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(54) **Heating cable and method producing the same**

Heizkabel und Herstellungsverfahren

Câble chauffant et procédé de fabrication

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(72) Inventor: **Torstensson, Lars Jonas Kenert**
51470 Grimsas (SE)

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(74) Representative: **Feray, Valérie et al**
Feray Lenne Conseil
44-52, rue de la Justice
75020 Paris (FR)

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(73) Proprietor: **Nexans**
75008 Paris (FR)

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Description

[0001] The present invention relates to electrical heating cables and in particular to heating cables of the selfregulating type. Such cables include two electrical conductors or electrodes and a PTC (Positive Temperature Coefficient) element arranged between the conductors. When the two conductors are connected to a current source, current will flow from one conductor to the other through the PTC material and generate controlled heat.

[0002] Such cables are generally known from EP 0 160 100 A1 which describes a PTC heating cable having a cord- or tape-like structure. A PTC heating element is provided between a pair of electrodes and the outer periphery of these members is covered with an insulation sheath. A mathematical formula is determined for setting the resistance value of the electrodes.

[0003] A selflimiting electrical heating device using a PTC element between two conductors is also known from SE 433 999. The PTC effect is obtained with a certain composition of materials. A defined gap or distance between the two conductors is maintained by means of a special distance element or by incorporating glass fiber material in the PTC element.

[0004] EP-0 312 204 discloses a heating cable comprising a core, comprising a polymer center element, two electrical conductors, a PTC element therebetween, made of an extruded layer of a PTC material arranged over the center element in contact with said conductors, and at least one layer of insulation material.

[0005] The object of the present invention is to improve the quality of selfregulating heating cables. This is obtained by making a new cable design and by simplifying the manufacturing method. The main features of the invention are defined in the claims.

[0006] The present invention also relates to methods and means for crosslinking the PTC and other polymers used in the cable. This has previously been done with irradiation technique, but such processes should be avoided. The silane crosslinking process can be undertaken by means of water and steam at a temperature of 20-100 °C.

[0007] With this invention we have obtained a manufacturing process by which the cable can be produced in a cost effective way, - resulting in a heating cable with stable PTC properties.

[0008] Above mentioned and other features and objects of the present invention will clearly appear from the following detailed description of embodiments of the invention taken in conjunction with the drawings, where

Figure 1 schematically shows a crosssection of the cable, and

Figures 2 to 4 illustrate process lines for manufacturing the cable.

[0009] In Figure 1 is indicated a laminated cable struc-

ture consisting of a center element 1, a semiconducting layer 2 and outer insulation 3. This polymer laminate is crosslinked by means of a silane process. Outer protecting sheaths (not shown) could consist of a metal sheath/layer and an outer corrosion protective layer of halogen free compound, PVC or Teflon. The illustration shows a circular crosssection and is not drawn to scale. The crosssection may alternatively be oval or flattened in other ways. The center element 1 and the insulation 3 may consist of polyethylene with silane/peroxide/antioxidant. The semiconducting layer 2 may consist of polyethylene/ethylene-octene/ethylene/spherulene, carbon black, silane/peroxide/antioxidant.

[0010] Two bare conductors 4 and 5 - of copper or other suitable material - are tangentially arranged in the center element 1 so that part of the conductor surfaces coincide with the surface of the center element. The conductors should preferably be arranged in opposite sides of the center element as illustrated. The PTC layer 2 is arranged over the center element in contact with said conductor surface parts. When the conductors 4 and 5 are connected to a current source, current will flow through the concentric PTC layer from one conductor to the other and generate controlled heat in the cable.

[0011] The cable core elements 1-5 may be assembled in a manufacturing line as illustrated in Figure 2 to provide the cable core illustrated in Figure 1. The line may include a number of polymer extruders arranged in tandem to provide a core which in a further process is spirallized and then crosslinked in order to lock the spirallization and bond the layers together.

