated wire 100 will be described.

① Reinforcing Wire (1)

[0028] The reinforcing wire 1 has a tensile strength of more than 200 kgf/mm. The reason why the range of the tensile strength is limited to more than 200 kgf/mm is because a tension sharing ratio of the reinforcing wire having a linear thermal expansion coefficient lower than that of aluminum is low in a tensile strength of less than 200 kgf/mm^2, thereby making it difficult to use an existing electric pole due to an increase in sag of the overhead insulated wire at 150°C.

[0029] An Invar wire having a very low coefficient of thermal expansion can be used as the reinforcing wire 1, but an ultra-high strength reinforcing wire 1 is preferably used as an example of the present invention in terms of economic efficiency because the Invar wire is expensive. The reinforcing wire 1 is preferably subjected to any one surface treatment selected from among galvanizing, zincaluminum misch metal alloy plating, and aluminum coating performed on the outer circumference thereof, and the surface treatment of the reinforcing wire 1 is performed to improve corrosion resistance.

② Conductor Layer (10)

[0030] The aluminum wire 2 has a tensile strength of 7 to 12 kgf/mm^2. The reason why the range of the tensile strength of the softened and heat-treated aluminum wire as a wire of the conductor layer is limited to 7 to 12 kgf/mm^2 is because frequent disconnection may occur during the stranding operation at the tensile strength of less than 7 kgf/mm^2, and the number of years of use of the conductor may be reduced due to a degradation in the tensile strength caused by thermal aging at the tensile strength exceeding 12 kgf/mm^2.

[0031] The cross-sectional shape of the aluminum wire is preferably a circular or trapezoidal shape, and in particular, a trapezoidal shape is adopted in a gap-type sag suppression overhead insulated wire in which a gap is defined between the reinforcing wire and the conductor layer so that the reinforcing wire is dedicated to ensuring a sag maintaining tension.

[0032] The softening heat treatment method and the heat treatment condition of the aluminum wire can be used without being particularly limited as long as they are commonly used departing from the technical spirit and scope of the invention widely known in the art to which the present invention pertains.

③ Semi-conductive Layer (20)

[0033] A base resin forming a polymeric matrix used as a material for the semi-conductive layer 20 may be used in combination of at least one selected from the group consisting of low density polyethylene, medium density polyethylene, high density polyethylene, polypropylene, ethylene methyl acrylate, ethylene vinyl acrylate, ethylene ethyl acrylate (EEA), ethylene butyl acrylate (EBA), polyacrylate, polyester, polycarbonate, polyurethane, polyimide, and polystyrene.

[0034] The carbon-based nanoparticles may be used in combination of at least one selected from the group consisting of various carbon-based nanomaterials such as carbon nanotube (CNT) graphene, graphene nano platelet, and nano carbon black.

[0035] The semi-conductive layer comprises a semi-conductive polymeric matrix containing 2 to 20 parts by weight of carbon-based nanoparticles based on 100 parts by weight of the resin composition. If the carbon-based nanoparticles are contained in an amount of less than 2 parts by weight, the electrical conductivity improving effect is decreased and the extrusion processability is lowered if the carbon-based nanoparticles are contained in an amount of more than 20 parts by weight.

[0036] An additive such as a crosslinking agent, an antioxidant, a processing aid, or the like is added to the base resin composition containing the carbon-based nanoparticles to form a semi-conductive polymer matrix composition. The kind and parts by weight of each additive based on 100 parts by weight of the base resin composition can be used without being particularly limited as long as they are commonly used departing from the technical spirit and scope of the invention widely known in the art to which the present invention pertains.

④ Insulation Layer (30)

[0037] As a base resin forming a polymeric matrix used as a material for the insulation layer 30, low density polyethylene (LDPE), medium density polyethylene, high density polyethylene, and ultrahigh molecular weight polyethylene (UHMW-PE) may be used alone or in combination of two or more thereof.

[0038] The carbon-based nanoparticles may be used in combination of at least one selected from the group consisting of various carbon-based nanomaterials such as carbon nanotube (CNT) graphene, graphene nano platelet, and nano carbon black.

