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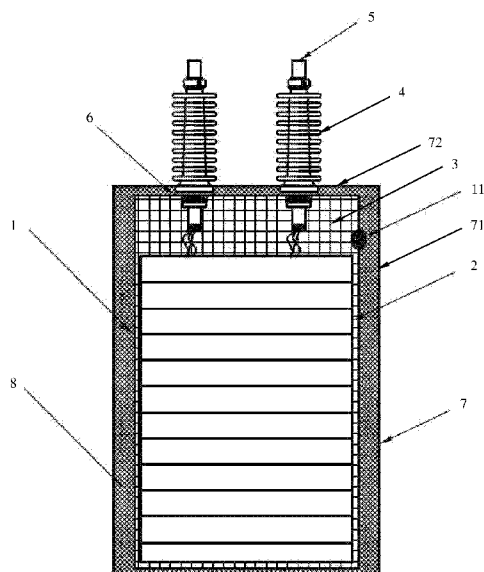


Fig.1

(57) Abstract: Disclosed are a power capacitor with fireproof functionality, and a method for manufacturing the same. The power capacitor comprises an inner capacitor unit comprising a capacitor casing (1), an elements package (2) arranged in the capacitor casing (1), an insulation fluid (3) filled in the capacitor casing (1), a pair of bushings (4) and a pair of capacitor electrodes (5). The power capacitor further comprises an outer shell (7) in which the inner capacitor unit is arranged, and a non-flammable solid mineral material (8) filled between the outer shell (7) and the capacitor casing (1). The pair of bushings (4) is configured to be hermetically fixed to and extend through the capacitor casing (1) and the outer shell (7), and the pair of capacitor electrodes (5) is configured to extend through the capacitor casing (1) and the outer shell (7) via the pair of bushings (4).

POWER CAPACITOR AND METHOD FOR MANUFACTURING THE SAME

TECHNICAL FIELD

5 The present disclosure relates to a power capacitor with fireproof functionality, and a method for manufacturing the same.

BACKGROUND

10 Power capacitors are widely used in underground/indoor substations, as well as in mining industry and other applications with a high-level fireproof requirement.

 At present, a high-voltage power capacitor typical comprises a metal capacitor casing and a plurality of capacitor elements electrically connected in parallel and in series. Each of the capacitor elements comprises a number of very thin layers of electrodes made of aluminum foils and separated by films of dielectric material. The films of dielectric material
15 are usually in the form of polymer films, such as polypropylene films, and wound into a roll that is flattened to be capable of being stacked into an elements package. The package is arranged inside the capacitor casing filled with insulation fluid.

 Since the insulation fluid is a kind of flammable material, a fire accident may occur once the insulation fluid leaks out due to a rupture of the casing. Meanwhile, filling material
20 of a dry-type capacitor cannot fulfill a high-level (e.g. UL94 V-0) fireproof requirement. Thereby, there is a strong demand for a reliable fireproof power capacitor in the market.

SUMMARY

25 In view of the above, the present disclosure aims to provide a power capacitor with fireproof functionality that overcomes the defects of the prior art.

 To this end, a first aspect of the present disclosure provides a power capacitor comprising an inner capacitor unit comprising a capacitor casing, an elements package arranged in the capacitor casing, an insulation fluid filled in the capacitor casing, a pair of bushings and a pair of capacitor electrodes. The power capacitor further comprises an outer
30 shell in which the inner capacitor unit is arranged, and a non-flammable solid mineral material

filled between the outer shell and the capacitor casing. The pair of bushings is configured to be hermetically fixed to and extend through the capacitor casing and the outer shell, and the pair of capacitor electrodes is configured to extend through the capacitor casing and the outer shell via the pair of bushings.

5 An obtainable effect based on this structure is that the probability of the insulation fluid leakage is notably reduced by adding the extra outer shell in combination with the non-flammable solid mineral material filled between the outer shell and the capacitor casing, thereby improving fireproof performance of the power capacitor.

10 Further, as an optimized non-flammable solid mineral material has a good thermal conductivity, the additional outer shell as well as the layer of the non-flammable solid mineral material would not affect heat dissipation of the power capacitor when in service, thereby ensuring thermal performance of the power capacitor.

 Moreover, the non-flammable solid mineral material has a noise reducing property, thereby improving acoustic performance of the power capacitor.

