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GAS INSULATION DEVICE

Abstract

A vacuum circuit breaker includes: a grounded tank and a movable-side support plate that constitute a part of a container in which an insulating gas is sealed; and a sealant layer provided at a coupling point between the grounded tank and the movable-side support plate, in which a joint surface of each of the grounded tank and the movable-side support plate is a flat surface, and the joint surfaces abut against each other, the sealant layer includes: a resin layer formed using a resin that is a dispersion medium; and a filler that is a dispersoid and is dispersed in the resin layer, the filler is formed containing a material having lower gas permeability than the resin that forms the resin layer, and a particle size of the filler is smaller than projections and recesses of the joint surface of each of the grounded tank and the movable-side support plate.

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Background/Summary

FIELD

[0001] The present disclosure relates to a gas insulation device in which a charging unit is accommodated in a container in which an insulating gas is sealed.

BACKGROUND

[0002] In devices such as a vacuum circuit breaker, a disconnector, and a switch used in an electric circuit through which a current of a voltage exceeding 7000 V flows, which is referred to as a special high voltage, a charging unit is accommodated in a container in which an insulating gas that is an insulating medium such as sulfur hexafluoride and dry air is sealed. The device in which the charging unit is accommodated in the container in which the insulating gas is sealed is referred to as a gas insulation device.

[0003] While the container in which the insulating gas is sealed is formed by connecting a plurality of tanks, it is necessary to prevent leakage of the insulating gas from a joint portion between the tanks in order to maintain insulation performance.

[0004] Patent Literature 1 discloses that a groove is formed on a joint surface of a flange of a container in which an insulating gas sealed, a gasket that is made of elastic rubber having a circular cross section and called an O-ring is attached, and a sealant is applied to the joint surface of the flange to impart waterproofness and gas sealability. Nitrile rubber is generally used for the O-ring, and a silicone resin is generally used for the sealant.

CITATION LIST

Patent Literature

[0005] Patent Literature 1: Japanese Patent Application Laid-open No. S55-103006

SUMMARY OF INVENTION

Problem to be Solved by the Invention

[0006] However, since flexible materials such as elastic rubber and a silicone resin have gas permeability, it is difficult to maintain a gas pressure in the container for a long period of time. In particular, in a case of reducing a size of the device by increasing a sealing pressure of the insulating gas or using an insulating gas having a small molecular weight such as dry air, an amount of the insulating gas that leaks through the O-ring and the sealant tends to increase. In the structure disclosed in Patent Literature 1, leakage of the insulating gas can be reduced by using the O-ring and the sealant in combination. However, it is necessary to perform groove processing on the joint surface of the flange and disposing work of the O-ring in the groove, and the number of man-hours for manufacturing work and the number of man-hours for assembly work of the container in which the insulating gas is sealed increase.

[0007] The present disclosure has been made in view of the above, and an object of the present disclosure is to obtain a gas insulation device capable of suppressing an increase in the number of man-hours for manufacturing work and the number of man-hours for assembly work of a container in which an insulating gas is sealed, and maintaining a gas pressure in the container for a long period of time.

Means to Solve the Problem

[0008] To solve the above-described problems and achieve the object, a gas insulation device according to the present disclosure includes: a first member and a second member constituting at least a part of a container in which an insulating gas is sealed; and a sealant layer provided at a coupling point between the first member and the second member. A joint surface of each of the first member and the second member is a flat surface, and the joint surfaces abut against each other. The sealant layer has a resin layer formed using a resin that is a dispersion medium, and a filler that is a dispersoid and is dispersed in the resin layer. The filler is formed using a material having lower gas permeability than the resin. A particle size of the filler is smaller than projections and recesses of the joint surface of each of the first member and the second member.

Effects of the Invention

[0009] The present disclosure exhibits an effect of providing a gas insulation device capable of preventing an increase in the number of man-hours for manufacturing work and the number of man-hours for assembly work of a container in which an insulating gas is sealed, and maintaining a gas pressure in the container for a long period of time.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0010] FIG. **1** is a cross-sectional view of a vacuum circuit breaker according to a first embodiment.

[0011] FIG. **2** is a cross-sectional view of an end portion of a grounded tank of the vacuum circuit breaker according to the first embodiment.

[0012] FIG. **3** is a cross-sectional view of a sealant layer of the vacuum circuit breaker according to the first embodiment.

[0013] FIG. **4** is a cross-sectional view of a sealant layer of a vacuum circuit breaker according to a second embodiment.

