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(54) POWER TRANSMISSION CABLE AND A PROCESS TO MANUFACTURE THE CABLE

KABEL ZUR LEISTUNGSÜBERTRAGUNG UND VERFAHREN ZUR HERSTELLUNG DES KABELS
CÂBLE DE TRANSPORT D'ÉNERGIE ET PROCÉDÉ DE FABRICATION DE CE CÂBLE

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EP 3 430 632 B1

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Description

TECHNICAL FIELD

[0001] The present invention relates to a power transmission cable comprising an insulation system and to a process for the production of the power transmission cable, as defined in the appended claims.

BACKGROUND ART

[0002] High voltage power transmission cables, herein referred to as power transmission cables, are used for the power transmission of medium or high voltages. Such power transmission cables may be buried under ground and are called land cables, or the power transmission cables may be buried into a sea bed or they may be arranged to extend between two fixing points in sea water. Cables used in sea applications are called submarine, sea water or underwater power cables.

[0003] Power transmission cables generally comprise a conductor covered by an insulation system and a protective jacket. The insulation system usually comprises at least one inner semi-conductive layer, an insulation layer and an outer semi-conductive layer. In addition, a protection system may be applied to protect the insulation system against e.g. moisture penetration, i.e. to block water from penetrating to the insulation and further to provide protection against mechanical wear or forces during for example production and installation.

[0004] It is known in the art that the insulation system may comprise or consists of multiple layers of paper-based material, which form the semi-conductive layers and an insulation layer of the insulation system. A semi-conductive layer in that case typically comprises paper comprising semi-conductive filler particles, such as carbon black, that renders the paper material semi-conductive. The paper may also be metallized and can comprise a layer of conductive material that renders the paper material semi-conductive. The layers of semi-conductive paper and layers of insulation layer are wrapped or lapped around a conductor to form the insulation system.

[0005] After the paper-based layers have been applied onto the cable, impregnation of cables is performed by using an impregnation liquid which can be a dielectric fluid. The dielectric fluid, such as high viscosity oil, is used to protect the insulation system against moisture pick-up and to fill up all pores and voids or other interstices in the insulation system. After impregnation, the insulation system is usually directly provided with a moisture barrier to keep the oil inside the insulation system and to protect the insulation system from moisture and air from the outside environment. Usually, the moisture barrier is provided in the form of an extruded lead sheath. The extrusion is performed onto the cable directly after it is lifted from the impregnation oil. The process for the production of power transmission cables with a paper-based insulation system, so called Mass Impregnated

(MI) cables, is further described for example in "Submarine Power Cables: Design, Installation, Repair, Environmental Aspects", Thomas Worzyk, Springer-Verlag Berlin Heidelberg, 2009, ISBN 978-3-642-01269-3, pp 126-130. Such MI-cables have traditionally enabled higher voltage levels in power transmission cables than extruded high voltage cables. However, the operational temperature of the MI-cables is limited due to the impregnation oil.

[0006] An attempt to improve the submarine cables is shown by US4271226 in which a tape made of a film of an axially orientated polymer having a thickness of less than 200 microns, a significant degree of crystalline order, high tensile strength, a high modulus of elasticity and the ability to cling to itself is used as the electrically insulating material. The tape is lapped or wound around a cable body so that successive layers of tape overlap each other. However, problems arise during the tape winding operation when air is unavoidably trapped in the very small spiral spaces which exist at the lateral edges of each tape layer. According to US 4271226 the problem is avoided by the introduction of a dielectric gas at the lateral edges of each layer of tape during or subsequent to the tape winding operation and the solution falls into the application of gas-pressurized cables. However, this complicates the manufacturing process.

[0007] Therefore, there is still a need for improvements in manufacturing processes of power transmission cables comprising a lapped insulation system. There is also a need to improve electrical properties of power cables comprising a lapped insulation system.

[0008] US 3 108 153 A discloses a power cable comprising an insulation layer, the insulation layer being composed of many layers of helically-wrapped polyethylene tape saturated with a dimethylpolysiloxane liquid.

SUMMARY OF THE INVENTION

[0009] In view of the problems stated above, there is thus a need to improve insulation materials and manufacturing processes of power transmission cables comprising a lapped insulation system. Further, there is a need to improve the electrical and mechanical properties of power transmission cables having an insulation system comprising multiple lapped layers of polymeric insulation material.

[0010] The object of the present invention is thus to provide power transmission cable with an insulation system that comprises polymeric insulation material which is easy to apply with existing equipment and which forms an electrically and mechanically stable insulation system for a power transmission cable. Especially, it is an object of the present invention to eliminate or at least minimize the amount of air which is trapped in the very small spiral spaces which exist at the lateral edges of each tape layer, i.e. it is an object to avoid voids in the insulation system.

[0011] It is a further object of the present invention to provide a process for the manufacture of a power trans-

mission high voltage cable which provides for an easier and quicker manufacturing process without the need for time consuming impregnation of the insulation system to avoid voids in the insulation material. It is a further object to provide a process which provides a power transmission cable with an insulation system which tolerates higher temperatures during use, and thus increases the maximum power level that can be transmitted with the power transmission cable.

[0012] According to the present invention, the objects above are attained by means of a power transmission cable as defined in the appended claims. The power transmission cable comprises a conductor and an insulation system. The insulation system comprises

- a first semi-conductive covering comprising a layer of semi-conductive material radially surrounding the conductor;
- an insulation covering comprising a layer of insulation material surrounding the first semi-conductive covering radially outwards;
- a second semi-conductive covering comprising a layer of semi-conductive material surrounding the insulation covering radially outwards;

wherein the semi-conductive material and the insulation material comprise a first polymeric material arranged to form a base film, and a second polymeric material arranged to fill in spaces and/or any voids in the insulation system,

wherein the first polymeric material and the second polymeric material have different physical and/or chemical properties, and

wherein at least the first polymeric material that forms the base film of the semi-conductive material and the insulation material is helically wound around the conductor or a cable body comprising the conductor and at least the first semi-conductive covering. The cable body may of course also additionally comprise the insulation layer. It is also possible that the cable body comprises the second semi-conductive covering.

[0013] By using the semi-conductive material and the insulation material which comprise a first polymeric material arranged to form a base film, and a second polymeric material arranged to fill in spaces and/or any voids in the insulation system according to the present invention, it is possible to obtain similar advantages in respect of power and voltage levels as in connection with mass-impregnated (MI) cables, i.e. it is possible to gain higher power and voltage levels than with extruded high voltage cables. Also, there is a smaller risk for faults in the insulation system when the film material is used and lapped around the conductor/cable body than in a bulk plastic material to be extruded as an insulation system for the cable. Further, the disadvantage of using impregnation oil as in connection with the MI-cables can be avoided, whereby the cable will not be as limited in operational temperature as MI-cables. By the present invention a

non-impregnated cable can be produced. This is a huge advantage since impregnation is very time-consuming. The cable will be dry, i.e. no impregnation oil will be moving inside the insulation system when the temperature of the cable rises. MI-cables with oil impregnation have normally a highest operational temperature of about 55°C. Since no impregnation oil or other liquid is used, the operational temperature will be higher, i.e. up to about 80°C with the cable according to the present invention, which is a remarkable increase. Thus, by the present invention it is possible to combine benefits from both MI-cable applications and extruded cable applications. Since at least the first polymeric material that forms the base film of the semi-conductive material and the insulation material is helically wound around the conductor or a cable body comprising the conductor and at least the first semi-conductive covering, it will be possible to utilize the same apparatus for lapping the film around the cable as in the manufacture of traditional MI-cables having a paper-based lapped insulation system. Thus, at least the base film in the first semi-conductive layer is helically wound around the conductor, at least the base film in the insulation layer is helically wound around the first semi-conductive layer and at least the base film in the second semi-conducting layer is helically wound around the insulation layer.

[0014] Suitably, the semi-conductive material comprises electrically conductive particles. The first and second polymeric materials, respectively, in the semi-conductive and insulation materials may be otherwise the same except that the semi-conductive material comprises electrically conductive particles. In this way the materials will be compatible and it will be easy to for example stabilize the insulation system and it will be easy to control the manufacturing process.

[0015] Preferably, the insulation covering is of a multi-layer structure and thus comprises at least two layers of insulation material. Alternatively or additionally, the first and second semi-conducting coverings are of multi-layer structure and comprise at least two layers of semi-conducting material. Thus, preferably, the insulation covering comprises at least two layers of insulation material and the first and second semi-conducting coverings comprise at least two layers of semi-conducting material. By the multi-layer structure it is possible to further improve the electrical properties of the cable. Especially, the breakdown strength of the cable can be increased compared to for example a cable having an extruded, plastic insulation system.

[0016] According to one embodiment, the first polymeric material as the base film is provided as a tape and the second polymeric material is provided as a liquid or a semisolid. In this way the second polymeric material may be applied to the insulation system by other means, e.g. by means of a separate liquid feeding arrangement, than the lapping equipment and additionally improved filling of gaps, spaces and voids in the insulation system can be obtained.