15 According to a preferred embodiment of the present disclosure, the non-flammable solid mineral material comprises at least one of sand, vermiculite, slag and perlite.

 According to a preferred embodiment of the present disclosure, the non-flammable solid mineral material comprises sand and perlite with a volume ratio of is 4:1.

20 According to a preferred embodiment of the present disclosure, the non-flammable solid mineral material has a particle diameter of 1-3mm.

 According to a preferred embodiment of the present disclosure, the non-flammable solid mineral material is added with at least one of water, solid-liquid phase change material, fireproof fluid, and fireproof powder.

25 According to a preferred embodiment of the present disclosure, the non-flammable solid mineral material has a moisture content of 0%-60%.

 According to a preferred embodiment of the present disclosure, the non-flammable solid mineral material has a moisture content of 30%.

30 According to a preferred embodiment of the present disclosure, the outer shell comprises a body having a top opening; and a top cover configured to be fixed on the body to cover the top opening and provided with a pair of holes for the pair of bushings to pass

through.

According to a preferred embodiment of the present disclosure, the inner capacitor unit further comprises a sealing flange sleeved on each of the bushings and hermetically fixed to the capacitor casing.

5 According to a preferred embodiment of the present disclosure, the power capacitor further comprises a sealing material filled between each of the bushings and the outer shell.

According to a preferred embodiment of the present disclosure, at least a portion of the capacitor casing is configured to be a corrugated structure or a convex structure.

10 According to a preferred embodiment of the present disclosure, the power capacitor further comprises a plurality of equal-thickness positioning members arranged between the capacitor casing and the outer shell to make the non-flammable solid mineral material to be uniform.

A second aspect of the present disclosure provides a method for manufacturing a power capacitor, comprising: providing an inner capacitor unit comprising a capacitor casing,
15 an elements package arranged in the capacitor casing, an insulation fluid filled in the capacitor casing, a pair of bushings and a pair of capacitor electrodes; providing an outer shell and arranging the inner capacitor unit in the outer shell; and providing a non-flammable solid mineral material and filling the non-flammable solid mineral material between the outer shell and the capacitor casing. The pair of bushings is configured to be hermetically fixed to and
20 extend through the capacitor casing and the outer shell, and the pair of capacitor electrodes is configured to extend through the capacitor casing and the outer shell via the pair of bushings.

According to a preferred embodiment of the present disclosure, the outer shell comprises a body having a top opening; and a top cover configured to be fixed on the body to cover the top opening and provided with a pair of holes for the pair of bushings to pass
25 through.

According to a preferred embodiment of the present disclosure, the method further comprises: providing a plurality of equal-thickness positioning members arranged between the capacitor casing and the outer shell to make the non-flammable solid mineral material to be uniform.

30 As the non-flammable solid mineral material is cheap, non-toxic and environmentally friendly, the method for manufacturing the power capacitor is easy to be implemented.

Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the element, apparatus, component, means, step, etc. are to be interpreted openly as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features and advantages of the present disclosure will be better understood through the following preferred embodiments described in detail with reference to the accompanying drawings, in which the same reference numerals indicate the same or similar components.

Fig. 1 is a schematic structural view of an embodiment of a power capacitor according to the present disclosure;

Fig. 2 is an enlarged view of a bushing of the power capacitor shown in Fig. 1; and

Fig. 3 is a schematic view showing the relationship between the moisture content and the thermal conductivity coefficient of the non-flammable solid mineral material of the power capacitor shown in Fig. 1.

DETAILED DESCRIPTION

The implementation and usage of the embodiments are discussed in detail below. However, it should be understood that the specific embodiments discussed are merely intended to illustrate specific ways of implementing and using the present disclosure, and are not intended to limit the protection scope of the present disclosure.

It should be noted that the drawings not only are used for the explanation and description of the present disclosure, but also are helpful for the definition of the present disclosure when necessary.

Fig. 1 is a schematic structural view of an embodiment of the power capacitor according to the present disclosure. As shown in Fig. 1, the power capacitor according to the present disclosure mainly comprises an inner capacitor unit, an outer shell 7 and a non-flammable solid mineral material 8 filled between the outer shell 7 and the inner

capacitor unit.

The inner capacitor unit has a configuration similar to that of a power capacitor in the prior art. Specially, the inner capacitor unit mainly comprises a capacitor casing 1, an elements package 2, an insulation fluid 3, a pair of bushings 4 and a pair of capacitor electrodes 5.