[0012] In Figure 2 the center element 1 is supplied from an extruder 10. The conductors 4 and 5 are supplied from reels 11 and 12 to a die 13 where the conductors are inserted into corresponding slots of the center element 1. The resulting core element 14 is passed through an extruder 15 for application of the PTC layer 2 and further through an extruder 16 for application of the insulation sheath 3 to produce the core 17. The extruders 15 and 16 could be a two layer extruder. This core 17 is wound on a reel 18 which is also rotated in a plane perpendicular to the line axis to give the core a desired spirallization on the reel. Finally - and before application of the outer protective layers (not shown) - the polymer materials of the core are crosslinked in a silane crosslinking process (not shown) whereby the spirallization is locked.

[0013] Alternatively to the first part of the process of Figure 2, the conductors 4 and 5 can be supplied from their reel directly into a center element extruder 20, Figure 3, for providing the core 14 which is passed through extruders 15/16 and further processing.

[0014] Alternatively to the process illustrated in Figures 2 and 3, the cable core can be assembled in a number of consecutive steps as illustrated in Figure 4. The elements 1+4+5 can be assembled in a first extruding process as outlined and the core 14 can be wound on a reel 30. In further processing the center element

reel 30 can be rotated in a plane perpendicular to the line axis to give the element 14 a desired spirallization before passing it through extruders 15 and 16 to produce a core 31 which is similar to the core 17 but which has a spirallized center element. This core is wound on a reel 32 for silane crosslinking and further processing.

[0015] Still alternatively the center element 1 can be premade with slots and spirallized and then crosslinked before inserting the conductors 4 and 5 into the slots and passing this cable core 1+4+5 through extruders 15-16 and further silane crosslinking means.

[0016] The spirallization is required in order to obtain a flexible cable which easily lends itself to installation in floors for room heating. Instead of a helical configuration the center element slots and conductors could have a wobble-waggle (S-Z) form.

[0017] The present invention use polymer based on metallocene technology and has to be grafted and crosslinked with the silane process.

[0018] The center element 1 consists of silane crosslinked polyethylene. The polyethylene includes molecules of vinyltrimethoxysilane containing an organo heavy metal compound in an amount of from 0.005 to 1% by weight based on the total amount of said composition as a crosslinking catalyst.

[0019] The PTC polymer layer 2 is based on ethylene and ethylene-octene copolymer with carbon black and silane grafted by direct feeding silane/peroxide or using a Master Batch (MB) containing components which are needed to crosslink and heat stabilize the polymer materials involved in a silane/peroxide/catalyst process.

[0020] The PTC layer 2 and the insulation layer 3 are crosslinked by cross-linking reaction of trimethoxysilane groups in said polyethylene and the PTC polymer in the presence of water.

[0021] The PTC layer 2 and the insulation layer 3 may as mentioned above be extruded in one process and the PTC layer contains an organo metal compound selected from the group consisting of dibutyltin dilaurate. The insulation layer 3 may be cured or crosslinked, by diffusion of the catalyst agent-dibutyltin dilaurate - from the PTC layer.

[0022] The above detailed description of embodiments of this invention must be taken as examples only and should not be considered as limitations on the scope of protection.

Claims

1. Heating cable comprising a core comprising :

- a polymer center element (1),
- two electrical conductors (4, 5),
- a PTC element therebetween, made of an extruded layer (2) of a PTC material arranged over the center element (1) in contact with said conductors (4, 5), and

- at least one outer layer (3) of insulation material,

characterized in that

- said center element (1) is extruded,
- said two conductors (4, 5) are arranged inside slots provided in said center element (1) so that part of the conductor surfaces coincide with the center element (1) surface
- said layer (2) of PTC polymer is in contact with said conductor surface parts
- said core comprises at least one outer extruded insulation layer (3).

2. Cable according to claim 1,

characterized in that

- the conductors (4,5) are spirallized or wobble-waggled in the center element.

3. Cable according to claim 1,

characterized in that

- at least two of the extruded polymer elements of the cable core - the center element (1) and the two layers (2,3) - are bonded together.

4. Cable according to claim 1,

characterized in that

- the polymer elements (1,2,3) of the cable core are crosslinked with a silane process.