DESCRIPTION OF EMBODIMENTS

[0014] Hereinafter, a gas insulation device according to embodiments will be described in detail with reference to the drawings.

First Embodiment

[0015] FIG. **1** is a cross-sectional view of a vacuum circuit breaker according to a first embodiment. A vacuum circuit breaker **50** according to the first embodiment is a gas insulation device in which a charging unit is accommodated in a container in which an insulating gas is sealed. The vacuum circuit breaker **50** according to the first embodiment includes: a grounded tank **1** having a tubular shape; and a vacuum valve **2** that includes a movable-side contact **2**_a_ and a fixed-side contact **2**_b_ and is insulated and supported in the grounded tank **1**. Note that, with an interface between the movable-side contact **2**_a_ and the fixed-side contact **2**_b_ as a boundary, a member in the half including the movable-side contact **2**_a_ among members constituting the vacuum circuit breaker **50** is referred to as being on a “movable-side”, and a member in the half including the fixed-side contact **2**_b_ is referred to as being on a “fixed-side”. Further, the vacuum circuit breaker **50** according to the first embodiment includes a pair of tubular bushings **13**_a_ and **13**_b_ extending upward from the grounded tank **1**, a movable-side bushing conductor **12**_a_ disposed in the bushing **13**_a_, and a fixed-side bushing conductor **12**_b_ disposed in the bushing **13**_b_.

[0016] A current transformer **15**_a_ that detects a current flowing through the movable-side bushing conductor **12**_a_ is installed in the bushing **13**_a_. A current transformer **15**_b_ that detects a current flowing through the fixed-side bushing conductor **12**_b_ is installed in the bushing **13**_b_.

[0017] In addition to the movable-side contact **2**_a_ and the fixed-side contact **2**_b_, the vacuum valve **2** includes: a vacuum container **2**_c_ that accommodates the movable-side contact **2**_a_ and the fixed-side contact **2**_b;_ and a movable conductor **7** having one end portion **7**_a_ electrically connected to the movable-side contact **2**_a_ and another end portion **7**_b_ protruding from the vacuum container **2**_c_. Further, the vacuum valve **2** includes a fixed conductor **21** electrically connected to the fixed-side contact **2**_b_, and a bellows **3** having a concertina tube shape in which one end portion **3**_a_ is fixed to the movable conductor **7** and another end portion **3**_b_ is fixed to the vacuum container **2**_c_.

[0018] Further, the vacuum circuit breaker **50** includes: an operation device **30** that is installed outside the grounded tank **1** and switches between a closing state and an open state by pushing and pulling an operation rod **31** along an axial direction of the grounded tank **1**; the operation rod **31** having one end portion **31***a* connected to the operation device **30** and another end portion **31***b* connected to the another end portion **7***b* of the movable conductor **7**; a movable-side frame **5** that electrically connects a lower end portion **121***a* of the movable-side bushing conductor **12***a* to the movable conductor **7**; and a fixed-side frame **17** that electrically connects a lower end portion **121***b* of the fixed-side bushing conductor **12***b* to the fixed conductor **21**. Moreover, the vacuum circuit breaker **50** includes: a movable-side insulation support tube **6** that insulates and causes the grounded tank **1** to support the movable-side frame **5**; and a fixed-side insulation support tube **18** that insulates and causes the grounded tank **1** to support the fixed-side frame **17**. The vacuum container **2***c* is fixed to the movable-side frame **5** and the fixed-side frame **17** individually with bolts (not illustrated). A hole **34** through which the operation rod **31** of the movable-side frame **5** passes is closed in an airtight state by a packing **35**.

[0019] An opening **1***a* at an end portion of the grounded tank **1** from which the operation rod **31** protrudes is covered with a movable-side support plate **8***a* in which a hole **32** through which the operation rod **31** passes is formed. The movable-side support plate **8***a* is an end face plate that covers the opening **1***a* at the end portion of the grounded tank **1**. An opening **1***b* at an end portion on the fixed-side of the grounded tank **1** is covered with a fixed-side support plate **8***b*. The fixed-side support plate **8***b* is an end face plate that covers the opening **1***b* at the end portion of the grounded tank **1**. The grounded tank **1**, the movable-side support plate **8***a*, and the fixed-side support plate **8***b* constitute a container in which an insulating gas is sealed.

[0020] A packing **33** is disposed in the hole **32** of the movable-side support plate **8***a*. A gap between the movable-side support plate **8***a* and the operation rod **31** is closed in a watertight state by the packing **33**.