The capacitor casing 1 is made of metal, such as stainless steel, and is generally cuboid in shape. The capacitor casing 1 is provided with an aperture 11 for filling the insulation fluid 3 into the capacitor casing 1. The elements package 2, which forms a capacitor core arranged in the capacitor casing 1, is constituted by stacking a plurality of capacitor elements electrically connected in parallel and in series. Each of the capacitor elements comprises a number of very thin layers of electrodes made of aluminum foils and separated by films of dielectric material, such as polypropylene films, and the films of dielectric material are wound into a roll. The insulation fluid 3 filled in the capacitor casing 1 may be insulation oil, in which the elements package 2 is immersed. The pair of bushings 4 is hermetically fixed to and extends through the top of the capacitor casing 1, as shown in Fig.1. The pair of capacitor electrodes 5, which is electrically connected to the elements package 2, extends through the top of the capacitor casing 1 via the pair of bushings 4.

Fig. 2 is an enlarged view of one of the bushings 4 of the power capacitor shown in Fig. 1. As shown in Fig. 2, the inner capacitor unit may further comprise a sealing flange 6 sleeved on each of the bushings 4 and hermetically fixed to the capacitor casing 1. Specially, the pair of bushings 4 is made of insulation material, such as ceramics, and the sealing flange 6 sleeved on each of the bushings 4 and typically made of metal is compressed and adhered to each of the bushings 4, and is welded to the top of the capacitor casing 1 so as to cover the gap between the capacitor casing 1 and the pair of bushings 4, thereby avoiding leakage of the insulation fluid 3 through the gap.

However, the insulation fluid 3 may leak out due to a rupture of the capacitor casing 1 and cause a fire accident. Thereby, the essence of the present disclosure is to add an extra outer shell 7 with a non-flammable solid mineral material 8 filled between the outer shell 7 and the capacitor casing 1, so as to improve fireproof performance of the power capacitor.

The outer shell 7, in which the inner capacitor unit is arranged, is made of metal, such as stainless steel, and is generally cuboid in shape. The outer shell 7 is configured to be connected with a container for accommodating the power capacitor by using Cu-braided wire

to ensure the grounding is reliable. Specially, in some embodiments, the outer shell 7 comprises a body 71 and a top cover 72. The body 71 has a top opening, and the top cover 72 is fixed on the body 71, for example, is welded on the body 71, so as to cover the top opening. The top cover 72 is provided with a pair of holes for the pair of bushings 4 to pass through. That is to say, the pair of bushings 4 of the inner capacitor unit is hermetically fixed to and extends through the outer shell 7 via the pair of holes, and the pair of capacitor electrodes 5 extends through the outer shell 7 via the pair of bushings 4. In view of the sealing property, the power capacitor preferably comprises a sealing material, such as polyurethane foam, filled between each of the bushings 4 and the top cover 72 of the outer shell 7, so as to cover the gap between the edge of the pair of holes and the pair of bushings 4, thereby avoiding leakage of the non-flammable solid mineral material 8 through the gap.

For example, the non-flammable solid mineral material 8 may comprise at least one of sand, vermiculite, slag and perlite. Each of sand, vermiculite and slag has a good thermal conductivity, the detailed comparison of which is shown in the table below. It should be noted that the “thickness” of the material refers to the distance between the outer shell 7 and the capacitor casing 1, and the “ Δt ” of the material refers to the temperature increase of the material when the power capacitor is in service.

Material	Thermal conductivity W/(m•K)	Thickness mm	Δt , K
Vermiculite	0.14	10	8.14
		15	12.22
		20	16.29
Slag	0.25	10	4.56
		15	6.84
		20	9.12
Sand	0.23	10	4.96
		15	7.44
		20	9.91

Perlite is a mineral substance having a thermal conductivity lower than that of each of sand, vermiculite and slag. However, perlite has a weight lower than that of each of sand, vermiculite and slag, so as to be capable of reducing the weight of the power capacitor. As a preferred example, the non-flammable solid mineral material 8 may be a mixture of sand and perlite, and the volume ratio of sand and perlite is preferably chosen as 4:1.

Preferably, the non-flammable solid mineral material 8 has a particle diameter of 1-3mm, which is capable of improving thermal conductive property as well as noise reducing property of the power capacitor.