5. Cable according to claim 1,

characterized in that

- the center element (1) consists of silane crosslinked polyethylene including molecules of vinyltrimethoxysilane containing an organo heavy metal compound in an amount of from 0.005 to 1% by weight based on the total amount of said composition as a crosslinking catalyst.

6. Cable according to claim 1,

characterized in that

- the PTC layer (2) is based on ethylene and ethylene-octene copolymer with carbon black and silane grafted by direct feeding silane/peroxide or using a Master Batch with silane/peroxide/catalyst.

7. Cable according to claim 1,

characterized in that

- the PTC layer (3) has a volume resistivity of 100 - 100 000 ohmcm.

8. Method for making a heating cable according to anyone of claims 1 to 7, said cable comprising a core having two electrical conductors (4,5), a PTC element therebetween and an outer layer (3) of insulation material,

characterized by

crosslinking the PTC element (2) and the insulation layer (3) using reaction of trimethoxysilane groups in the polyethylene and in the PTC polymer in the presence of water.

9. Method according to claim 8, **characterized by** including in the PTC layer (2) an organo metal compound selected from the group consisting of dibutyltin dilaurate.
10. Method according to claim 9, and where the PTC layer (2) and the insulation layer (3) are extruded in one process, **characterized by** curing or crosslinking the insulation layer (3) by diffusion of the catalyst agent - dibutyltin dilaurate - from the PTC layer.

Patentansprüche

1. Heizkabel mit einer Ader, welches die folgenden Merkmale umfasst:

- ein mittleres Polymer-Element (1),
- zwei elektrische Leiter (4,5),
 - ein dazwischen angeordnetes PTC-Element, das aus einer extrudierten Schicht (2) eines PTC-Materials besteht, die über dem in Kontakt mit den Leitern (4, 5) befindlichen mittleren Element (1) angeordnet ist, und
 - wenigstens eine Außenschicht (3) aus Isoliermaterial,

dadurch gekennzeichnet, dass

- das mittlere Element (1) extrudiert ist,
- die beiden Leiter (4,5) in Schlitzen angeordnet sind, die in dem mittleren Element (1) so vorgesehen sind, dass die Leiteroberflächen teilweise in Berührung mit der Oberfläche des mittleren Elements (1) sind,
- die Schicht (2) aus PTC-Polymer sich in Kontakt mit diesen Teilen der Leiteroberfläche befindet,
- die Ader wenigstens eine extrudierte Außenisolierschicht (3) umfasst.

2. Kabel nach Anspruch 1, **dadurch gekennzeichnet, dass** die Leiter (4, 5) in dem mittleren Element in Spiral- oder Zickzackform vorliegen.

3. Kabel nach Anspruch 1, **dadurch gekennzeichnet, dass** extrudierten Polymer-Elemente der Kabelader - das mittlere Element (1) und die beiden

Schichten (2, 3) - zusammengefügt sind.

4. Kabel nach Anspruch 1, **dadurch gekennzeichnet, dass** die Polymer-Elemente (1, 2, 3) der Kabelader mit einem Silanverfahren vernetzt werden.

5. Kabel nach Anspruch 1, **dadurch gekennzeichnet, dass** das mittlere Element (1) silanvernetztes Polyethylen mit Vinyl-trimethoxysilan umfasst, welches eine organische Schwermetallverbindung in einer Menge von 0,005 bis 1 Gewichtsprozent enthält, basierend auf der Gesamtmenge dieser Zusammensetzung als Vernetzungskatalysator.

6. Kabel nach Anspruch 1, **dadurch gekennzeichnet, dass** die PTC-Schicht (2) auf Ethylen und Ethylen-Okten-Copolymer mit Carbon-Black und Silan basiert, das durch direktes Zuführen von Silan/Peroxid oder mittels eines Masterbatch mit Silan/Peroxid/Katalysator aufpolymerisiert wird.

7. Kabel nach Anspruch 1, **dadurch gekennzeichnet, dass** die PTC-Schicht (3) einen spezifischen Durchgangswiderstand von 100 - 100.000 Ohm/cm aufweist.