[0021] A driving force of the operation device **30** is transmitted to the movable-side contact **2***a* via the operation rod **31** and the movable conductor **7**. The movable-side contact **2***a* can take a closing state in which the movable-side contact **2***a* is in contact with the fixed-side contact **2***b* by receiving the driving force of the operation device **30** and an open state in which the movable-side contact **2***a* is separated from the fixed-side contact **2***b*. A contact pressure spring (not illustrated) is attached to the operation rod **31**, and a force pressing the movable-side contact **2***a* against the fixed-side contact **2***b* is applied to the operation rod **31** in the closing state. Therefore, energization performance between the movable-side contact **2***a* and the fixed-side contact **2***b* in the closing state is secured.

[0022] The movable-side bushing conductor **12***a* has a tubular shape, and the lower end portion **121***a* is connected to an opening **5***a* of the movable-side frame **5**.

[0023] When the vacuum circuit breaker **50** performs an opening operation, the operation device **30** moves the operation rod **31** in a direction pulling out from the grounded tank **1**. Therefore, the movable conductor **7** fixed to the operation rod **31** moves in a direction approaching the movable-side support plate **8***a*. Since the one end portion **3***a* of the bellows **3** is fixed to the movable conductor **7**, the bellows **3** contracts as the movable conductor **7** moves.

[0024] FIG. **2** is a cross-sectional view of an end portion of the grounded tank of the vacuum circuit breaker according to the first embodiment. The grounded tank **1** and the movable-side support plate **8***a* constitute a part of a container in which an insulating gas is sealed. That is, one of the grounded tank **1** and the movable-side support plate **8***a* is a first member constituting a part of the container in which the insulating gas is sealed, while another of the grounded tank **1** and the movable-side support plate **8***a* is a second member constituting a part of the container in which the insulating gas is sealed. Here, a coupling point between the grounded tank **1** and the movable-side support plate **8***a* is taken as an example, but this similarly applies to a coupling point between the grounded tank **1** and the fixed-side support plate **8***b*. That is, one of the grounded tank **1** and the fixed-side support plate **8***b* may be the first member constituting a part of the container in which the insulating gas is sealed, while another of the grounded tank **1** and the fixed-side support plate **8***b* may be the second member constituting a part of the container in which the insulating gas is sealed.