Preferably, the non-flammable solid mineral material 8 is added with water or solid-liquid phase change material, such as paraffin, for improving thermal conductive property of the power capacitor. The non-flammable solid mineral material 8 may have a moisture content of 0%-60%. As a preferred example, the non-flammable solid mineral material 8 has a moisture content of 30%. In some embodiments, the non-flammable solid mineral material 8 is alternatively added with fireproof fluid and/or fireproof powder.

Fig. 3 is a schematic view showing the relationship between the moisture content and the thermal conductivity coefficient of the non-flammable solid mineral material 8 of the power capacitor. As shown in Fig.3, the thermal conductivity coefficient of the non-flammable solid mineral material 8 would increase along with the increase of its moisture content. However, considering that the non-flammable solid mineral material 8 has the function of adsorbing/accommodating the leakage of the insulation fluid 3, the moisture content of the non-flammable solid mineral material 8 is not likely to be too high.

Preferably, at least a portion of the capacitor casing 1 is configured to be a corrugated structure or a convex structure, so as to increase the contact surface of the capacitor casing 1 with the non-flammable solid mineral material 8, thereby further improving the thermal conductive property of the power capacitor.

The three-dimensional size of the outer shell 7 is about 20-40mm larger than that of the capacitor casing 1. That is to say, the distance between the outer shell 7 and the capacitor casing 1, i.e. the thickness of the non-flammable solid mineral material 8, is about 10-20mm. In order to facilitate the positioning of the capacitor casing 1 in the outer shell 7, as well as to make the non-flammable solid mineral material 8 to be uniformly distributed between the capacitor casing 1 and the outer shell 7, in some embodiments, the power capacitor may further comprise a plurality of equal-thickness positioning members arranged between the capacitor casing 1 and the outer shell 7. It should be noted that the "thickness" direction of the positioning members corresponds to that of the non-flammable solid mineral material 8. For example, in case of a cuboid capacitor casing 1 as well as a cuboid outer shell 7, five equal-thickness positioning members may be respectively arranged on the four lateral external surfaces and the bottom external surface of the capacitor casing 1, or on the five corresponding internal surfaces of the outer shell 7, and have an equal thickness, so as to make the non-flammable solid mineral material 8 to be uniform when the inner capacitor unit is placed into the outer shell 7.

A method for manufacturing the above power capacitor is described below.

First, the inner capacitor unit comprising the capacitor casing 1, the elements package 2, the insulation fluid 3, the pair of bushings 4 and the pair of capacitor electrodes 5 is provided. It should be noted that the capacitor elements forming the elements package 2 are electrically connected in parallel and in series according to the required capacitor voltage, capacity and other parameters.

Then, the outer shell 7 preferably comprising a body 71 and a top cover 72 is provided, and the inner capacitor unit is placed into the body 71 of the outer shell 7. The above-mentioned equal-thickness positioning members may be arranged on the external surfaces of the capacitor casing 1, or on the internal surfaces of the body 71 of the outer shell 7.

Then, the non-flammable solid mineral material 8 is provided and filled between the body 71 of the outer shell 7 and the capacitor casing 1. In case that the non-flammable solid mineral material 8 is added with water, after mixing the non-flammable solid mineral material 8 with water, it is typically necessary to cover the obtained mixture with a polyethylene film and leave it stand for about 24 hours, such that the particles of the non-flammable solid mineral material 8 is capable of spreading uniformly, and the mixture is capable of being moisturized before use. Further, in case that the equal-thickness positioning members are arranged, it is possible to fill the non-flammable solid mineral material 8 to the bottom of the body 71 until a positioning height (about 10~20mm), which equals to the thickness of the non-flammable solid mineral material 8, before placing the inner capacitor unit into the body 71, and then the body 71 can be placed on a vibration platform, and the non-flammable solid mineral material 8 is continued to be filled between the body 71 and the capacitor casing 1.

Finally, the top cover 72 is hermetically fixed on the body 71 and on the pair of bushings 4 after the non-flammable solid mineral material 8 is completely filled between the outer shell 7 and the capacitor casing 1. Specially, the top cover 72 may be welded on the top of body 71 by means of a welding robot, and then, as the pair of bushings 4 extends out of the outer shell 7 through the holes provided in the top cover 72, a polyurethane foam nozzle can be placed at the gap between the edge of the pair of holes and the pair of bushings 4 for introducing the polyurethane foam into the gap, and finally the introduced polyurethane foam is shaped and sealed by polyurethane sealant.