8. Verfahren zur Herstellung eines Heizkabels nach einem der Ansprüche 1 bis 7, wobei das Kabel eine Ader mit zwei elektrischen Leitern (4, 5), ein dazwischen angeordnetes PTC-Element und eine Außenschicht (3) aus Isoliermaterial umfasst, **gekennzeichnet durch** Vernetzen des PTC-Elements (2) und der Isolierschicht (3) mittels Reaktion der Trimethoxysilan-Gruppen in dem Polyethylen und in dem PTC-Polymer in Anwesenheit von Wasser.

9. Verfahren nach Anspruch 8, **gekennzeichnet durch** Beifügen einer aus der Dibutyltin-Dilaurat umfassenden Gruppe gewählten organischen Metallverbindung in die PTC-Schicht (2).

10. Verfahren nach Anspruch 9, bei dem die PTC-Schicht (2) und die Isolierschicht (3) in einem Verfahren extrudiert werden, **gekennzeichnet durch** Härten oder Vernetzen der Isolierschicht (3) **durch** Diffusion des Katalysators-Dibutyltin-Dilaurat- aus der PTC-Schicht.

Revendications

1. Câble chauffant comprenant un noyau comprenant :

- un élément central en polymère (1),
- deux conducteurs électriques (4, 5),
- un élément à PTC entre eux, constitué d'une

- couche extrudée (2) en matériau à PTC agencée sur l'élément central (1) en contact avec lesdits conducteurs (4, 5) et
- au moins une couche externe (3) en matériau isolant,
- caractérisé en ce que**
- ledit élément central (1) est extrudé,
 - lesdits deux conducteurs (4, 5) sont agencés à l'intérieur de fentes prévues dans ledit élément central (1) de sorte qu'une partie des surfaces conductrices coïncide avec la surface de l'élément central (1),
 - ladite couche (2) de polymère à PTC est en contact avec lesdites parties de surface conductrices,
 - ledit noyau comprend au moins une couche isolante extrudée externe (3).
2. Câble selon la revendication 1, **caractérisé en ce que** les conducteurs (4, 5) sont spiralés ou en zigzag dans l'élément central.
3. Câble selon la revendication 1, **caractérisé en ce qu'** au moins deux des éléments en polymère extrudé du noyau du câble-l'élément central (1) et les deux couches (2,3) sont collés entre eux.
4. Câble selon la revendication 1, **caractérisé en ce que** les éléments de polymère (1, 2, 3) du noyau du câble sont réticulés par un processus au silane.
5. Câble selon la revendication 1, **caractérisé en ce que** l'élément central (1) est constitué de polyéthylène réticulé au silane comprenant des molécules de vinyl-triméthoxysilane contenant un composé en métal lourd organique en une quantité comprise entre 0,005 et 1 % en poids sur la base de la quantité totale de ladite composition comme catalyseur de réticulation.
6. Câble selon la revendication 1, **caractérisé en ce que** la couche à PTC (2) est basée sur un copolymère éthylène et éthylène-octène avec du noir de carbone et du silane greffés par l'apport direct de silane/peroxyde ou par utilisation d'un mélange maître avec du silane/peroxyde/catalyseur.
7. Câble selon la revendication 1, **caractérisé en ce que** la couche à PTC (3) présente une résistivité du volume de 100 à 100 000 ohmcm.
8. Procédé pour la création d'un câble chauffant selon l'une quelconque des revendications 1 à 7, ledit câble comprenant un noyau ayant deux conducteurs électriques (4, 5), un élément à PTC entre eux et une couche externe (3) de matériau isolant, **caractérisé par** la réticulation de l'élément à PTC (2) et la couche isolante (3) utilisant la réaction des groupes de triméthoxysilane dans le polyéthylène et dans le polymère à PTC en présence d'eau.
9. Procédé selon la revendication 8, **caractérisé par** l'inclusion dans la couche à PTC (2) d'un composé de métal organique choisi parmi le groupe composé du dilaurate de dibutylétain.
10. Procédé selon la revendication 9, et dans lequel la couche à PTC (2) et la couche isolante (3) sont extrudées en un processus, **caractérisé par** le traitement ou la réticulation de la couche isolante 3 par diffusion de l'agent catalyseur, du dilaurate de dibutylétain, à partir de la couche à PTC.

