

POWER TRANSFORMER WITH AMORPHOUS ALLOY CORE

Field of the invention:

The present invention relates to a transformer with an amorphous alloy core formed using an amorphous magnetic ribbon, and more particularly, to
5 a transformer with an amorphous alloy core formed using an amorphous magnetic ribbon, wherein the capacity of the transformer can be increased.

Description of related art:

Recently, the energy-saving for a transformer
10 connected to an electric apparatus is being required with an increase in electric power demand. As one example, an attempt has been made to provide an improvement in a transformer in which an amorphous magnetic ribbon is used to form a core in order to
15 decrease the loss due to a core loss of the core constituting the transformer.

There is such a type of a transformer in which a core and a winding wound around the core are contained in a vessel of the transformer, and an
20 insulating cooling medium, including an insulating oil such as a mineral oil or an insulating gas such as SF₆ gas is encapsulated in the vessel of the transformer (for example, see JP-A-2000-82625).

There is also a transformer in which a core

constituting the transformer is covered with a casing, and silicone oil is filled within the casing (for example, see JP-A-06-120049).

Summary of the invention:

5 The amorphous magnetic ribbon used for forming the core of the transformer as described above has a thickness on the order of 0.03 mm and a high electric resistivity and hence, has an excellent magnetic characteristic such that a decrease in core
10 loss to 1/3 to 1/4 of that of a usually used core made of a silicon steel can be expected. However, for the reason of constituents of the core, the core has a saturation flux density of about 1.56 T (tesla) which is lower by 20 % or more than that (about 2.01 T) of
15 the silicon steel.

For this reason, in the transformer with the amorphous alloy core, the size of the core is necessarily increased in order to determine the rated voltage for the transformer at the same level as for
20 the transformer with the silicon steel core. With the increase in size of the core, an increase in size of the winding wound around the core is also induced. As a result, the transformer with the amorphous alloy core has an essential disadvantage that the entire
25 transformer is heavy in weight and large in size, as compared with the transformer with the silicon steel core.

Many attempts have been made to provide improvements in core manufacturing technology and in structure of the core, but in the present situation, it is difficult to provide drastic improvements due to an essential problem associated with amorphous materials.

The present invention has been accomplished with such circumstance in view, and it is an object of the present invention to provide a transformer with an amorphous alloy core, wherein the loss due to a loss (a core loss) of the amorphous alloy core can be further alleviated, and an increase in capacity can be provided.

To achieve the above object, according to a first aspect and feature of the present invention, there is provided a transformer with an amorphous alloy core, comprising transformer contents including an amorphous alloy core made using an amorphous magnetic ribbon, and a winding mounted on the core, and a tank in which the transformer contents are contained, characterized in that a liquid is encapsulated in the tank so as to contact with the core constituting one of the transformer contents within the tank to perform a function of inhibiting the dissipation of heat of the core.

According to a second aspect and feature of the present invention, there is provided a transformer with an amorphous alloy core, comprising transformer contents including an amorphous alloy core made using

an amorphous magnetic ribbon, and a winding mounted on the core, and a tank in which said transformer contents are contained, characterized in that a silicone liquid is encapsulated in said tank so as to contact with the
5 core constituting one of the transformer contents within the tank to perform a function of inhibiting the dissipation of heat of the core.

According to a third aspect and feature of the present invention, there is provided a transformer
10 with an amorphous alloy core, comprising transformer contents including an amorphous alloy core made using an amorphous magnetic ribbon, and a winding mounted on the core, and a tank in which the transformer contents are contained, characterized in that a silicone liquid
15 is encapsulated in the tank so as to contact with the core constituting one of the transformer contents within the tank to perform a function of inhibiting the dissipation of heat of the core to raise the temperature of the core.

20 According to a fourth aspect and feature of the present invention, there is provided a transformer with an amorphous alloy core, comprising transformer contents including an amorphous alloy core made using an amorphous magnetic ribbon, and a winding mounted on
25 the core, and a tank in which the transformer contents are contained, characterized in that a plastic-based coating insulating material is mounted around an outer periphery of the winding so as to contact with the core

constituting one of the transformer contents within the tank to perform a function of inhibiting the dissipation of heat of the core, and a silicone liquid is encapsulated in the tank so as to contact with the core to perform a function of inhibiting the
5 dissipation of heat of the core.