[0017] According to another variant, the first polymeric material as the base film and/or the second polymeric material are provided as a tape. In this way the existing lapping equipment that is normally used for paper insulation system can be used, which is an advantage from the process point of view. The tape preferably comprises the first polymeric material as the base film and the second polymeric material as a coating layer adhered to the base film. The base film may be covered with the second polymeric material on one or both sides of the base film. This means that the tape may comprise the second polymeric material as a coating layer adhered to the base film on both sides of the base film. In this way, both materials may be applied simultaneously to the conductor or cable body, whereby faster production process can be obtained.

[0018] The thickness of the second polymeric material may be from 1 to 300 μm . The thickness of the base film may be from 1 to 300 μm . For example a tape with such a thickness can be easily applied and the existing equipment used. Suitably, the at least two layers of the semi-conductive material and the insulation material are wound in an overlapping manner and the total thickness of the respective covering is from 2 μm to 50 mm, depending on the amount of layers. The amount of layers is not limited to any specific amount, but could be for example from 5-700 layers, depending on the desired thickness of the respective covering. The thickness of the respective covering may vary for example between 2 μm to 50 mm, but is not limited to the range. The thickness of each of the semi-conductive coverings may be thinner than the thickness of the insulation covering. In this way, the insulation system may provide further improved electrical properties.

[0019] The first polymeric material forming the base film may comprise or consist of a polyolefin, such as polypropylene or polyethylene, such as high density polyethylene, low density polyethylene or cross-linked polyethylene, or polyethylene terephthalate, polyethylene naphthalate, or sulfoned plastic, such as polyethersulfone (PES), polyphenylene sulphide (PPS) and polysulfone (PSU), polycarbonate, poly(methyl methacrylate) (PMMA), polyaramid or any blend thereof. Such film materials have sufficient mechanical strength and can be used in power transmission cable applications.

[0020] Preferably, the second polymeric material comprises or consists of an adhesive and/or hotmelt material. Such materials can be pressure sensitive, can be provided as liquids, suitably with high viscosity, or semisolids and can be dried or cured to solids. Thus, the materials provide a great flexibility in the manufacturing process while they are applicable for use in power transmission cables.

[0021] The insulation system may be additionally comprised in a cable joint of the power transmission cable. Thus, the entire cable may comprise the same kind of insulation system.

[0022] The objects and advantages above are also at-

tained by a process for the production of a power transmission cable according to the invention. The cable comprises a conductor and an insulation system surrounding the conductor, wherein the process comprises the steps of:

I. providing a conductor for the power transmission cable;

II. providing a semi-conductive material comprising a first polymeric material arranged to form a base film and a second polymeric material arranged to fill in spaces and/or any voids in the insulation system, and applying the semi-conductive material onto the conductor by helically winding at least the base film of the semi-conductive material to radially surround the conductor and by arranging the second polymeric material to fill in spaces and/or any voids and thus provide a first semi-conductive covering and a cable body comprising the conductor and the first semi-conductive covering;

III. providing an insulation material comprising a first polymeric material arranged to form a base film and a second polymeric material arranged to fill in spaces and/or any voids in the insulation system, and applying the insulation material by helically winding at least the base film of the insulation material to surround the cable body radially outwards and by arranging the second polymeric material to fill in spaces and/or any voids and thus provide a cable body further comprising an insulation covering;

IV. helically winding at least the base film of the semi-conductive material to surround the insulation covering and by arranging the second polymeric material to fill in spaces and/or any voids to provide a cable body with an insulation system comprising a second semi-conductive covering;

V. optionally providing protective materials to cover the insulation system, such as armouring and/or protective sheaths, wherein

the first polymeric material and the second polymeric material have different physical and/or chemical properties.

[0023] Preferably, a multi-layer structure for the insulation system is provided. Thus, the insulation covering comprises at least two layers of insulation material and wherein the first and second semi-conducting coverings comprise at least two layers of semi-conducting material. Suitably, the base film is wound or wrapped in an overlapping manner. In this way gaps between the film edges can be minimized. However, the film could be alternatively wrapped in an edge-to-edge manner, or in a manner that a butt gap space exists between the two edges.

[0024] Suitably, during the steps II) to IV) the power transmission cable body is subjected to increased temperature, radiation, or increased pressure step to activate the second polymeric material so that it fills the spaces and the voids in the insulation system. If the second pol-

ymeric material is provided as liquid or semisolid, the activation step may not be necessary, but may be used if the viscosity of the second polymeric material needs to be lowered. If the second polymeric material is in liquid form, the process may further comprise curing the cable body before the step V.

[0025] To improve the adherence of the layers in respective covering, the process may further comprise corona surface treatment of the cable body before the step V.

[0026] As already mentioned above, the semi-conductive and/or the insulation materials are preferably in the form of a tape to facilitate the manufacturing process. Thus, the semi-conductive and/or the insulation materials can be helically wrapped around the cable body by means of rows of lapping heads.

[0027] According to another variant, the first polymeric material forming the base film is provided in the form of a tape that is helically wrapped around the conductor or the cable body comprising the conductor and the first semi-conductive covering and optionally the insulation covering and the second semi-conductive covering, and wherein the second polymeric material is applied in liquid form during the wrapping. The liquid may be added by means of a liquid feeding apparatus, die or any other suitable means. In this way the spaces, gaps or voids in the insulation system may be further filled and thus the spaces, gaps or voids may be eliminated from the insulation system.

[0028] Further features, objects and advantages of the present invention will be explained in the below detailed description with reference to the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029]

Fig. 1a is a partially cut side view of the cable comprising an insulation system according to the present invention;

Fig. 1b is a radial cross section of the cable comprising an insulation system according to the present invention;

Fig. 2 is a radial cross section view of an HVAC cable comprising cables with an insulation system according to the present invention;

Fig. 3a shows schematically a tape comprising first and second polymeric materials according to the invention;

Fig. 3b shows schematically two layers of the tape comprising first and second polymeric materials according to the invention;

Fig. 3c shows schematically three layers of the tape

comprising first and second polymeric materials according to the invention;

Fig. 4 is a flow chart illustrating the steps of the process for the production of the cable according to the present invention;

Fig. 5 shows experimental results from DC breakdown tests on flat samples.

DETAILED DESCRIPTION

[0030] The power transmission cables of the present invention generally comprise a metal conductor, an insulation system and optionally a protection system arranged to protect the insulation system and the cable against mechanical forces and/or moisture.

[0031] The insulation system of the present invention is a non-impregnated insulation system wound and/or lapped around the conductor. This means that no oil or other impregnation liquid is used to impregnate the insulation material and thus fill in empty spaces or voids in the insulation material or in the lapped construction of the insulation system. In this application, equally with the definition "wrapped" is used "wound". By "lapped" is meant helically wound insulation system in which the materials in the coverings are helically wound in an overlapping manner or in a manner where the edges of the wound material are positioned edge-to-edge or in a manner that a butt gap space exists between the two edges of the wound material. The lapped structure can be obtained by means of using a tape. The tape may for example comprise two different polymeric materials with different properties. The insulation material of the present invention could be also used for cable joints.

[0032] The conductor is usually mainly constituted by a metal such as copper or aluminium. The conductor may be solid or stranded. Normally, the conductor has a generally circular cross section, even though alternative shapes might be conceived. The conductor is electrically conductive and can therefore transmit electricity. The conductivity of a conductive material is suitably more than about 10^6 S/m at 20 °C. Basically there is no upper limit, but in practical solutions the upper limit is about 10^8 S/m at 20 °C.

[0033] The conductor is surrounded by an insulation system. The insulation system may have a cross-section with an outer peripheral shape corresponding to the outer peripheral shape of the conductor, normally a generally circular outer periphery. The conductor may be directly or indirectly surrounded by the insulation system, i.e. the electric power cable may comprise at least one material layer between the conductor and the insulation system, e.g. a semi-conductive tape.

[0034] The electric insulation system comprises a first, inner, semi-conductive covering comprising a layer, preferably multiple layers of semi-conductive material radially surrounding the conductor. Semi-conductive mate-

rial has semi-conductive properties which can be obtained for example by the use of electrically conductive filler particles. The filler particles may be for instance carbon black, which has a conductivity of about 1000 S/m. The particles may be dispersed or pre-added in the first and/or the second polymeric material. By semi-conductive properties of a material is meant a material that has an electrical conductivity that is lower than that of a conductor but that is not an insulator. The conductivity of the semi-conductive material may be typically larger than 10^{-5} S/m at 20 °C, such as up to about 10^3 S/m. Typically, the conductivity is less than 10^3 S/m at 20 °C, and preferably more than or equal with 10^{-3} S/m.

[0035] By a multi-layer structure is meant that there are multiple layers, i.e. at least two layers of respective material in the respective covering. The amount of layers in a multi-layer structure can be varied widely and can be for example from 2 to 700, but is not limited to this interval. For example, the amount of layers can be from 2 to 50 layers for the semi-conductive covering and from 2 to 700 layers for the insulation covering.