[0025] A flange **1***c* is formed at an end portion of the grounded tank **1**. A through hole **1***d* is formed in the flange **1***c*.
[0026] A screw hole **8***c* is formed in the movable-side support plate **8***a*. The movable-side support plate **8***a* is fixed to the end portion of the grounded tank **1** by screwing a screw **9** penetrating the through hole **1***d* of the flange **1***c* into the screw hole **8***c*. A sealant layer **10** is provided at the coupling point between the grounded tank **1** as the first member and the movable-side support plate **8***a* as the second member. In the vacuum circuit breaker **50** according to the first embodiment, the sealant layer **10** is provided between the flange **1***c* and the movable-side support plate **8***a*. In the flange **1***c* of the grounded tank **1** and the movable-side support plate **8***a*, joint surfaces **1***e* and **8***d* are flat surfaces, and the joint surfaces **1***e* and **8***d* abut against each other. Now, here, one of the members constituting a part of the container in which the insulating gas is sealed is the plate-shaped movable-side support plate **8***a*, but a structure may be adopted in which tanks in which flanges are formed are coupled to each other.
[0027] FIG. **3** is a cross-sectional view of the sealant layer of the vacuum circuit breaker according to the first embodiment. The joint surface **1***e* of the flange **1***c* of the grounded tank **1** and the joint surface **8***d* of the movable-side support plate **8***a* are provided with projections and recesses due to machining. Generally, the joint surfaces **1***e* and **8***d* are formed by milling processing, but may be formed by other processing methods. The sealant layer **10** includes a resin layer **10***a* formed using a resin as a dispersion medium and a filler **10***b* as a dispersoid. The resin layer **10***a* is formed using a silicone resin. The filler **10***b* is formed containing a material having lower gas permeability than the resin that forms the resin layer **10***a*. For example, silica or alumina can be used as the material of the filler **10***b*. A particle size of the filler **10***b* is smaller than the projections and recesses of each of the flange **1***c* and the movable-side support plate **8***a*. Therefore, the filler **10***b* enters a recess of the flange **1***c* and the movable-side support plate **8***a*.
[0028] In the vacuum circuit breaker **50** according to the first embodiment, the filler **10***b* having lower gas permeability than the resin layer **10***a* formed by the resin as the dispersion medium is dispersed in the resin layer **10***a*, so that molecules of the insulating gas moving in the resin layer **10***a* move while bypassing the filler **10***b*. Therefore, in the vacuum circuit breaker **50** according to the first embodiment, a leakage path of the insulating gas becomes longer as compared with a structure in which a resin layer in which a filler is not dispersed is used as the sealant layer and a structure in which an O-ring is used. Therefore, in the vacuum circuit breaker **50** according to the first embodiment, the insulating gas is less likely to leak as compared with the structure in which the resin layer in which the filler is not dispersed is used as the sealant and the structure in which the O-ring is used.
[0029] Note that, when a particle size of the filler **10***b* is too small, it is difficult for molecules of the insulating gas to bypass the filler **10***b*, and an effect of lengthening the leakage path of the insulating gas is reduced. In addition, when a particle size of the filler **10***b* is too small, the filler **10***b* is not uniformly dispersed but easily aggregated. When the joint surfaces **1***e* and **8***d* are formed by milling processing, the projections and recesses are about 1 μm to 10 μm. Therefore, by setting the particle size of the filler **10***b* to 1 μm to 10 μm, it is possible to lengthen the leakage path of molecules of the insulating gas while suppressing aggregation of the filler **10***b*.
[0030] Further, when a ratio of the filler **10***b* in the sealant layer **10** is too large, flexibility of the sealant layer **10** is impaired, and adherence to the flange **1***c* or the movable-side support plate **8***a* tends to be deteriorated. Therefore, the ratio of the filler **10***b* in the sealant layer **10** is preferably 50% or less.
[0031] In the vacuum circuit breaker **50** according to the first embodiment, the flange **1***c* of the grounded tank **1** and the movable-side support plate **8***a* are coupled to each other with the joint surfaces **1***e* and **8***d*, which are flat surfaces, abutting against each other. Therefore, it is not necessary to form a groove for disposing the O-ring on the flange **1***c* and the movable-side support plate **8***a*. Accordingly, the vacuum circuit breaker **50** can suppress an increase in the number of

man-hours for manufacturing work and the number of man-hours for assembly work of the grounded tank **1**, which is the container in which the insulating gas is sealed.

[0032] In addition, it is necessary to maintain a constant gas pressure in the tube so that the bellows **3** of the vacuum valve **2** not to be exposed to a high pressure by the sealed gas in the grounded tank **1**. Therefore, the movable-side frame **5** and the bellows **3** of the vacuum valve **2** constitute the container in which the insulating gas is sealed, and a gas pressure in a space inside the movable-side frame **5** and the tube of the bellows **3** is made lower than a gas pressure in a space inside the grounded tank **1** and outside the tube of the movable-side frame **5**. Therefore, in order to maintain the performance of the vacuum circuit breaker **50**, it is necessary to consider not only the air pressure difference between the inside and outside of the grounded tank **1** but also the gas sealability between different gas pressure sections in the grounded tank **1**. Therefore, for example, by providing the sealant layer **10** formed by the resin layer **10***a* and the filler **10***b* also at a connection point between the movable-side frame **5** and the vacuum valve **2** and a connection point between the movable-side frame **5** and the movable-side insulation support tube **6**, it is possible to suppress leakage of the insulating gas in the space having different pressure sections inside the grounded tank **1**.

[0033] In particular, in the vacuum circuit breaker **50** according to the first embodiment, an effect of maintaining a gas pressure in the grounded tank **1** for a long period of time can be remarkably obtained in a case of increasing a sealing pressure of the insulating gas to reduce a size of the gas insulation device or in a case of using an insulating gas having a small molecular weight such as dry air.

Second Embodiment

[0034] FIG. **4** is a cross-sectional view of a sealant layer of a vacuum circuit breaker according to a second embodiment. In the vacuum circuit breaker **50** according to the second embodiment, the sealant layer **10** is formed containing an epoxy resin. Further, in the vacuum circuit breaker **50** according to the second embodiment, the filler **10***b* is not dispersed in the epoxy resin, and the sealant layer **10** is formed by only the resin layer **10***a*.

[0035] By using, for example, a two-component curing type epoxy resin capable of controlling a curing time, it is possible to suppress curing of the epoxy resin during work of fixing the movable-side support plate **8***a* to the flange **1***c*.