According to a fifth aspect and feature of the present invention, in addition to any of the first to fourth features, the liquid adapted to perform the
10 function of inhibiting the dissipation of heat of the core is a silicone liquid having a lower viscosity.

According to a sixth aspect and feature of the present invention, in addition to the fifth feature, the silicone liquid has a temperature of flash
15 point in a range of 180°C to 320°C.

According to a seventh aspect and feature of the present invention, in addition to the fifth feature, the silicone liquid has a dynamic viscosity coefficient in a range of from 20 cSt to 50 cSt.

20 According to an eighth aspect and feature of the present invention, in addition to the fifth feature, the silicone liquid has a temperature of flash point in a range of 180°C to 320°C and a dynamic viscosity coefficient in a range of from 20 cSt to 50
25 cSt.

According to a ninth aspect and feature of the present invention, there is provided a process for operating a transformer with an amorphous alloy core,

comprising transformer contents including an amorphous alloy core made using an amorphous magnetic ribbon, and a winding mounted on said core, and a tank in which the transformer contents are contained, characterized in
5 that the transformer is operated in a manner that a silicone liquid is encapsulated in the tank so as to contact with the core constituting one of the transformer contents within the tank to perform a function of inhibiting the dissipation of heat of the
10 core to raise the temperature of the core, the silicone liquid having a temperature of flash point in a range of 180°C to 320°C and a dynamic viscosity coefficient in a range of from 20 cSt to 50 cSt.

According to the present invention, it is
15 possible to decrease the loss generated in the amorphous alloy core by the inhibition of the dissipation of the heat of the amorphous alloy core. Therefore, it is possible to achieve an increase in capacity of the transformer and to provide the
20 transformer having characteristics excellent in the prevention of disasters and the environmental protection in addition to an energy-saving property inherently possessed by the transformer with the amorphous alloy core.

25 With the process according to the present invention, the transformer is operated with the silicone liquid, particularly, the silicone liquid having the lower viscosity used as the liquid

contacting with the core constituting one of the transformer contents within the tank to perform the function of inhibiting the dissipation of the heat of the core. Therefore, it is possible to decrease the
5 loss (the core loss) of the amorphous alloy core and to further enhance the energy-saving property inherently possessed by the transformer with the amorphous alloy core.

Other objects, features and advantages of the
10 invention will become apparent from the following description of the embodiments of the invention taken in conjunction with the accompanying drawings.

Brief description of drawings:

15 Fig. 1 is a vertical cross-sectional view of a transformer with an amorphous alloy core according to an embodiment of the present invention.

Fig. 2 is a sectional view taken along a line II-II and showing the transformer with the amorphous
20 alloy core as shown in Fig. 1 according to the embodiment of the present invention.

Fig. 3 is a front view of the amorphous alloy core constituting the transformer with the amorphous alloy core shown in Fig. 1 according to the embodiment
25 of the present invention.

Fig. 4 is a vertical cross-sectional view of a winding constituting the transformer with the amorphous alloy core shown in Fig. 1 according to the

embodiment of the present invention.

Fig. 5 is a characteristic diagram of the relationship between the temperature of the core and the core loss in the transformer with the amorphous alloy core according to the embodiment of the present invention.

Fig. 6 is a vertical cross-sectional view of a transformer with an amorphous alloy core according to another embodiment of the present invention.

10 Fig. 7 is a sectional view taken along a line VII-VII and showing the transformer with the amorphous alloy core shown in Fig. 6 according to the other embodiment of the present invention.

Fig. 8 is a vertical cross-sectional view of a transformer with an amorphous alloy core according to a further embodiment of the present invention.

Fig. 9 is a sectional view taken along a line IX-IX and showing the transformer with the amorphous alloy core shown in Fig. 8 according to the further embodiment of the present invention.

Detailed description of the invention:

Embodiments of a transformer with an amorphous alloy core according to the present invention will now be described with reference to the accompanying drawings.

Fig. 1 is a vertical cross-sectional front view showing one embodiment of a transformer with an

amorphous alloy core according to the present invention, and Fig. 2 is a side view taken along a line II-II in Fig. 1. In Figs. 1 and 2, the numeral 1 denotes a tank of a transformer, which is provided at its upper portion with an opening which enables the removal and insertion of transformer contents comprising a core 2 and a winding 3 wound around the core 2, which will be described hereinafter. The numeral 4 denotes a cover which closes the opening of the tank 1, and each of the numerals 5 and 6 denotes a lead-out terminal which is mounted on the cover 4 and connected to the winding 3.