[0039] The inorganic nanoparticles may be used in combination of at least one selected from the group consisting of inorganic nanomaterials such as AIN (Aluminum Nitride), Al_2O_3 (Aluminum Oxide or Alumina), $Al(OH)_3$ (Aluminum Trihydroxide), ATH (Alumina Trihydrate), BN (Boron Nitride), BeO (Beryllium Oxide), $BaTiO_3$ (Barium Titanate), $CaCO_3$ (Calcium Carbonate), LS (Layered Silicate), MgO (Magnesium Oxide), SiC (Silicon Carbide), SiO_2 (Silicon Dioxide or Silica), TiO_2 (Titanium Oxide or Titania), and ZnO(Zinc Oxide).

[0040] The insulation layer comprises an insulating polymeric matrix containing 0.5 to 5.0 parts by weight of carbon-based nanoparticles and inorganic nanoparticles based on 100 parts by weight of the resin composition. If the carbon-based nanoparticles and inorganic nanoparticles are contained in an amount of less than 0.5 parts by weight, the mechanical property improving effect cannot be exhibited, and if the carbon-based nanoparticles and inorganic nanoparticles are contained in an amount of more than 0.5 parts by weight, the insulation breakdown voltage performance may be degraded.

[0041] An additive such as a crosslinking agent, an oxidation stabilizer, a UV stabilizer, a processing aid or the like is added to the base resin containing the carbon-based nanoparticles and the inorganic nanoparticles to form an insulating polymer matrix composition.

[0042] The kind and parts by weight of each additive based on 100 parts by weight of the resin composition can be used without being particularly limited as long as they are commonly used departing from the technical spirit and scope of the invention widely known in the art to which the present invention pertains.

⑤ Thermal Conductive Layer (40)

[0043] As a base resin forming a polymeric matrix used as a material for the thermal conductive layer, low density polyethylene (LDPE), medium density polyethylene, high density polyethylene, and ultrahigh molecular weight polyethylene (UHMW-PE) may be used alone or in combination of two or more thereof.

[0044] The carbon-based nanoparticles may be used in combination of at least one selected from the group consisting of various carbon-based nanomaterials such as carbon nanotube (CNT) graphene, graphene nano platelet, and nano carbon black.

[0045] The inorganic nanoparticles may be used in combination of at least one selected from the group consisting of inorganic nanomaterials such as AIN (Aluminum Nitride), Al_2O_3 (Aluminum Oxide or Alumina), $Al(OH)_3$ (Aluminum Trihydroxide), ATH (Alumina Trihydrate), BN (Boron Nitride), BeO (Beryllium Oxide), $BaTiO_3$ (Barium Titanate), $CaCO_3$ (Calcium Carbonate), LS (Layered Silicate), MgO (Magnesium Oxide), SiC (Silicon Carbide), SiO_2 (Silicon Dioxide or Silica), TiO_2 (Titanium Oxide or Titania), and ZnO(Zinc Oxide).

[0046] The thermal conductive layer comprises a thermal conductive polymeric matrix containing 5.0 to 15.0 parts by weight of carbon-based nanoparticles and inorganic nanoparticles based on 100 parts by weight of the resin composition. If the carbon-based nanoparticles and inorganic nanoparticles are contained in an amount of less than 5.0 parts by weight, the thermal conductive property improving effect cannot be exhibited, and if the carbon-based nanoparticles and inorganic nanoparticles are contained in an amount of more than 15.0 parts by weight, the insulation breakdown voltage performance may be degraded.

[0047] An additive such as a crosslinking agent, an oxidation stabilizer, a UV stabilizer, a processing aid or the like is added to the base resin containing the carbon-based nanoparticles and the inorganic nanoparticles to form an insulating polymer matrix composition. The kind and parts by weight of each additive based on 100 parts by weight of the resin composition can be used without being particularly limited as long as they are commonly used departing from the technical spirit and scope of the invention widely known in the art to which the present invention pertains.

