

TITLE OF THE INVENTION

STATIC INDUCTIVE APPARATUS WITH SILICONE LIQUID

CLAIM OF PRIORITY

5 This application claims priority from Japanese application Serial No. 2005-74768, filed on August 16, 2005, the content of which is hereby incorporated into this application.

BACKGROUND OF THE INVENTION

10 Field of Technology

The present invention relates to a static inductive apparatus with silicone liquid, like a transformer using a silicone liquid as an insulating cooling medium.

15 Background of Art

Insulating oil such as mineral oil has been used as the insulating cooling medium of a transformer. Use of a flame resistant silicone liquid in place of the mineral oil leads to improvement of the fire resistant properties and increase of operation temperature, whereby a compact apparatus configuration is ensured. In the case of silicone liquid, however, if the operation temperature is increased over the conventional value, a decomposition product
20 characterized by smaller molecular weight and lower
25

boiling point will be produced due to thermal degradation. This will reduce the flash temperature (hereinafter referred to as "flash point"), with the result that silicone liquid tends to catch fire during
5 operation. A greater amount of the decomposition product generated will be generated as the thermal degradation temperature is higher.

Patent Document 1 describes an electrical apparatus containing a solid insulating material and
10 silicone liquid, wherein the silicone liquid includes an adsorbent such as zeolite and silica gel, thereby preventing an increase in the amount of evaporation resulting from degeneration of silicone liquid.
According to the disclosure in the Patent Document 2,
15 an oil cooling pipe of a transformer is provided with a conduit including an adsorbent for preventing degeneration of the silicone liquid to ensure easy replacement of the adsorbent. The Patent Document 2 mentions silica gel and synthetic zeolite as an
20 adsorbent.

[Patent Document 1] Japanese Application Patent Laid-Open Publication No. Sho 50-41098

[Patent Document 2] Japanese Application Patent Laid-Open Publication No. Sho 50-161625

25 The decomposition product of low molecular weight

and low boiling point generated by the thermal degradation of the silicone liquid is mainly composed of a ring or straight chain compound having the same basic structure as that of the silicone liquid. This
5 being the case, the method of an adsorbent contained in the silicone liquid fails to ensure selective adsorption and removal of the silicone decomposition product by the adsorbent, even if water content in the silicone liquid can be adsorbed by the adsorbent.

10 SUMMARY OF THE INVENTION

An object of the present invention is to provide a static inductive apparatus with silicone liquid capable of efficient removal or reduction of the decomposition product of low molecular weight and low
15 boiling point generated by thermal degradation of the silicone liquid.

The present invention provides a stationary inductive apparatus with silicone liquid wherein an iron core and a winding mounted on the iron core are
20 immersed in an insulating cooling medium composed of the silicone liquid in a tank having a gas phase above the cooling medium, the stationary inductive apparatus comprising a decomposition product removing mechanism for removing the decomposition products produced by
25 thermal degradation of the silicone liquid during the

operation of the apparatus, and released into the gas phase.

According to embodiments of the present invention, it is possible to provide efficient removal or
5 reduction of the decomposition products of low molecular weight and low boiling point generated by thermal degradation of the silicone liquid, using an adsorbent or the like. This arrangement prevents lowering of flash temperature of the silicone liquid.

10 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic diagram of the transformer provided with a container for recovering silicone decomposition products, as an embodiment of the present invention;

15 Fig. 2 is a schematic diagram representing another embodiment of the present invention;

Fig. 3 is a schematic diagram representing still another embodiment of the present invention;

Fig. 4 is a schematic diagram of the transformer
20 arranged to remove silicone liquid decomposition products using an adsorbent, as another embodiment of the present invention;

Fig. 5 is a schematic diagram representing another embodiment of the type using an adsorbent;

25 Fig. 6 is a schematic diagram representing another

embodiment of the type using an adsorbent; and

Fig. 7 is a schematic diagram representing the structure of a transformer having no silicone decomposition product removing mechanism.

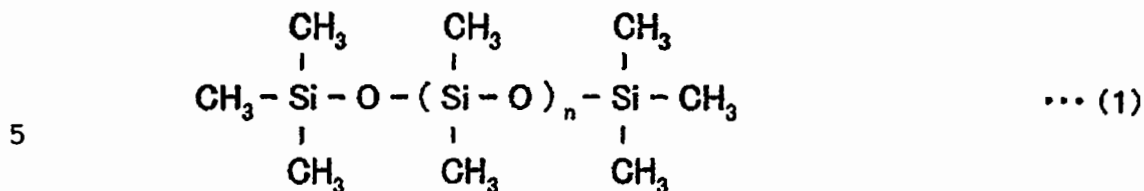
5 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention removes the decomposition products of low molecular weight and low boiling point generated by thermal degradation of the silicone liquid released into the gas phase formed in a gas
10 phase above the cooling medium in the tank , using an adsorbent or the like. The methods used in the decomposition products removing mechanism include the aforementioned technique of using the adsorbent, and the technique of using a pipe through which the
15 decomposition product released into the gas phase is recovered into a container.