[0036] The first, inner, semi-conductive covering is surrounded by an insulation covering which comprises a layer, preferably multiple layers, of insulation material. The insulation material has insulating properties, i.e. no conductivity or very low conductivity. By insulating properties of a material is meant that the material resists electricity. The conductivity of the insulation material may be for example of from about $1 \cdot 10^{-8}$ to about $1 \cdot 10^{-22}$ S/m at 20 °C, typically from $1 \cdot 10^{-9}$ to $1 \cdot 10^{-18}$, depending of the magnitude of the electric field and/or temperature.

[0037] The insulation covering is then normally surrounded by a second, outer, semi-conductive covering comprising a layer, preferably multiple layers of semi-conductive material as described above and as further described below.

[0038] The semi-conductive and the insulation material according to the present invention comprise a first polymeric material arranged to form a base film, and a second polymeric material arranged to fill in spaces, such as butt gap spaces, and/or any voids in the insulation system. The first polymeric material and the second polymeric material have different properties, i.e. physical and/or chemical properties and the first and second polymeric materials preferably comprise different polymeric compositions. The first polymeric material and the second polymeric material form a composite material which can have insulation or semi-conductive properties depending on the additives used.

[0039] The first and second polymeric materials may both be thermoplastic and have a Vicat softening point defined at specific conditions and according to specific standards, i.e. ASTM D 1525 and/or ISO 306. Alternatively or additionally, the first and second polymeric materials may have a respective glass transition temperature and a melting point or melting temperature defined at specific conditions and according to specific standards. According to one variant, the melting point or melt-

ing temperature of the first polymeric material at the specific conditions may be higher than the melting point or melting temperature of the second polymeric material at the same conditions. For example, the first polymeric material may have a melting point or melting temperature of at least 110°C, preferably at least 140°C or 160°C, so that it will not melt during temperature peaks during the normal operation of the cable. The second polymeric material can then correspondingly have a melting point or melting temperature of below 110°C or below 140°C or below 160°C, but preferably above 90°C, so that it will not melt during the normal operation of the cable. It should be noted that only the crystalline part of semi-crystalline thermoplastic materials has a melting point or melting temperature, amorphous and thermoset materials do not have a melting point or melting temperature. According to another variant, the melting point or melting temperature of the first polymeric material is lower or equal with the second polymeric material, but the viscosity of the second polymeric material during the manufacturing conditions is lower than the viscosity of the first polymeric material, which is preferably solid at the manufacturing conditions. Thereby, the second polymeric material may fill in spaces and/or any voids in the insulation system while the base film can be helically wound around the conductor or a cable body. Thus, according to a further variant the second polymeric material may be liquid or semisolid. By semisolid is meant that the second polymeric material has a thick consistency between liquid and solid, whereby the material can support its own weight and hold its shape but wherein the material can flow under pressure or when heated. The liquid or semisolid second polymeric material suitably has a viscosity which is sufficiently high so that it will stay adhered to the base film at the winding conditions, i.e. 20°C and atmospheric pressure, or other winding temperatures.

[0040] In case there is a need to stabilize the structure of the insulation system, it is possible to add a cross-linking agent to the second polymeric material. After the insulation system has been lapped over the conductor, the cable or cable body may therefore be cured. The second polymeric material may be initially thermoplastic and thus have a certain initial melting temperature or melting point before cross-linking, for example during winding. However, when the second polymeric material is heated and crosslinked, the material will become solid and normally thermoset and not thermoplastic anymore.

[0041] Suitable materials for the first polymeric material forming the base film may be any plastic film materials having mechanical and thermal properties that tolerate the mechanical forces acting on the cable and the thermal conditions during a normal operation of a power transmission cable. Further, the first polymeric material per se should be electrically insulating, but may be rendered semi-conductive properties by addition of conductive filler particles. Suitable first polymeric materials comprise or consist of a polyolefin polymer, such as polypropylene (PP) or polyethylene (PE) or blends of them. The poly-

ethylene film may comprise or consist of a high density polyethylene (HDPE), low density polyethylene (LDPE) or cross-linked polyethylene (XLPE). Further examples for suitable first polymeric materials include polyethylene terephthalate (PET) film, polyethylene naphthalate (PEN) film, sulfonated plastic films, such as polyethersulfone (PES), polyphenylene sulphide (PPS) and polysulfone (PSU) films, polycarbonate, poly(methyl methacrylate), polyaramid, or any blend thereof, i.e. any blend of all of the above-mentioned first polymeric materials. Other plastic film materials with characteristics suitable for use in power transmission cable applications could be used.

[0042] Suitable second polymeric material is an adhesive material. The adhesive materials may be pressure sensitive. Alternatively or additionally the second polymeric material is a hotmelt material, e.g. a hotmelt type of adhesive. Any type of second polymeric material could be used that is suitable for use in power transmission cables, has insulating properties and is able to fill in spaces or voids in the insulation system. Such materials are known in the art and the adhesive materials may comprise or consist of for example acrylic adhesive, rubber-based adhesive or silicone-based adhesive. Other types such as epoxy-based adhesives could be used. The hotmelt is a polymer with a narrow melting point range. The hotmelt can be solid with mechanical properties corresponding to the mechanical properties of the base film during winding. If the hotmelt is adhered to the base film and the first polymeric material as the base film and the second polymeric material are provided as a tape, the tape will look like a plastic laminate during winding. However, when the tape is heated to a certain temperature, the hotmelt melts and thus fills in empty spaces and voids in the insulation system. In case the second polymeric material is an adhesive, e.g. acrylic adhesive, it can be in liquid or semisolid form. However, the viscosity of the second polymeric material is in that case sufficiently high that it will stay on the base film during the winding conditions, e.g. at atmospheric pressure and at 20°C or other pressures or temperatures. The first polymeric material as the base film can be provided as a tape and the second polymeric material can be provided as a liquid or a semisolid.

[0043] Preferably, the first polymeric material as the base film and the second polymeric material are provided as a tape. The tape may comprise the first polymeric material as the base film and the second polymeric material as a coating layer adhered to the base film. The tape may comprise the second polymeric material as a coating layer adhered to the base film on both sides of the base film.

[0044] The thickness of the second polymeric material can be from 1 to 300 μm and the thickness of the base film can be from 1 to 300 μm . However, the thickness is not particularly limited and other thicknesses may be used if applicable during the application of the material layers. However, for example, if the thicknesses above

are used, and at least two layers of the semi-conductive material and the insulation material are wound in an overlapping manner, the total thickness of the respective covering can be from for example 2 μm to 50 mm preferred between 2 μm and 5 mm for the semi-conductive coverings and between 2 mm and 50 mm for the insulation covering, if for example up to 700 layers of material are used.

[0045] The insulation system as described above may be used in an entire power transmission cable and is thus also usable additionally in a cable joint of the power transmission cable.

[0046] When the power transmission cable is manufactured, at least the first polymeric material that forms the base film of the semi-conductive material and/or the insulation material is helically wound around the conductor or a cable body. By the cable body is meant an unfinished power transmission cable comprising the conductor and at least the first, inner, semi-conductive covering and optionally the insulation covering and optionally the second semi-conductive covering. When the base film is helically wound around the conductor or cable body the successive layers of at least the base film preferably overlap. By winding helically at least the base film in the respective covering, a lapped structure for the insulation system can be formed. The second polymeric material is then arranged to fill in butt gap spaces and/or any voids in the insulation system.

[0047] It is important that there is substantially no air or water present in the insulation system. Therefore, any voids or spaces need to be filled to protect the insulation against moisture pick-up. According to the present invention, no impregnation needs to be performed since the second polymeric material is arranged to fill in spaces or voids in the insulation systems.

[0048] The base film is non-porous which means that the first polymeric material forms a base film with no pores that are permeable to water, air or other fluids. Thus, no air or moisture will be trapped in the material.

[0049] The cable body that comprises the lapped insulation system is usually provided with a moisture barrier to protect the insulation system from water. The moisture barrier is liquid resistant. By "resistant" is meant that the material provides a barrier against liquids, e.g. water and optionally air, but which is not necessarily completely impermeable to e.g. water and/or air. Moisture barriers are needed since the inherent properties of the electric insulation system may deteriorate and it may lose its insulation effect if it is subjected to moisture during a long period. However, since the insulation system of the present invention comprises the first polymeric material as the base film, which is non-porous and thus impermeable for water per se, further improved moisture protection for the conductor is provided.

[0050] The conductor, the insulation system and the moisture barrier can be surrounded by further layers of material that can be included in a protection system of the cable. Further materials and layers may have differ-

ent tasks such as that of holding the different cable parts together, giving the power transmission cable mechanical strength and protecting the cable against physical as well as chemical attacks, e.g. corrosion. Such materials and layers are commonly known to the person skilled in the art. For example, such further materials may include armouring, for example steel wires, and outer protective sheaths.

[0051] The power transmission cables according to the present invention can be single phase, i.e. direct current (DC), cables or three-phase, i.e. alternating current (AC), power transmission cables. DC-cables comprise one conductor surrounded by the insulation system. Three-phase cables comprise three conductors, each of which is surrounded by a separate electric insulation system. The three phase power transmission cable may also comprise further material and layers arranged around and enclosing the rest of the cable as described above. Such further material and layers may have different tasks such as that of holding the different cable parts, as described above, together, and giving the cable mechanical strength and protection, against physical as well as chemical attack, e.g. corrosion, and are commonly known to the person skilled in the art.