⑥ Weather Resistant Covering Layer (50)

[0048] As a base resin forming a polymeric matrix used as a material for the weather resistant covering layer 50, low density polyethylene (LDPE), medium density polyethylene, high density polyethylene, and ultrahigh molecular weight polyethylene (UHMW-PE) may be used alone or in combination of two or more thereof.

[0049] The carbon-based nanoparticles may be used in combination of at least one selected from the group consisting of various carbon-based nanomaterials such as carbon nanotube (CNT) graphene, graphene nano platelet, and nano carbon black.

[0050] The inorganic nanoparticles may be used in combination of at least one selected from the group consisting of inorganic nanomaterials such as AIN (Aluminum Nitride), Al_2O_3 (Aluminum Oxide or Alumina), $Al(OH)_3$ (Aluminum Trihydroxide), ATH (Alumina Trihydrate), BN (Boron Nitride), BeO (Beryllium Oxide), $BaTiO_3$ (Barium Titanate), $CaCO_3$ (Calcium Carbonate), LS (Layered Silicate), MgO (Magnesium Oxide), SiC (Silicon Carbide), SiO_2 (Silicon Dioxide or Silica), TiO_2 (Titanium Oxide or Titania), and ZnO(Zinc Oxide).

[0051] The weather resistant covering layer 50 comprises a polymeric matrix containing 2.0 to 9.9 parts by weight of carbon-based nanoparticles and inorganic nanoparticles based on 100 parts by weight of the resin composition. If the carbon-based nanoparticles and inorganic nanoparticles are contained in an amount of less than 2.0 parts by weight, the tracking resistance and the mechanical property improving effect cannot be exhibited, and if the carbon-based nanoparticles and inorganic nanoparticles are contained in an amount of more than 9.9 parts by weight, the insulation breakdown voltage performance may be degraded.

[0052] An additive such as a crosslinking agent, an oxidation stabilizer, a UV stabilizer, a processing aid, a water repellent or the like is added to the base resin containing the carbon-based nanoparticles and the inorganic nanoparticles to form an weather resistant covering polymer matrix composition. The kind and parts by weight of each additive based on 100 parts by weight of the base resin composition can be used without being particularly limited as long as they are commonly used departing from the technical spirit and scope of the invention widely known in the art to which the present invention pertains. The overhead insulated wire 100 according to the present invention has an allowable current capacity increased by 50% compared to an existing overhead insulated wire through the increase of the continuous use temperature to 150°C.

[0053] While the present invention has been described in connection with the exemplary embodiments illustrated in the drawings, they are merely illustrative embodiments, and the invention is not limited to these embodiments. It is to be understood that various equivalent modifications and variations of the embodiments can be made by a person having an ordinary skill in the art without departing from the spirit and scope of the present invention. Therefore, the true technical scope of the present invention should be defined by the technical spirit of the appended claims.

Claims

1. A high capacity overhead insulated wire comprising:

a reinforcing wire (1);
a conductor layer (10) comprising an aluminum wire (2) surrounding the reinforcing wire (1);
a semi-conductive layer (20) containing carbon-based nanoparticles, which surrounds the conductor layer (10);
an insulation layer (30) containing carbon-based nanoparticles and inorganic nanoparticles, which surrounds the semi-conductor layer (20);
a thermal conductive layer (40) containing carbon-based nanoparticles and inorganic nanoparticles, which surrounds the insulation layer (30); and
a weather resistant covering layer (50) containing carbon-based nanoparticles and inorganic nanoparticles, which surrounds the thermal conductive layer (40).

2. The high capacity overhead insulated wire according to claim 1, wherein the reinforcing wire (1) has a tensile strength of more than 200 kgf/mm^2.

3. The high capacity overhead insulated wire according to claim 1, wherein the aluminum wire (2) has a tensile strength of 7 to 12 kgf/mm^2.