The technical content and technical features of the present disclosure have been

disclosed above. However, it is conceivable that, under the creative ideas of the present disclosure, those skilled in the art can make various changes and improvements to the concepts disclosed above, but these changes and improvements all belong to the protection scope of the present disclosure. The description of the above embodiments is exemplary
5 rather than limiting, and the protection scope of the present disclosure is defined by the appended claims.

CLAIMS

1. A power capacitor, comprising:

an inner capacitor unit comprising:

a capacitor casing (1),

5 an elements package (2) arranged in the capacitor casing (1),

an insulation fluid (3) filled in the capacitor casing (1),

a pair of bushings (4),

a pair of capacitor electrodes (5);

an outer shell (7), the inner capacitor unit being arranged in the outer shell (7); and

10 a non-flammable solid mineral material (8) filled between the outer shell (7) and the capacitor casing (1),

wherein the pair of bushings (4) is configured to be hermetically fixed to and extend through the capacitor casing (1) and the outer shell (7), and the pair of capacitor electrodes (5) is configured to extend through the capacitor casing (1) and the outer shell (7) via the pair of
15 bushings (4).

2. The power capacitor according to claim 1, wherein the non-flammable solid mineral material (8) comprises at least one of sand, vermiculite, slag and perlite.

20 3. The power capacitor according to claim 2, wherein the non-flammable solid mineral material (8) comprises sand and perlite with a volume ratio of 4:1.

4. The power capacitor according to claim 1, wherein the non-flammable solid mineral material (8) has a particle diameter of 1-3mm.

25

5. The power capacitor according to claim 1, wherein the non-flammable solid mineral material (8) is added with at least one of water, solid-liquid phase change material, fireproof fluid and fireproof powder.

6. The power capacitor according to claim 5, wherein the non-flammable solid mineral material (8) has a moisture content of 0%-60%.

5 7. The power capacitor according to claim 6, wherein the non-flammable solid mineral material (8) has a moisture content of 30%.

8. The power capacitor according to any one of claims 1 to 7, wherein the outer shell (7) comprises:

10 a body (71) having a top opening; and

a top cover (72) configured to be fixed on the body (71) to cover the top opening and provided with a pair of holes for the pair of bushings (4) to pass through.

9. The power capacitor according to any one of claims 1 to 7, wherein the inner capacitor
15 unit further comprises a sealing flange (6) sleeved on each of the bushings (4) and hermetically fixed to the capacitor casing (1).

10. The power capacitor according to any one of claims 1 to 7, wherein the power capacitor further comprises a sealing material filled between each of the bushings (4) and the
20 outer shell (7).

11. The power capacitor according to any one of claims 1 to 7, wherein at least a portion of the capacitor casing (1) is configured to be a corrugated structure or a convex structure.

25 12. The power capacitor according to any one of claims 1 to 7, wherein the power capacitor further comprises a plurality of equal-thickness positioning members arranged between the capacitor casing (1) and the outer shell (7) to make the non-flammable solid mineral material (8) to be uniform.

13. A method for manufacturing a power capacitor, comprising:

providing an inner capacitor unit comprising:

a capacitor casing (1),

5 an elements package (2) arranged in the capacitor casing (1),

an insulation fluid (3) filled in the capacitor casing (1),

a pair of bushings (4),

a pair of capacitor electrodes (5);

providing an outer shell (7) and arranging the inner capacitor unit in the outer shell (7);

10 and

providing a non-flammable solid mineral material (8) and filling the non-flammable solid mineral material (8) between the outer shell (7) and the capacitor casing (1),

wherein the pair of bushings (4) is configured to be hermetically fixed to and extend through the capacitor casing (1) and the outer shell (7), and the pair of capacitor electrodes (5)
15 is configured to extend through the capacitor casing (1) and the outer shell (7) via the pair of bushings (4).

14. The method according to claim 13, wherein the outer shell (7) comprises:

a body (71) having a top opening; and

20 a top cover (72) configured to be fixed on the body (71) to cover the top opening and provided with a pair of holes for the pair of bushings (4) to pass through.