[0052] The power transmission cables according to the invention may be underwater power cables or the cables may be land cables. The cable is preferably a power transmission cable having a rated voltage of 50 kV or higher, and is thus suitable for use as a high voltage transmission power cable. For example, the cables may be high voltage direct current (HVDC) cables, high voltage alternating current (HVAC) cables, extra high voltage cables (EHV), ultra-high voltage cables (UHV), medium-voltage cables and low-voltage cables.

[0053] Fig. 1a and Fig. 1b show an example of a power transmission cable comprising a lapped insulation system according to the present invention. In Fig. 1a, a transmission power cable 10 is shown in a partially cut side view and in Fig. 1b in a radial cross-section view and reference is made equally to both figures. The electric power cable comprises a metal conductor 1, which may be a solid or stranded metal conductor of conductive metal, such as aluminium or copper. The cable 10 further comprises an insulation system 2 (indicated in Fig. 1a) comprising an inner semi-conductive covering 4 comprising multiple layers of semi-conductive material radially and coaxially surrounding the conductor 1. The inner semi-conductive covering 4 may be in direct contact with the conductor 1, or a layer of for example conductive tape (not shown) may be arranged in between the conductor 1 and the inner semi-conductive covering 4. The inner semi-conductive covering 4 comprises multiple layers of a composite semi-conductive material comprising a first polymeric material arranged to form a base film, and a second polymeric material arranged to fill in spaces and/or any voids in the insulation system and e.g. carbon black as filler to render the material semi-conductive. Other conductive filler particles may be of course used.

[0054] The inner semi-conductive covering 4 is surrounded coaxially and radially outwards by an insulation covering 5 which comprises multiple layers of a composite insulation material of the present invention comprising a first polymeric material arranged to form a base film, and a second polymeric material arranged to fill in spaces and/or any voids in the insulation system and having insulating properties. Both the composite material for the inner semi-conductive covering 4 and the insulation covering 5 are suitably provided in the form of a tape and helically wrapped around the conductor 1 by means of rows of lapping heads (not shown). The insulation covering 5 is surrounded coaxially and radially outwards by a second, outer semi-conductive covering 6 which comprises multiple layers of the composite material of the present invention having semi-conductive properties. The cable 10 further comprises a protection system comprising a moisture barrier 8, which can be a welded metal layer and which can be corrugated or smooth.

[0055] Fig. 2 shows an example of an alternating current (AC) electric power cable 20 comprising three conductors 21 with an insulation system 22 and a moisture barrier 28. All conductors are identical, but for the reasons of clarity, only one conductor with respective insulation system and moisture barrier has been provided with reference signs. Each conductor 21 is surrounded coaxially and radially by the insulation system 22 comprising multiple layers of insulation and semi-conductive material. Each insulation system 22 comprises an inner semi-conductive covering 24, an insulation covering 25 and an outer semi-conductive covering 26, whereby each of the coverings comprise multiple layers of the composite insulation or semi-conductive material of the present invention. The insulation system 22 is in turn surrounded coaxially and radially outwards by a protection system comprising a moisture barrier 28, which can be a metal layer that can be corrugated or smooth. The three conductors 21 are surrounded by an outer shield 29 that keeps the three conductors 21 together within the AC cable 20. Based on design, the shape of the each cable or each conductor can be of other form, an oval or a sector for instance and alternatively the moisture barrier 28 can be manufactured to cover all together the three insulated conductors at the same time and in this case just one moisture barrier system is needed.

[0056] In Fig. 3a, 3b and 3c (3a-3c) the principle of how the second polymeric material fills spaces or voids in the insulation system has been illustrated. In Fig. 3a two variants of a tape comprising a first polymeric material forming a base film and a second polymeric material forming a coating are shown. The tape 30 comprises the base film 31, which is covered on one side with a second polymeric material forming the coating 32. The tape 30' comprises the base film 31', which is covered on both sides with a second polymeric material forming the coating 32'. When pressed together they form a laminate structure. The base film provides mechanical strength and the coating is arranged to fill spaces between the base film and

a second layer of the tape and also the gaps that occur between different tape layers during a helical lapping process. The second polymeric material forming the coating could either be an adhesive or a hotmelt, i.e. a polymer that melts rapidly at a certain temperature.

[0057] Generally, the coating, i.e. the second polymeric material, may have a lower melting temperature or melting point than the base film, i.e. the first polymeric material. In this way it is possible to let the second material melt and thus fill in gaps, spaces and voids in the insulation system while the base film keeps the structure of the insulation system stable. According to another variant, the melting temperature or melting point of the coating is higher than or the same as the melting temperature or melting point of the base film, but the viscosity of the coating is lower than the viscosity of the base film at a specific manufacturing temperature. Thereby it is possible for the coating to fill in gaps, spaces or voids in the insulation system during the manufacture of the cable. According to another variant, the coating 32 or the second polymeric material can be a pressure sensitive adhesive and/or the adhesive can be heated to flow better and fill spaces, gaps or voids. When the insulation system is lapped and cooled, a solid structure for the insulation system is formed. According to a further variant, it is also possible that the second polymeric material is an adhesive or hotmelt in liquid form and applied directly in the spaces, voids or gaps by means of any suitable liquid application means while lapping. The second polymeric material could be either a thermoplastic or thermoset material. Upon cooling it is also possible to crosslink in different ways, e.g. by means of UV curing of adhesive or by means of a chemical crosslinker. When the second polymeric material is cross-linked, better stability of the insulation system at operational temperature can be provided.

[0058] In Fig. 4, the process according to the present invention is illustrated in a flow chart. In the first step I) of the process a conductor 1 for the power transmission cable is provided. The conductor can be any of the kind described above.

[0059] In the second step II) of the process a semi-conductive material comprising a first polymeric material arranged to form a base film and a second polymeric material arranged to fill in spaces and/or any voids in the insulation system is provided. The second step comprises also applying the semi-conductive material onto the conductor by helically winding at least the base film of the semi-conductive material to radially surround the conductor and by arranging the second polymeric material to fill in spaces and/or any voids and thus provide a first semi-conductive covering and a cable body comprising the conductor and the first semi-conductive covering..

[0060] In the third step III) of the process an insulation material comprising a first polymeric material arranged to form a base film and a second polymeric material arranged to fill in spaces and/or any voids in the insulation system is provided. The process step further comprises

applying the insulation material by helically winding at least the base film of the insulation material to surround the cable body radially outwards and by arranging the second polymeric material to fill in spaces and/or any voids.

[0061] In the fourth step IV) of the process at least the base film of the semi-conductive material is helically wound to surround the insulation covering and the second polymeric material is arranged to fill in spaces and/or any voids to provide a cable body with an insulation system comprising a second semi-conductive covering.

[0062] In the fifth step V) of the process, which is optional, protective materials to cover the insulation system, such as armouring and/or protective sheaths, are provided.

[0063] In the method the first polymeric material and the second polymeric material have different physical and/or chemical properties, as already explained above.

[0064] The semi-conductive and the insulation material are applied by wrapping or lapping the material around the conductor by means of wrapping equipment. Such equipment can be of any type known in the art. Preferably, at least two layers of the insulation material are applied in the insulation covering and at least two layers of the semi-conductive material are applied in the first and second semi-conductive coverings. Thus, the insulation covering comprises at least two layers of insulation material and wherein the first and second semi-conducting coverings comprise at least two layers of semi-conducting material, i.e. the insulation system has a multilayer-structure in each covering.

[0065] During the steps II) to IV) the power transmission cable body is subjected to an increased temperature, radiation, or increased pressure step to activate the coating material so that it fills the butt gap spaces and the voids in the insulation system.

[0066] According to a variant of the present invention, the second polymeric material comprises a cross-linking agent which can be cured to obtain a cross-linked and thermoset insulation system. In that case, the process further comprises curing the cable body before the step V. Curing may be performed at an increased temperature, i.e. heating or by means of radiation, e.g. UV-radiation.

[0067] Also, the process may further comprise corona surface treatment of the semi-conductive coverings and/or the insulation coverings before the step V, suitably in connection with each of the step II to IV. Corona treatment is a standard method to improve adhesion between layers of different polymers. It mainly treats the surface. Corona surface treatment can be performed for example by putting a film inside needle(s)/plane electrode system. The surface of the film can then be treated by the corona generated by the needle(s) electrode under an AC voltage.

[0068] Preferably, the semi-conductive and/or the insulation materials are in the form of a tape. Suitably, the tape is a laminate comprising the first polymeric material

as a base film and the second polymeric material as a coating.

[0069] Suitably, the semi-conductive and/or the insulation materials are helically wrapped around the cable body by means of rows of lapping heads. Such lapping heads are well known in the art and of the known arrangements could be used.