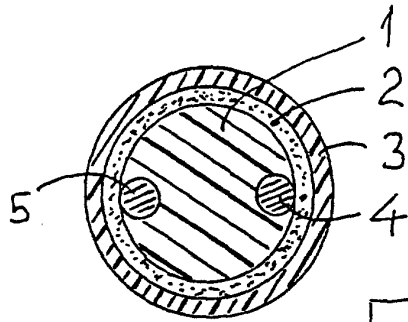


Fig. 1

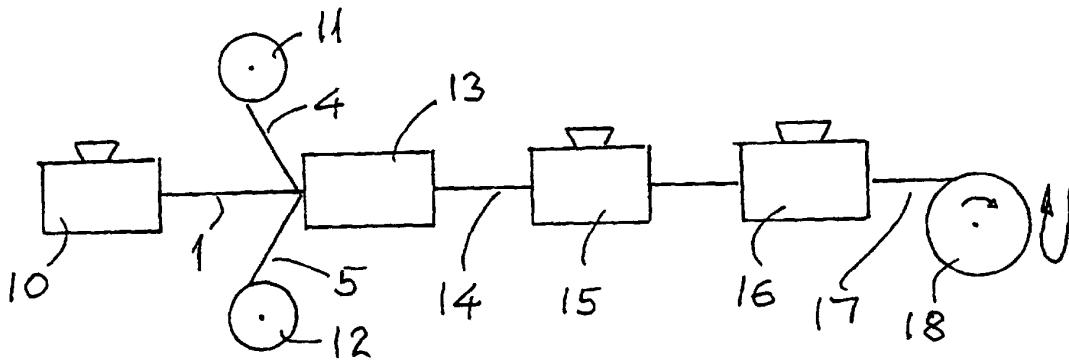


Fig. 2

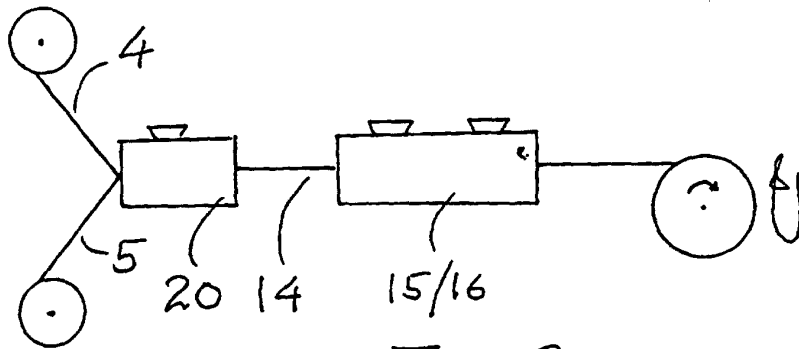


Fig. 3

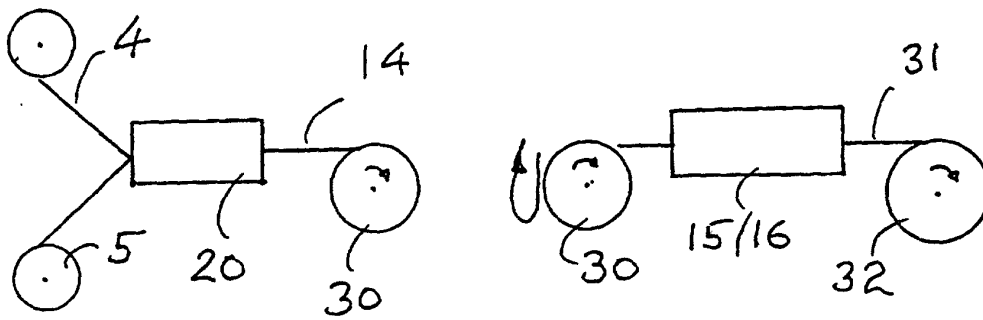


Fig. 4