15. The method according to claim 13, further comprising:

providing a plurality of equal-thickness positioning members arranged between the
25 capacitor casing (1) and the outer shell (7) to make the non-flammable solid mineral material (8) to be uniform.

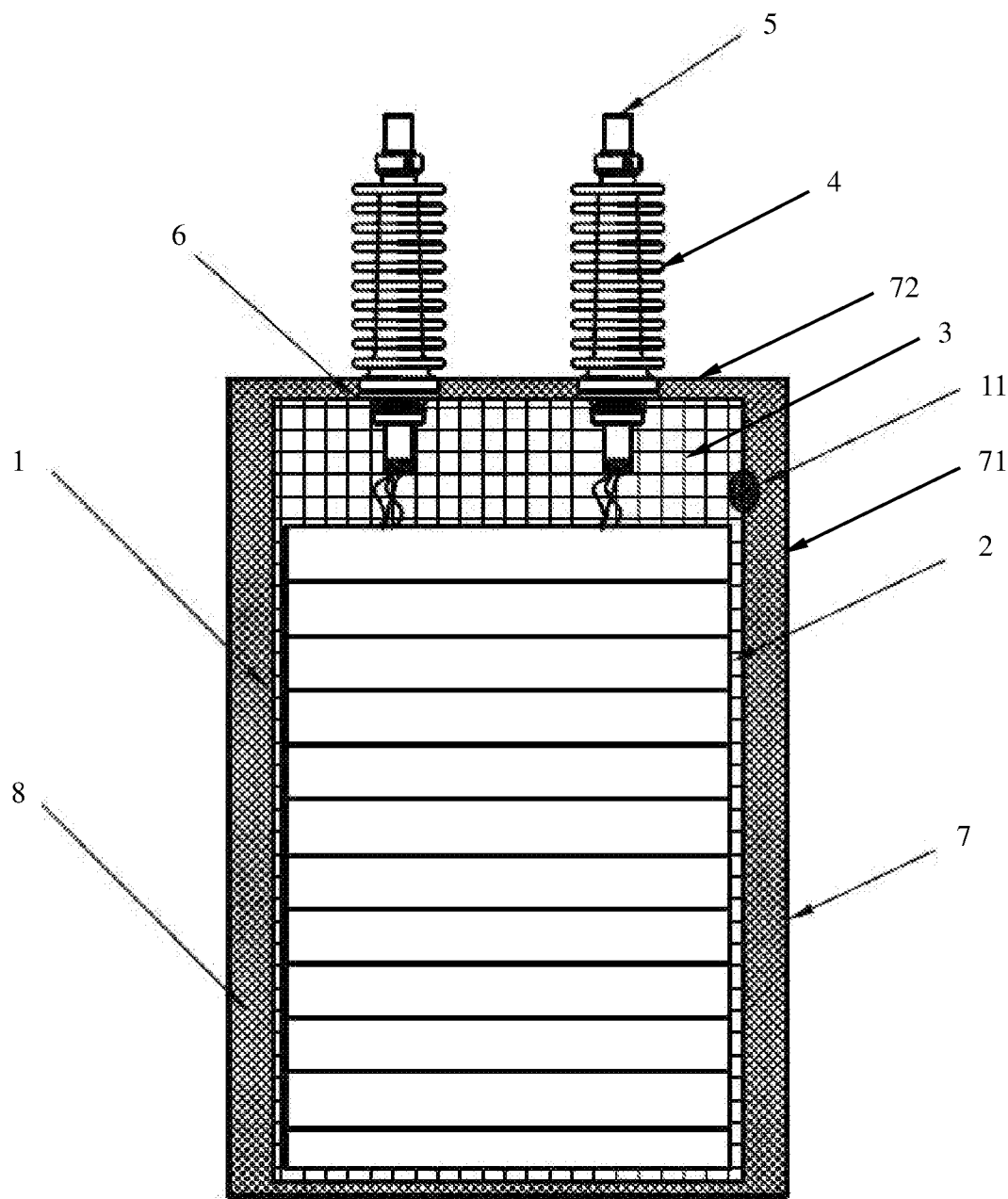


Fig.1

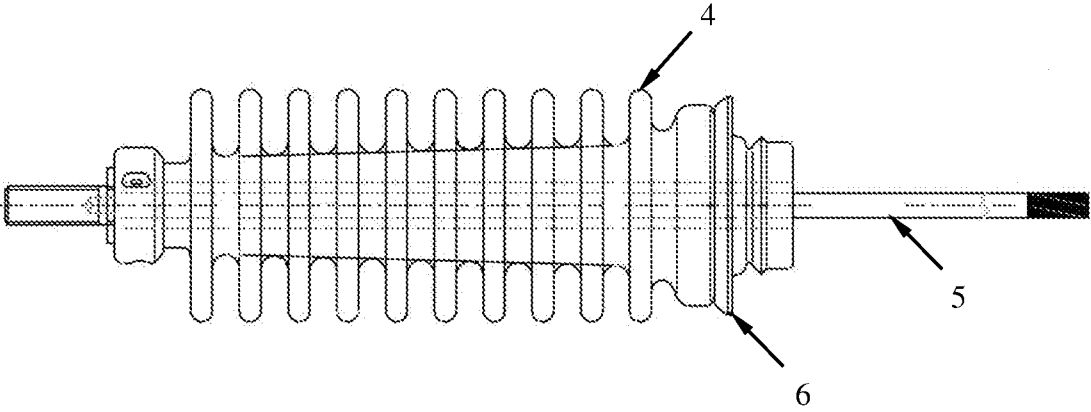


Fig.2

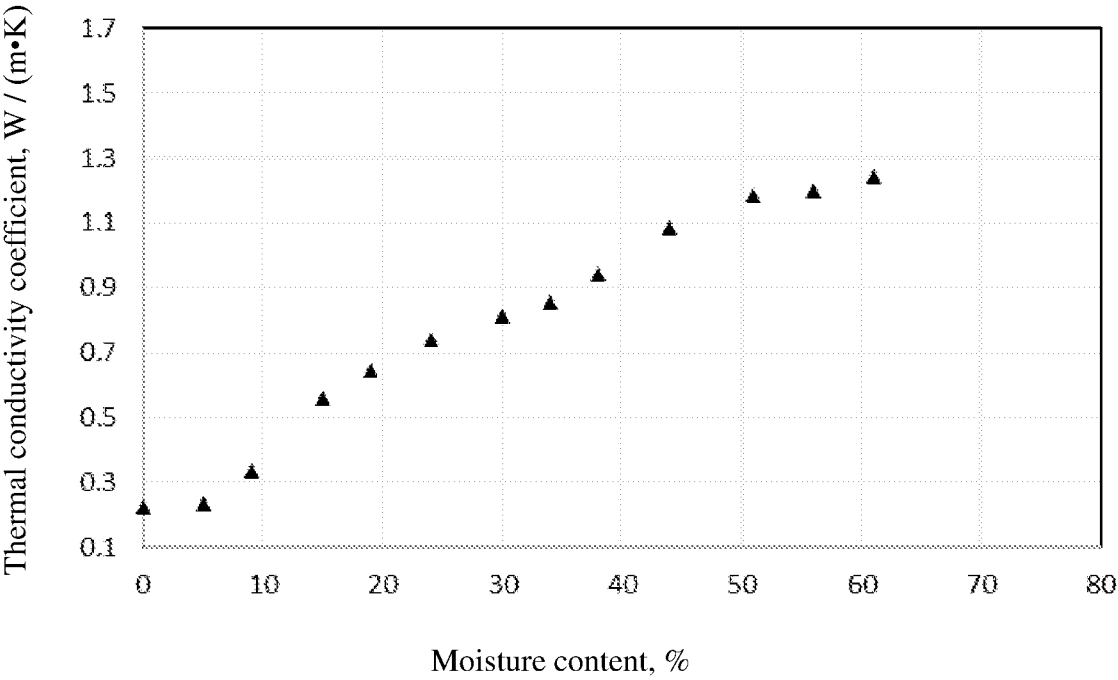


Fig.3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2020/109785

A. CLASSIFICATION OF SUBJECT MATTER

H01G 2/10(2006.01)i; H01G 4/224(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01G

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

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

CNPAT, WPI, CNKI, IEEE: capacitor, power, shell, fireproof, mineral, slag, sand, vermiculite, granular, perlite, solid, leak+, +fire+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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

“&” document member of the same patent family

Date of the actual completion of the international search

03 May 2021

Date of mailing of the international search report

19 May 2021

Name and mailing address of the ISA/CN

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Facsimile No. (86-10)62019451

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2020/109785

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

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