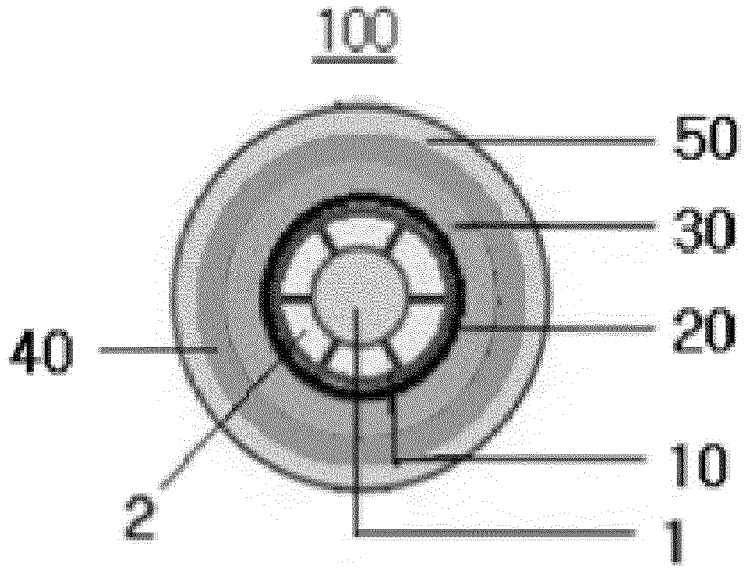
4. The high capacity overhead insulated wire according to claim 1, wherein the semi-conductive layer (20) contains 2 to 20 parts by weight of carbon-based nanoparticles based on 100 parts by weight of the total resin composition.

5. The high capacity overhead insulated wire according to claim 1, wherein the insulation layer (30) contains 0.5 to 5.0 parts by weight of carbon-based nanoparticles and inorganic nanoparticles based on 100 parts by weight of the total resin composition.

6. The high capacity overhead insulated wire according to claim 1, wherein the thermal conductive layer (40) contains 5.0 to 15.0 parts by weight of carbon-based nanoparticles and inorganic nanoparticles based on 100 parts by weight of the total resin composition.

7. The high capacity overhead insulated wire according to claim 1, wherein the weather resistant covering layer (50) contains 2.0 to 9.9 parts by weight of carbon-based nanoparticles and inorganic nanoparticles based on 100 parts by weight of the total resin composition.

FIG. 1



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2020/007632

A. CLASSIFICATION OF SUBJECT MATTER

H01B 7/17(2006.01)i, H01B 7/42(2006.01)i, H01B 7/00(2006.01)i, H01B 9/00(2006.01)i, H01B 1/02(2006.01)i, H01B 3/18(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 7/17; H01B 1/02; H01B 1/04; H01B 1/24; H01B 3/02; H01B 7/00; H01B 9/00; H01B 9/02; H01B 7/42; H01B 3/18

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: electric wire, conductor, semiconductor, carbon nanoparticle, inorganic nanoparticle

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR 10-2012-0086072 A (LS CABLE & SYSTEM LTD.) 02 August 2012 See paragraphs [0009] and [0010].	1-7
Y	KR 10-2013-0089217 A (KOREA ELECTRIC POWER CORPORATION et al.) 09 August 2013 See paragraphs [0028]-[0052].	1-7
Y	KR 10-2015-0071692 A (KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE) 26 June 2015 See paragraphs [0020]-[0043].	2,3
A	US 2018-0233253 A1 (THE BOEING COMPANY) 16 August 2018 See claims 1-4.	1-7
A	US 2012-0012362 A1 (KIM, Yoon-jin et al.) 19 January 2012 See claims 1-11.	1-7

☐ 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
"E" earlier application or patent but published on or after the international filing date
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"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	Date of mailing of the international search report
17 SEPTEMBER 2020 (17.09.2020)	**17 SEPTEMBER 2020 (17.09.2020)**

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Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2020/007632

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Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- ES 61450021 **[0006]**
- KR 1020110020126 **[0008]**
- KR 1020110098548 **[0009]**
- KR 1020110020126 A **[0011]**
- KR 1020110098548A **[0011]**
- KR 1020190000063 A **[0011]**
- KR 100747932 B1 **[0011]**