[0070] According to another variant, the first polymeric material forming the base film could be provided in the form of a tape that is helically wrapped around the conductor or the cable body comprising the conductor and the first semi-conductive covering and optionally the insulation covering and the second semi-conductive covering, and wherein the second polymeric material could be added in liquid form during the wrapping. In this case, the second polymeric material should be dried or cured to obtain a solid insulation structure.

Example 1

Lapping process

[0071] Samples were produced in order to prove the concept by lapping with different materials on aluminium tubes. The tubes are used in order to be able to evaluate them electrically without having to produce a long cable. A winding machine was used to lap the samples. One set of samples was prepared with 7 layers of tape having PEN as the base film and acrylic pressure sensitive adhesive as a coating and as further defined below. Another set of samples was prepared with PP as the base film and acrylic UV-curing coating as the coating.

Partial discharge (PD) evaluation

[0072] If the filling material has not fully filled all gaps, then voids are formed which will give rise to PD activity much below its breakdown value. Therefore PD measurements were performed in order to detect any voids.

[0073] Lapped aluminium tubes with 7 layers of 25 μm -thick PEN film (Teonex®) having a width of 19 mm with 50 μm acrylic adhesive forming total thickness of 0.5 mm, were prepared for this purpose and as final process step in order to apply pressure a shrink tape was applied and subsequently heat treated. All samples prepared in this way showed only PD close to the breakdown value.

DC breakdown strength

[0074] DC breakdown test on flat samples was made, comparing PP capacitor film to PP blend granules, extrusion grade, pressed in a hot press to a plaque. In Fig. 5 results of Weibull probability of DC breakdown strength of flat samples of PP film and of PP blend plaque measured in Biotemp oil at room temperature using 0.5 kV/mm ramp rate are shown. As can be seen, the multilayer structure of PP films has higher breakdown value than the single layer of PP blend of extrusion grade.

[0075] The foregoing description and examples of the present invention have been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise embodiments disclosed. Obviously, many modifications and variations will be apparent to practitioners skilled in the art. The embodiments were chosen and described in order to best explain the principles of the invention and its practical applications, thereby enabling others skilled in the art to understand the invention for various embodiments and with the various modifications as are suited to the particular use contemplated. The features specified above may be combined between different embodiments specified within the framework of the invention defined in the appended claims.

Claims

1. A power transmission cable (10; 20) comprising a conductor (1; 21) and an insulation system (2; 22), wherein the insulation system (2; 22) comprises:
 - a first semi-conductive covering (4; 24) comprising a layer of semi-conductive material radially surrounding the conductor (1; 21);
 - an insulation covering (5; 25) comprising a layer of insulation material surrounding the first semi-conductive covering (4; 24) radially outwards;
 - a second semi-conductive covering (6; 26) comprising a layer of semi-conductive material surrounding the insulation covering (5; 25) radially outwards;
 wherein the semi-conductive material and the insulation material comprise a first polymeric material arranged to form a base film (31; 31'), and a second polymeric material arranged to fill in spaces and/or any voids in the insulation system, wherein the first polymeric material and the second polymeric material have different physical and/or chemical properties, wherein the second polymeric material is an adhesive material, and wherein at least the first polymeric material that forms the base film (31; 31') of the semi-conductive material and the insulation material is helically wound around the conductor (1; 21) or a cable body comprising the conductor (1; 21) and at least the first semi-conductive covering (4; 24).
2. Power transmission cable according to claim 1, wherein the insulation covering comprises at least two layers of insulation material and wherein the first and second semi-conducting coverings comprise at least two layers of semi-conducting material.

3. Power transmission cable according to any one of claims 1 to 2, wherein the first polymeric material as the base film (31; 31') is provided as a tape and the second polymeric material is provided as a liquid or a semisolid. 5
4. Power transmission cable according to any one of claims 1 to 3, wherein the first polymeric material as the base film (31; 31') and/or the second polymeric material are provided as a tape. 10
5. Power transmission cable according to claim 4, wherein the tape (30; 30') comprises the first polymeric material as the base film (31; 31') and the second polymeric material as a coating layer (32; 32') adhered to the base film (31; 31'). 15
6. Power transmission cable according to any of claims 4 to 5, wherein the thickness of the second polymeric material is from 1 to 300 μm . 20
7. Power transmission cable according to any one of the preceding claims, wherein the thickness of the base film is from 1 to 300 μm . 25
8. The power transmission cable according to any one of the preceding claims, wherein the first polymeric material forming the base film comprises or consists of a polyolefin, such as polypropylene, polyethylene, such as high density polyethylene, low density polyethylene or cross-linked polyethylene, or polyethylene terephthalate, polyethylene naphthalate or sulfonated plastic, such as polyethersulfone (PES), polyphenylene sulphide (PPS) and polysulfone (PSU), or polycarbonate, poly(methyl methacrylate), polyaramid, or any blend thereof. 30 35
9. The power transmission cable according to claim 8, wherein the first polymeric material as the base film (31; 31') and the second polymeric material are provided as a tape and wherein the tape (30; 30') comprises the first polymeric material as the base film (31; 31') and the second polymeric material as a coating layer (32; 32') adhered to the base film (31; 31') and wherein the second polymeric material is a hotmelt material. 40 45
10. The power transmission cable according to any one of the preceding claims, wherein the insulation system is additionally comprised in a cable joint of the power transmission cable. 50
11. Process for the production of a power transmission cable (10; 20) comprising a conductor (1; 21) and an insulation system (2; 22) surrounding the conductor (1; 21), wherein the process comprises the steps of: 55

I. providing a conductor (1; 21) for the power

transmission cable (10; 20);

II. providing a semi-conductive material comprising a first polymeric material arranged to form a base film (31; 31') and a second polymeric material arranged to fill in spaces and/or any voids in the insulation system, and applying the semi-conductive material onto the conductor by helically winding at least the base film (31; 31') of the semi-conductive material to radially surround the conductor (1; 21) and by arranging the second polymeric material to fill in spaces and/or any voids, and thus provide a first semi-conductive covering (4; 24) and a cable body comprising the conductor (1; 21) and the first semi-conductive covering (4; 24);

III. providing an insulation material comprising a first polymeric material arranged to form a base film (31; 31') and a second polymeric material arranged to fill in spaces and/or any voids in the insulation system, and applying the insulation material by helically winding at least the base film (31; 31') of the insulation material to surround the cable body radially outwards and by arranging the second polymeric material to fill in spaces and/or any voids, and thus provide a cable body further comprising an insulation covering (5; 25);

IV. helically winding at least the base film (31; 31') of the semi-conductive material to surround the insulation covering (5; 25) and by arranging the second polymeric material to fill in spaces and/or any voids to provide a cable body with an insulation system (2; 22) further comprising a second semi-conductive covering (6; 26);

V. optionally providing protective materials to cover the insulation system (2; 22), such as armouring and/or protective sheaths;

wherein the first polymeric material and the second polymeric material have different physical and/or chemical properties, and wherein the second polymeric material is an adhesive material.

12. Process according to claim 11, wherein the insulation covering comprises at least two layers of insulation material and wherein the first and second semi-conducting coverings comprise at least two layers of semi-conducting material.

13. Process according to claim 11 or 12, wherein during the steps II) to IV) the power transmission cable body is subjected to an increased temperature, radiation, or increased pressure step to activate the second polymeric material so that it fills the spaces and the voids in the insulation system.

14. Process according to any one of claims 11 to 13, wherein the semi-conductive and/or the insulation

materials are in the form of a tape (30; 30').

15. Process according to any one of claims 11-14, wherein the first polymeric material forming the base film (31; 31') is provided in the form of a tape (30; 30') that is helically wrapped around the conductor (1; 21) or the cable body comprising the conductor (1; 21) and the first semi-conductive covering (4; 24) and optionally the insulation covering (5; 25) and optionally the second semi-conductive covering (6; 26), and wherein the second polymeric material is applied in liquid form during the wrapping.

Patentansprüche

1. Starkstromübertragungskabel (10; 20), das einen Leiter (1; 21) und ein Isoliersystem (2; 22) umfasst, wobei das Isoliersystem (2; 22) umfasst:

- eine erste halbleitende Abdeckung (4; 24), die eine Schicht aus halbleitendem Material umfasst, die den Leiter (1; 21) radial umgibt;
- eine Isolierabdeckung (5; 25), die eine Schicht aus Isoliermaterial umfasst, welche die erste halbleitende Abdeckung (4; 24) radial nach außen umgibt;
- eine zweite halbleitende Abdeckung (6; 26), die eine Schicht aus halbleitendem Material umfasst, welche die Isolierabdeckung (5; 25) radial nach außen umgibt;

wobei das halbleitende Material und das Isoliermaterial ein erstes Polymermaterial, das dazu angeordnet ist, eine Basisfolie (31; 31') auszubilden, und ein zweites Polymermaterial, das dazu angeordnet ist, Räume und/oder jegliche Leerräume in dem Isoliersystem auszufüllen, umfassen, wobei das erste Polymermaterial und das zweite Polymermaterial unterschiedliche physikalische und/oder chemische Eigenschaften aufweisen, wobei das zweite Polymermaterial ein klebendes Material ist und wobei wenigstens das erste Polymermaterial, das die Basisfolie (31; 31') des halbleitenden Materials und das Isoliermaterial ausbildet, spiralförmig um den Leiter (1; 21) oder einen Kabelkörper, der den Leiter (1; 21) und wenigstens die erste halbleitende Abdeckung (4; 24) umfasst, gewickelt ist.