The numeral 7 denotes a lower fastener mounted on a bottom within the tank 1. The lower fastener 7 is comprised of a lower member 7a fixed to the bottom within the tank 1, rising members 7b provided at opposite ends of the lower member 7a, respectively, and a flange 7c provided at a lengthwise intermediate portion between upper ends of the rising members 7b. The numeral 8 denotes a winding underside-supporting member mounted inside each of the rising members 7b of the lower fastener 7, and the numeral 9 denotes a vibration-proofing material which is mounted on the lower member 7a of the lower fastener 7, and on which the core 2 is placed.

The numeral 10 denotes a plate member inserted into a space between an upper end of the winding 3 and the core 2; the numeral 11 denotes a

flange provided at each of opposite ends of the plate member 10; the numerals 12 denotes a winding upside-supporting member mounted between a lower surface of the plate member 10 and the upper end of the winding 3; and the numeral 13 denotes a clamp mounted between the flange 7c of the lower fastener 7 and the flange 11 of the plate member 10. The winding 3 constituting the transformer contents is interposed between the winding upside-supporting member 12 and the winding underside-supporting member 8 and clamped by the clamp 13, whereby the transformer contents are supported in a vibration-proofing manner within the tank 1.

The transformer contents are immersed in a silicone liquid 14 serving as an electrical/thermal insulating and cooling liquid thrown into the tank 1 to perform an electrical insulating and cooling function and a function of inhibiting the heat dissipation of the core. It is preferable to select a silicone liquid 14 which performs the function of inhibiting the dissipation of the heat of the core to maintain the core at a higher temperature, in addition to the electrical insulating and cooling function, and which has a lower viscosity from the viewpoints of the prevention of disasters and the environmental protection and has physical properties such as a flash point in a range of from 180°C to 320°C and a coefficient of dynamic viscosity in a range of from 20 to 50 cSt. Further, it is most preferable to use a

silicone liquid having a flash point equal to or higher than 250°C and a coefficient of dynamic viscosity of 20 cSt.

Fig. 3 is a front view showing one example of
5 a core 2 which is one of transformer contents
constituting one embodiment of a transformer with an
amorphous alloy core according to the present
invention. In Fig. 3, the core 2 is formed by winding
a plurality of laminated amorphous magnetic ribbons 2a,
10 then spreading them once, inserting the ribbons in this
state into the winding 3 and winding the spread
portions of the amorphous magnetic ribbons 2a again.

Fig. 4 is a front view showing one example of
a winding 3 which is one of transformer contents
15 constituting one embodiment of a transformer with an
amorphous alloy core according to the present
invention. In Fig. 4, the winding 3 is formed by
winding a lower-voltage electric wire 3a into a coil
configuration on an inner side, winding a higher
20 voltage electric wire 3b into a coil configuration
outside the lower-voltage electric wire 3a, and
disposing a layer insulating material 3c between layers
of the electric wires 3a and 3b.

A surface of the winding 3 is an exposed
25 portion of each of the electric wires 3a and 3b.
Therefore, the exposed portion is covered with a
plastic-based coating insulating material 3d having a
heatproof characteristic, for example, at 30 K (Kelvin)

or more, as compared with a conventional cellulose-based insulating material. The plastic-based coating insulating material 3d which may be used includes, for example, a polyamide, a polyethylene terephthalate, a polyphenylene sulfide, a polyimide and the like. A portion of the plastic-based coating insulating material 3d contacting with an outer peripheral surface of the core 2 exhibits a coating insulating function for the winding 3 and a heat dissipation-inhibiting function for the core 2.

The operation of the transformer with the amorphous alloy core according to the present invention and one embodiment of a method for operating the transformer will be described below.

When an alternating voltage is applied to the lower-voltage electric wire 3a of the winding 3, an alternating current flows in the lower-voltage electric wire 3a to generate a magnetic flux within the core 2. The generation of the magnetic flux causes an induced voltage to be generated in the higher-voltage electric wire 3b by an electromagnetic induction. Thus, a power source voltage supplied is transformed and delivered.