[0036] In the vacuum circuit breaker **50** according to the second embodiment, the sealant layer **10** is formed by the resin layer **10***a* made of epoxy resin having lower gas permeability than silicone resin, so that the insulating gas is less likely to leak from the grounded tank **1**, and the gas pressure in the grounded tank **1** can be maintained for a long period of time.

[0037] Similarly to the vacuum circuit breaker **50** according to the first embodiment, in the vacuum circuit breaker **50** according to the second embodiment, it is not necessary to form a groove for disposing an O-ring in the flange **1***c* and the movable-side support plate **8***a*. Therefore, the vacuum circuit breaker **50** can suppress an increase in the number of man-hours for manufacturing work and the number of man-hours for assembly work of the grounded tank **1**, which is the container in which the insulating gas is sealed.

Third Embodiment

[0038] The sealant layer **10** of the vacuum circuit breaker **50** according to the third embodiment has the filler **10***b* similarly to the vacuum circuit breaker **50** according to the first embodiment. However, an epoxy resin is used for the resin layer **10***a* formed using a resin as a dispersion medium.

[0039] In the vacuum circuit breaker **50** according to the third embodiment, the resin layer **10***a* is formed using an epoxy resin having gas permeability lower than that of a silicone resin as a dispersion medium, so that it is possible to reduce leakage of the insulating gas as compared with the vacuum circuit breaker **50** according to the first embodiment. Further, similarly to the vacuum circuit breaker **50** according to the first embodiment, since the filler **10***b* as a dispersoid is

contained in the sealant layer **10**, a leakage path of molecules of the insulating gas becomes long. Therefore, the vacuum circuit breaker **50** according to the third embodiment can reduce leakage of the insulating gas as compared with the vacuum circuit breaker **50** according to the second embodiment. As described above, the vacuum circuit breaker **50** according to the third embodiment can maintain a gas pressure in the grounded tank **1** for a long period of time.
[0040] Note that, in the above description, the case where the gas insulation device is the vacuum circuit breaker **50** has been described as an example, but similar implementation is possible on a gas insulation device other than a circuit breaker, such as a disconnector or a switch.
[0041] The configurations illustrated in the above embodiments illustrate one example of the contents and can be combined with another known technique, and it is also possible to omit and change a part of the configuration without departing from the subject matter.
REFERENCE SIGNS LIST
[0042] **1** grounded tank; **1***a*, **1***b*, **5***a* opening; **1***c* flange; **1***d* through hole; **1***e*, **8***d* joint surface; **2** vacuum valve; **2***a* movable-side contact; **2***b* fixed-side contact; **2***c* vacuum container; **3** bellows; **3***a*, **7***a*, **31***a* one end portion; **3***b*, **7***b*, **31***b* another end portion; **5** movable-side frame; **6** movable-side insulation support tube; **7** movable conductor; **8***a* movable-side support plate; **8***b* fixed-side support plate; **8***c* screw hole; **9** screw; **10** sealant layer; **10***a* resin layer; **10***b* filler; **12***a* movable-side bushing conductor; **12***b* fixed-side bushing conductor; **13***a*, **13***b* bushing; **15***a*, **15***b* current transformer; **17** fixed-side frame; **18** fixed-side insulation support tube; **21** fixed conductor; **30** operation device; **31** operation rod; **32**, **34** hole; **33**, **35** packing; **50** vacuum circuit breaker; **121***a*, **121***b* lower end portion.

Claims

1. A gas insulation device comprising: a first member and a second member constituting at least a part of a container in which an insulating gas is sealed; and a sealant layer provided at a coupling point between the first member and the second member, wherein a joint surface of each of the first member and the second member is a flat surface, and the joint surfaces abut against each other, the sealant layer includes a resin layer formed using a resin that is a dispersion medium, and a filler that is a dispersoid and is dispersed in the resin layer, the filler is formed using a material having lower gas permeability than the resin, and a particle size of the filler is smaller than projections and recesses of the joint surface of each of the first member and the second member.
2. The gas insulation device according to claim 1, wherein the resin is an epoxy resin.
3. (canceled)
4. The gas insulation device according to claim 1, wherein the first member is a grounded tank having a tubular shape, and the second member is an end face plate that covers an opening of an end face of the grounded tank.
5. The gas insulation device according to claim 4, comprising a vacuum valve accommodated in the grounded tank.
6. The gas insulation device according to claim 2, wherein the first member is a grounded tank having a tubular shape, and the second member is an end face plate that covers an opening of an end face of the grounded tank.