2. Starkstromübertragungskabel nach Anspruch 1, wobei die Isolierabdeckung wenigstens zwei Schichten aus Isoliermaterial umfasst und wobei die erste und zweite halbleitende Abdeckung wenigstens zwei Schichten aus halbleitendem Material umfassen.
3. Starkstromübertragungskabel nach einem der Ansprüche 1 bis 2, wobei das erste Polymermaterial

als die Basisfolie (31; 31') als ein Band vorgesehen ist und das zweite Polymermaterial als eine Flüssigkeit oder ein halbfester Stoff vorgesehen ist.

4. Starkstromübertragungskabel nach einem der Ansprüche 1 bis 3, wobei das erste Polymermaterial als die Basisfolie (31; 31') und/oder das zweite Polymermaterial als ein Band vorgesehen ist/sind.
5. Starkstromübertragungskabel nach Anspruch 4, wobei das Band (30; 30') das erste Polymermaterial als die Basisfolie (31; 31') und das zweite Polymermaterial als eine Beschichtungsschicht (32; 32'), die an der Basisfolie (31; 31') haftet, umfasst.
6. Starkstromübertragungskabel nach einem der Ansprüche 4 bis 5, wobei die Dicke des zweiten Polymermaterials 1 bis 300 μm beträgt.
7. Starkstromübertragungskabel nach einem der vorhergehenden Ansprüche, wobei die Dicke der Basisfolie 1 bis 300 μm beträgt.
8. Starkstromübertragungskabel nach einem der vorhergehenden Ansprüche, wobei das erste Polymermaterial, das die Basisfolie ausbildet, ein Polyolefin umfasst oder aus einem solchen besteht, wie etwa Polypropylen, Polyethylen, wie etwa Polyethylen mit hoher Dichte, Polyethylen mit niedriger Dichte oder vernetztes Polyethylen, oder Polyethylenterephthalat, Polyethylennaphthalat oder Sulfon-Kunststoff, wie etwa Polyethersulfon (PES), Polyphenylensulfid (PPS) und Polysulfon (PSU), oder Polycarbonat, Poly(methylmethacrylat), Polyaramid oder eine beliebige Mischung derselben.
9. Starkstromübertragungskabel nach Anspruch 8, wobei das erste Polymermaterial als die Basisfolie (31; 31') und das zweite Polymermaterial als ein Band vorgesehen sind und wobei das Band (30; 30') das erste Polymermaterial als die Basisfolie (31; 31') und das zweite Polymermaterial als eine Beschichtungsschicht (32; 32'), die an der Basisfolie (31; 31') haftet, umfasst und wobei das zweite Polymermaterial ein Heißschmelzmaterial ist.
10. Starkstromübertragungskabel nach einem der vorhergehenden Ansprüche, wobei das Isoliersystem außerdem in einem Kabelverbinder des Starkstromübertragungskabels enthalten ist.
11. Verfahren zur Herstellung eines Starkstromübertragungskabels (10; 20), das einen Leiter (1; 21) und ein Isoliersystem (2; 22), das den Leiter (1; 21) umgibt, umfasst, wobei das Verfahren folgende Schritte umfasst:

I. Bereitstellen eines Leiters (1; 21) für das Stark-

stromübertragungskabel (10; 20);

II. Bereitstellen eines halbleitenden Materials, das ein erstes Polymermaterial, das dazu angeordnet ist, eine Basisfolie (31; 31') auszubilden, und ein zweites Polymermaterial, das dazu angeordnet ist, Räume und/oder jegliche Leerräume in dem Isoliersystem auszufüllen, umfasst, und Aufbringen des halbleitenden Materials auf den Leiter durch spiralförmiges Wickeln wenigstens der Basisfolie (31; 31') aus dem halbleitenden Material, so dass sie den Leiter (1; 21') radial umgibt, und durch Anordnen des zweiten Polymermaterials dazu, Räume und/oder jegliche Leerräume auszufüllen, und somit Bereitstellen einer ersten halbleitenden Abdeckung (4; 24) und eines Kabelkörpers, der den Leiter (1; 21) und die erste halbleitende Abdeckung (4; 24) umfasst;

III. Bereitstellen eines Isoliermaterials, das ein erstes Polymermaterial, das dazu angeordnet ist, eine Basisfolie (31; 31') auszubilden, und ein zweites Polymermaterial, das dazu angeordnet ist, Räume und/oder jegliche Leerräume in dem Isoliersystem auszufüllen, umfasst, und Aufbringen des Isoliermaterials durch spiralförmiges Wickeln wenigstens der Basisfolie (31; 31') aus dem Isoliermaterial, so dass sie den Kabelkörper radial nach außen umgibt, und durch Anordnen des zweiten Polymermaterials dazu, Räume und/oder jegliche Leerräume auszufüllen, und somit Bereitstellen eines Kabelkörpers, der ferner eine Isolierabdeckung (5; 25) umfasst;

IV. spiralförmiges Wickeln wenigstens der Basisfolie (31; 31') aus dem halbleitenden Material, so dass sie die Isolierabdeckung (5; 25) umgibt, und durch Anordnen des zweiten Polymermaterials dazu, Räume und/oder jegliche Leerräume auszufüllen, um einen Kabelkörper mit einem Isoliersystem (2; 22), das ferner eine zweite halbleitende Abdeckung (6; 26) umfasst, bereitzustellen;

V. optional Bereitstellen von Schutzmaterialien, um das Isoliersystem (2; 22) abzudecken, wie etwa Bewehrungs- und/oder Schutzummantelungen;

wobei das erste Polymermaterial und das zweite Polymermaterial unterschiedliche physikalische und/oder chemische Eigenschaften aufweisen und wobei das zweite Polymermaterial ein klebendes Material ist.

12. Verfahren nach Anspruch 11, wobei die Isolierabdeckung wenigstens zwei Schichten aus Isoliermaterial umfasst und wobei die erste und zweite halbleitende Abdeckung wenigstens zwei Schichten aus halbleitendem Material umfassen.

13. Verfahren nach Anspruch 11 oder 12, wobei während der Schritte II) bis IV) der Starkstromübertragungskabel-Körper einem Schritt mit erhöhter Temperatur, Strahlung oder erhöhtem Druck ausgesetzt wird, um das zweite Polymermaterial zu aktivieren, so dass es die Räume und die Leerräume in dem Isoliersystem ausfüllt.

14. Verfahren nach einem der Ansprüche 11 bis 13, wobei das halbleitende und/oder das Isoliermaterial in Form eines Bandes (30; 30') vorliegt/vorliegt.

15. Verfahren nach einem der Ansprüche 11-14, wobei das erste Polymermaterial, das die Basisfolie (31; 31') ausbildet, in Form eines Bandes (30; 30') bereitgestellt wird, das spiralförmig um den Leiter (1; 21) oder den Kabelkörper, der den Leiter (1; 21) und die erste halbleitende Abdeckung (4; 24) und optional die Isolierabdeckung (5; 25) und optional die zweite halbleitende Abdeckung (6; 26) umfasst, gewickelt wird, und wobei das zweite Polymermaterial während des Wickelns in flüssiger Form aufgebracht wird.

Revendications

1. Câble de transmission d'énergie (10 ;20) comprenant un conducteur (1 ;21) et un système d'isolation (2 ;22), dans lequel le système d'isolation (2 ;22) comprend :

- un premier couvercle semi-conducteur (4 ;24) comprenant une couche de matériau semi-conducteur entourant radialement le conducteur (1 ;21) ;
- un couvercle isolant (5 ;25) comprenant une couche de matériau isolant entourant le premier couvercle semi-conducteur (4 ;24) radialement vers l'extérieur ;
- un seconds couvercle semi-conducteur (6 ;26) comprenant une couche de matériau semi-conducteur entourant le couvercle d'isolation (5 ;25) radialement vers l'extérieur ;

dans lequel le matériaux semi-conducteur et le matériau d'isolation comprennent un premier matériau polymère disposé afin de former un film de base (31 ; 31') et un second matériau polymère disposé afin de remplir des espaces et/n'importe quels vides dans le système d'isolation, dans lequel le premier matériau polymère et le seront matériau polymère ont des propriétés physiques et/ou chimiques différentes, dans lequel le second matériau polymère est un matériau adhésif, et dans lequel au moins le premier matériau polymère qui forme le film de base (31 ;31') du matériau semi-