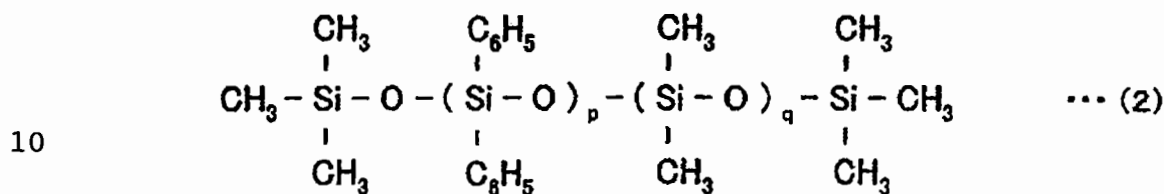
Examples of the silicone liquids in the specification are liquid polymers of an organic silicon compound. They are straight chain compounds
20 having a chemical structure expressed by the following formula (1)、 (2) or (3). They are also called silicone oil. The silicone liquid or silicone oil are basically the same with each other. The silicone liquid can be used independently or in combination
25 with other compound. The dimethyl silicone liquid

defined by (1) is preferably used.

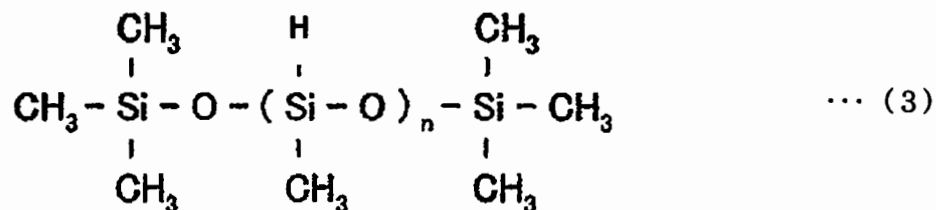
[Chemical Formula 1]



[Chemical Formula 2]



[Chemical formula 3]



Referring to the drawings, the following describes the embodiments of the present invention, the present invention being not restricted thereto:

[Embodiment 1]

Before describing the embodiments of the present invention, the general structure of a transformer with silicone liquid will be described with reference to Fig. 7. An iron core 2, a primary winding 3 and a

secondary winding 4 mounted on the iron core, and an insulation sleeve 5 are stored inside the tank 1, together with an insulating cooling medium 6 made up of silicone liquid, and nitrogen gas 7 in the gas phase. A cooler 8 are connected outside the tank 1 via cooling pipes 9a and 9b. The insulating cooling medium 6 flows inside the cooler 8 as shown by an arrow mark through the upper cooling pipe 9a, and is cooled by the cooler 8. After that, it flows through the primary winding 3 and secondary winding 4 by way of the cooling pipe 9b, thereby taking away generated heat. The iron core 2 is clamped by clamps 10a and 10b, and the upper and lower portions of the winding are held by insulations 11 through 14. The iron core 2 is provided with a cooling oil inlet 15.

Fig. 1 shows an embodiment of the present invention. In Fig. 1, a decomposition product removing mechanism made up of a pipe 16 and a container 17 is provided in order to remove the silicone decomposition products released into the gas phase portion, namely, nitrogen gas 7 due to decomposition of the silicone liquid. During the operation of the transformer, the heated gas on the surface of the silicone liquid is fed toward the cooler 8 indicated by an arrow mark, while being cooled. In this case, part of the silicone

decomposition products of low molecular weight and low boiling point flow into the pipe 16 and are recovered by the container 17. Then they are liquefied or solidified inside the container 17. This arrangement prevents lowering of the flash point of the silicone liquid.

Fig. 2 shows another example . In the transformer of Fig. 2, the container 17 is installed on the upper portion of the cooler 8, adjacent to the cooler 8. As shown, the container 17 is cooled with the cooler 8 by placing the container 17 in contact with the cooler 8. This promotes cooling of the decomposition products recovered by the container 17 and accelerates solidification in the container.

Fig. 3 shows another variation of the example. In Fig. 3, a cooling apparatus 18 is provided to cool the container 17. This structure also accelerates solidification of the silicone decomposition product.

As described above, lowering of the flash point of the silicone liquid can be prevented by installing a mechanism for removing the silicone decomposition products generated by thermal degradation of the silicone liquid and released into gas phase during the operation.

The silicone liquid circulates between the tank 1

and the cooler 8 connected thereto through the pipe,
and cools the iron core and winding inside the tank.
This being the case, viscosity of the silicone liquid
is preferred to be low. Particularly, the kinetic
5 viscosity coefficient at 25 °C is preferably 50 mm²/s
or less. Generally the flash point of the silicone
liquid depends on the molecular weight. The smaller
the molecular weight, the lower the viscosity of the
silicone liquid. Accordingly, the lower the viscosity,
10 the lower the flash point of the silicone liquid;
hence the greater the amount of the decomposition
products of low molecular weight and low boiling point.
When a compact apparatus configuration is ensured by
improvement of the fire resistant properties and
15 increase of operation temperature, the flame
retardancy of the silicone liquid is preferred. The
flash point of the silicone liquid is preferably
higher than 250 °C. This being the case, it is
effective to use the silicone liquid having a flash
20 point exceeding 250 °C and a kinetic viscosity of 50
mm²/s or less at 25 °C. In the present invention, such
an additive as an antistatic agent used in the
transformer with mineral oil can be added to the
silicone liquid.