- conducteur et le matériau d'isolation est enroulé de manière hélicoïdale autour du conducteur (1 ; 21) ou un corps de câble comprenant le conducteur (1 ; 21) et au moins le premier couvercle semi-conducteur (4 ; 24).
2. Câble de transmission d'énergie selon la revendication 1, dans lequel le couvercle isolant comprend au moins deux couches de matériau d'isolation et dans lequel le premier et le second couvercle semi-conducteur comprend au moins deux couches de matériau semi-conducteur.
3. Câble de transmission d'énergie selon une quelconque des revendications 1 à 2, dans lequel le premier matériau polymère en tant que film de base (31 ; 31') est fourni sous forme d'un ruban et le second matériau polymère est fourni sous forme d'un liquide ou un semi solide.
4. Câble de transmission d'énergie selon une quelconque des revendications 1 à 3, dans lequel le premier matériau polymère en tant que film de base (31 ; 31') et/ou le second matériau polymère sont fournis sous forme d'un ruban.
5. Câble de transmission d'énergie selon la revendication 4, dans lequel le ruban (30 ; 30') comprend le premier matériau polymères en tant que film de base (31 ; 31') et le second matériau polymère comme une couche de revêtement (32 ; 32') collée au film de base (31 ; 31').
6. Câble de transmission d'énergie selon une quelconque des revendications 4 à 5, dans lequel l'épaisseur du second matériau polymère est de 1 à 300 μm .
7. Câble de transmission d'énergie selon une quelconque des revendications précédentes, dans lequel l'épaisseur du film de base est de 1 à 300 μm .
8. Câble de transmission d'énergie selon une quelconque des revendications précédentes, dans lequel le premier matériau polymère formant le film de base comprend ou est constitué d'une polyoléfine, tel que du polypropylène, polyéthylène, tel qu'un polyéthylène à haute densité, un polyéthylène à basse densité ou un polyéthylène réticulé, ou un polyéthylène téréphtalate, polyéthylène naphhtalate ou plastique sulfoné, tel que du polyéthersulfone (PES), sulfure de polyphénylène (PPS) et polysulfone (PSU), ou du polycarbonate, poly(méthyl métacrylate), polyaramide ou n'importe quel mélange de ces derniers.
9. Câble de transmission d'énergie selon la revendication 8, dans lequel le premier matériau polymère en tant que film de base (31 ; 31') et le second matériau polymère sont fournis sous forme d'un ruban et dans lequel le ruban (30 ; 30') comprend le premier matériau polymère de film de base (31 ; 31') et le second matériau polymère comme une couche de revêtement (32 ; 32') collée au film de base (31 ; 31') et dans lequel le second matériau polymère est un matériau fondu à chaud.
10. Câble de transmission d'énergie selon une quelconque des revendications précédentes, dans lequel le système d'isolation est additionnellement compris dans un joint de câble du câble de transmission d'énergie.
11. Processus pour la production d'un câble de transmission d'énergie (10 ; 20) comprenant un conducteur (1 ; 21) et un système d'isolation (2 ; 22) entourant le conducteur (1 ; 21), dans lequel le processus comprend les étapes consistant à :
- fournir un conducteur (1 ; 21) pour le câble de transmission d'énergie (10 ; 20) ;
 - fournir un matériau semi-conducteur comprenant un premier matériau polymère disposé afin de former un film de base (31 ; 31') et un second matériau polymère agencé pour remplir des espaces et/ou n'importe quels vides dans le système d'isolation et appliquer le matériau semi-conducteur sur le conducteur en enroulant la manière hélicoïdale au moins le film de base (31 ; 31') du matériau semi-conducteur afin d'enrouler radialement le conducteur (1 ; 21) et en disposant le second matériau polymères afin de remplir des espaces et/n'importe quels vides, et fournir ainsi un premier couvercle semi-conducteur (4 ; 24) et un corps de câble comprenant le conducteur (1 ; 21) et le premier couvercle semi-conducteur (4 ; 24) ;
 - fournir un matériau d'isolation comprenant un premier matériau polymère disposé afin de former un film de base (31 ; 31') et un second matériau polymère agencé pour remplir l'espace et/ou n'importe quels vides dans le système d'isolation, et appliquer le matériau d'isolation en enroulant de manière hélicoïdale au moins le film de base (31 ; 31') du matériau isolant afin d'entourer le corps de câble radialement vers extérieur et en disposant le second matériau polymère afin de remplir des espaces et/ou n'importe quels vides, et ainsi fournir un corps de câble comprenant en outre un couvercle d'isolation (5 ; 25) ;
 - enrouler de manière hélicoïdale au moins le film de base (31 ; 31) du matériau semi-conducteur afin d'enrouler le couvercle d'isolation (5 ; 25) et agencer le second matériau polymère afin de remplir des espaces et/ou n'importe quels vides afin de fournir un corps de câble avec un

système d'isolation (2 ; 22) comprenant en outre un second couvercle semi-conducteur (6 ; 26) ; V. fournir optionnellement des matériaux protecteurs pour couvrir le système d'isolation (2 ; 22) tel qu'un blindages et/ou des gaines protectrices ; 5

dans lequel le premier matériau polymère et le second matériau polymères ont des propriétés physiques et/ou chimiques différentes et dans lequel le second matériau polymère est un matériau adhésif. 10

12. Processus selon la revendication 11, dans lequel le couvercle d'isolation comprend au moins deux couches de matériaux d'isolation et dans lequel le premier et le second couvercle semi-conducteurs comprennent au moins deux couches de matériau semi-conducteur. 15

13. Processus selon la revendication 11 ou 12, dans lequel pendant les étapes II) à IV) le corps de câble de transmission d'énergie est soumis à une température accrue, un rayonnement accru ou une étape de pression accrue pour activer le second matériau polymères de sorte qu'il remplisse les espaces et les vides dans le système d'isolation. 20 25

14. Processus selon une quelconque des revendications 11 à 13, dans lequel le matériau semi-conducteur et/ou le matériau d'isolation prennent la forme d'un ruban (30 ; 30'). 30

15. Processus selon une quelconque des revendications 11-14, dans lequel le premier matériau polymère formant le film de base (31 ; 31') est fourni sous la forme d'un ruban (30 ; 30') qui est enroulé de manière hélicoïdale autour du conducteur (1 ; 21) ou du corps de câble comprenant le conducteur (1 ; 21) et le premier couvercle semi-conducteur (4 ; 24) et optionnellement le couvercle d'isolation (5 ; 25) et optionnellement le second couvercle semi-conducteur (6 ; 26), et dans lequel le second matériau polymères est appliqué sous forme liquide pendant l'emballage. 35 40 45

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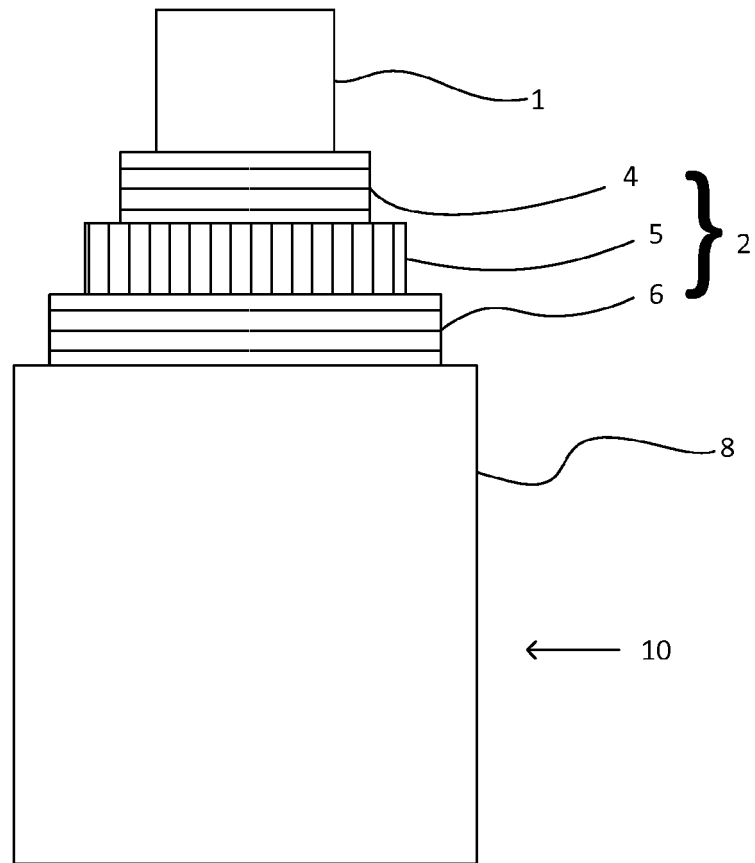