Referring to Fig. 4, the following describes the embodiment of removing decomposition product from the silicone liquid, using an adsorbent. In Fig. 4, an adsorbent 19 is provided as a silicone decomposition product removing mechanism in the gas phase portion on the surface of the silicone liquid in the tank 1.

The silicone liquid and the decomposition product thereof have basically the same chemical structure. Accordingly, selective adsorption and removal of the decomposition product cannot be achieved by adding an adsorbent into the silicone liquid. However, efficient removal and reduction of the decomposition product of silicone liquid can be achieved by the adsorbent, when an adsorbent is placed in the gas phase portion on the surface of the silicone liquid, as in the present embodiment.

Use of activated carbon is most preferred as an adsorbent. Synthetic zeolite or silica gel can also be used. Use of a combination thereof is also acceptable. A combination of activated carbon with synthetic zeolite or silica gel is preferred since it removes the water content from the silicone liquid at the same time. The Patent Document 1 describes that the activated carbon is not a preferable adsorbent. In the present invention, the activated carbon is one of the

particularly preferable adsorbents.

The adsorbent 19 can be placed inside the container 17 installed outside the tank 1 through the pipe 16, as shown in Fig. 5. As shown in Fig. 6, an
5 adsorbent 19 can be placed inside the container 17, or a filter 20 carrying the adsorbent 19 can be placed there. In addition, a gas circulation apparatus 21 can be installed for forcible circulation of the gas in the gas phase portion. The arrangement shown in Fig. 6
10 further improves the efficiency in removing the silicone liquid decomposition product. The gas circulation apparatus 21 need not be operated at all times. It can be operated on a periodic basis, depending on the operating conditions of the
15 transformer.

An on-off valve (not illustrated) or the like can be installed in the pipe 16 of Fig. 6 to create an enclosed space. This arrangement allows periodic replacement of the container 17, adsorbent 19 or
20 filter 20.

WHAT IS CLAIMED

1. A stationary inductive apparatus with silicone liquid, which comprises a tank for accommodating silicone liquid as an electrical insulating cooling medium, which forms a gas phase above the silicone liquid; an iron core; a winding mounted on said iron core, the iron core and winding being immersed in the insulating cooling medium composed of silicone liquid in the tank, and a decomposition product removing mechanism for removing the decomposition products produced by thermal degradation of said silicone liquid during the operation of the apparatus the decomposition product being of a ring or straight chain compound having the same basic structure as that of silicone liquid, the products being released into the gas phase with which the decomposition product removing mechanism being communicated, wherein said

decomposition product removing mechanism has an adsorbent arranged in a container .

2. The stationary inductive apparatus with silicone liquid described in Claim 1, wherein said decomposition product removing mechanism recovers said decomposition products released into said gas phase through a pipe to the tank having an adsorbent .

3. The stationary inductive apparatus with silicone liquid according to Claim 1, wherein said decomposition product removing mechanism recovers said decomposition products released into said gas phase through a pipe to a container, an adsorbent is accommodated in said container by itself or in combination with a filter carrying the adsorbent, the gas flowing through said pipe being circulated between said gas phase and said container.

4. The stationary inductive apparatus with silicone liquid according to Claim 1, wherein a flash point of said silicone liquid is over 250 °C, and the kinetic viscosity coefficient at 25 °C does not exceed 50 mm²/s.

5. A stationary inductive apparatus with silicone liquid, which comprises; a tank for accommodating an electrical insulating cooling medium, wherein the tank forms a gas phase above the cooling medium; an iron core; a winding mounted on said iron core, the iron core and the winding being immersed in the insulating cooling medium composed of silicone liquid in the tank; a cooler, disposed outside the tank, for cooling the insulating cooling medium and then returning it into the tank ; and a decomposition product removing mechanism for removing the decomposition products produced by thermal degradation of said silicone liquid during the operation of the apparatus and then returning the recovered products into the gas phase, with which the decomposition product removing mechanism being communicated; the decomposition product being of a ring or straight chain compound having the same basic structure as that of silicone liquid, wherein said decomposition product removing mechanism further comprises an adsorbent arranged in said gas phase inside the tank.

6. The stationary inductive apparatus with silicone liquid according to Claim 5, wherein said decomposition product removing mechanism comprises:

· a pipe connected to the gas phase for allowing inflow of said decomposition products released to said 25 gas phase;

a container for recovering said decomposition products that have flown into said pipe;

wherein said container is arranged in contact with said cooler in such a way that the decomposition products recovered into the container is cooled.

7. The stationary inductive apparatus with silicone liquid according to Claim 5, wherein the flash point of said silicone liquid is above 250 °C, and the kinetic viscosity coefficient at 25 °C does not exceed 50 mm²/s.