Fig. 1a

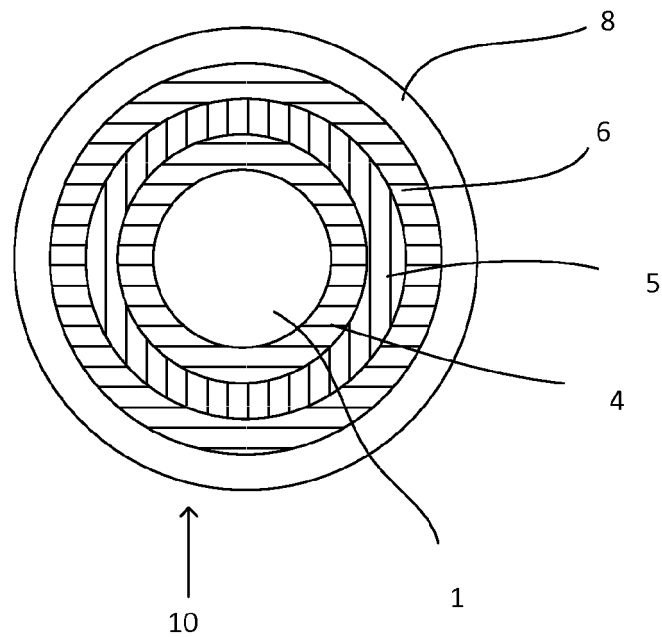


Fig. 1b

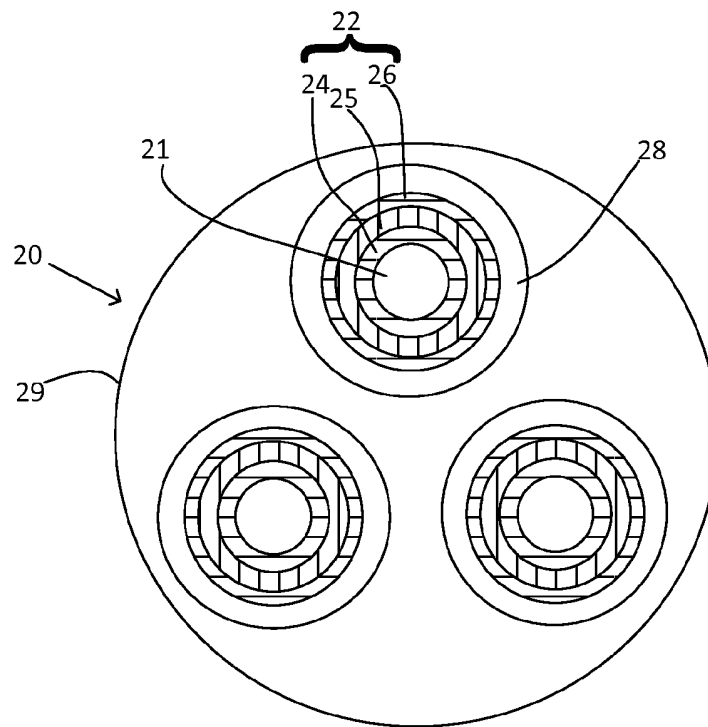


Fig. 2

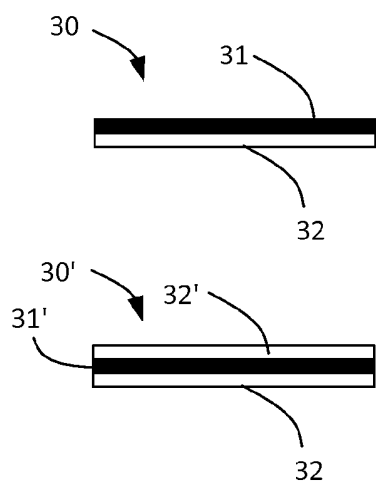


Fig. 3a

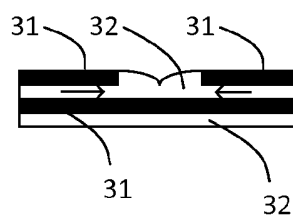


Fig. 3b

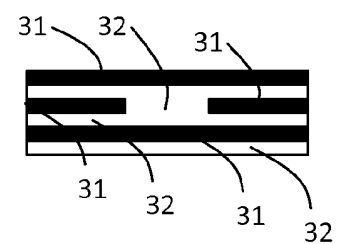


Fig. 3c

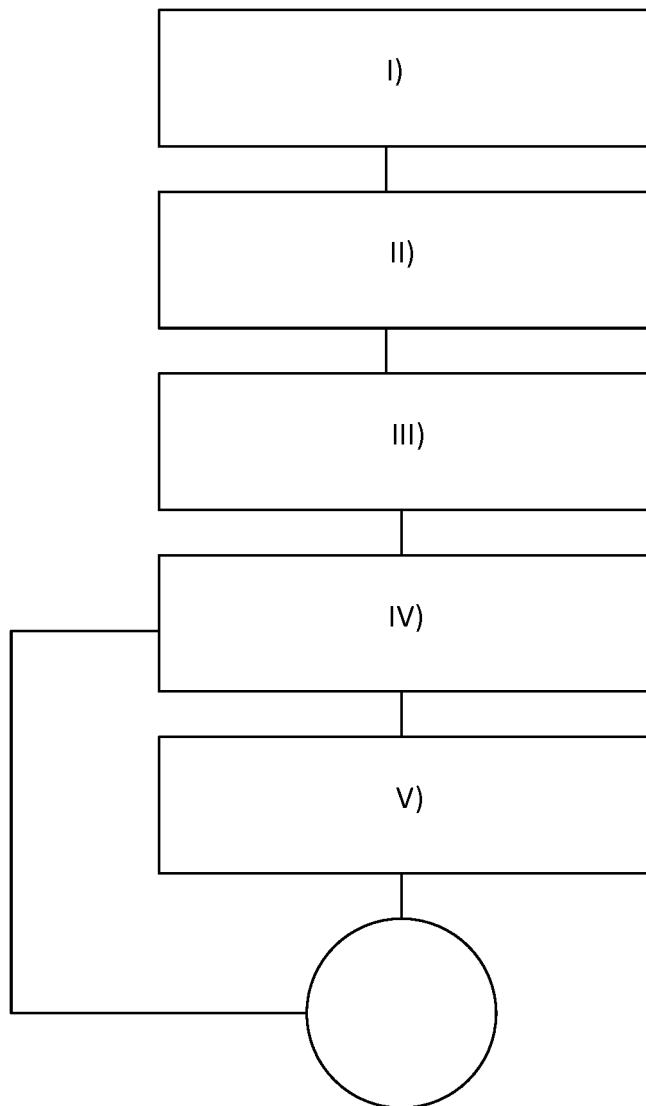


Fig. 4

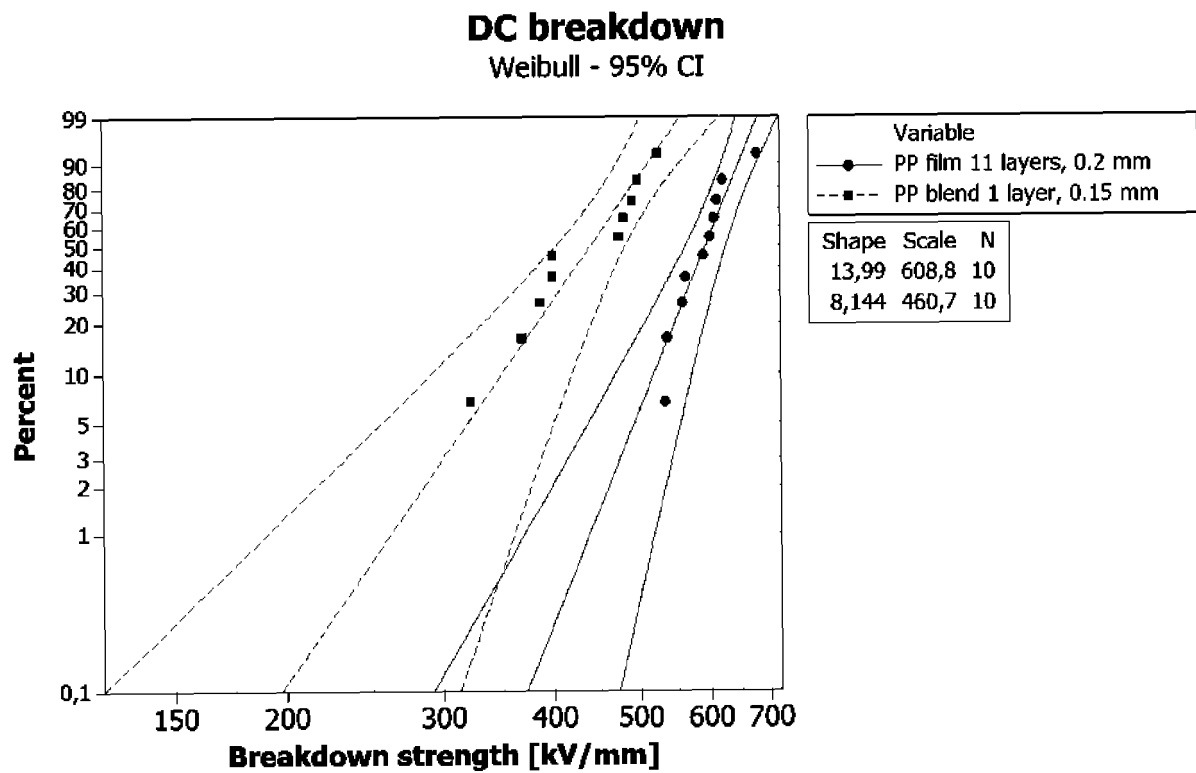


Fig. 5

REFERENCES CITED IN THE DESCRIPTION

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