During the transformation of the voltage, a heat is generated in the core 2 due to a core loss such as a hysteresis loss and an eddy-current loss, but the dissipation of the generated heat is inhibited by the silicone liquid 14 contacting an outer surface of the core 2. In this embodiment, the dissipation of the

heat of the core 2 is inhibited even by the plastic-based coating insulating material 3d on the winding 3.

When the dissipation of the heat of the core 2 is inhibited, the temperature of the core 2 is raised and maintained at a higher level. As a result of the raising of the temperature of the core 2, the electric resistance within the core 2 is increased, and the eddy-current loss generated in the core 2 is decreased, resulting in a decrease in core loss. The loss (core loss) generated in the amorphous alloy core 2 is lowered as the temperature of the core is raised, as shown in Fig. 5. This is mainly due to a decrease in eddy-current loss in the amorphous alloy core 2, but at a temperature of 100°C, a decrease in loss equal to or higher than 5 % of the core loss at generally room temperature can be achieved.

The above-described decrease in core loss of the core 2 ensures that a difficulty to increase the flux density due to an essential problem of the amorphous alloy core 2 can be improved. Therefore, for example, if the transformer according to the present invention is formed at the same size as a conventional transformer of an amorphous alloy core type, then it is possible to raise the operating temperature for the transformer from 120°C to 180°C in a range of 15 K to 75 K or higher, as compared with the conventional transformer, and to increase the capacity of the transformer.

If the capacity of the transformer is set at the same level as the conventional transformer of the amorphous alloy core type, then a reduction in size of the core 2 is achieved. This also influences the winding 3 mounted on the core 2 to largely promote a reduction in size of the winding 3. Thus, the application of the plastic-based coating insulating material 3d and the silicone liquid to the winding 3 of the transformer with the amorphous alloy core enables the raising of the temperature of the entire transformer contents, leading even to a remarkable reduction in size of a cooling duct between the lower-voltage electric wire 3a and the higher-voltage electric wire 3b, thereby further promoting reductions in size and weight of the winding 3.

Further, the raising of temperature of the entire transformer enables reductions in sizes of other cooling ducts between the winding 3 and the core 2 and between the winding 3 and the tank 1, thereby exhibiting a large effect to reductions in sizes and weights of not only the amorphous alloy core 2 but also the entire transformer.

As described above, according to the embodiment of the present invention, it is possible to improve the difficulty to increase the flux density due to the essential problem of the amorphous alloy core 2 to increase the capacity. It is also possible to provide reductions in size and weight of the entire

transformer, as compared with the conventional transformer having the same capacity.

Figs. 6 and 7 show another embodiment of a transformer with an amorphous alloy core according to the present invention. In these figures, the same reference characters as in Figs. 1 and 2 designate the same portions as those in Figs. 1 and 2 and hence, the description of them is omitted.

The numeral 15 denotes an upper fastener disposed above a core 2. The upper fastener 15 is comprised of an upper member 15a located above the core 2, down members 15b mounted at opposite ends of the upper member 15a, and a flange 15c mounted at a lengthwise intermediate portion between lower ends of the down members 15b. The numeral 16 denotes a winding upside-supporting member mounted inside each of the down members 15b of the upper fastener 15.

The numeral 17 denotes a vibration-proofing material mounted on the upper member 15a of the upper fastener 15. The vibration-proofing material 17 is mounted in contact with an upper portion of the core 2 to prevent the vibration of transformer contents by cooperation with the above-described lower vibration-proofing material 9. The transformer contents are interposed between the lower fastener 7 and the above-described upper fastener 15 and clamped by the clamp 13, whereby they are supported in a vibration-proofing manner within the tank 1.

The numeral 18 denotes an opening provided in each of the rising member 7b and the winding underside-supporting member 8 in the lower fastener 7 and the upper member 15a, the down member 15b and the winding upside-supporting member 16 in the upper fastener 15. Each of the opening 18 permits the passage of the silicone liquid 14 in a direction toward the core 2 to some degree.

In this embodiment, the lower and upper sides of the core 2 are covered with the lower fastener 7 and the upper fastener 15, respectively, and an intermediate portion of the core 2 is covered with the winding 3. Therefore, the flowing of the silicone liquid 14 toward the core 2 is suppressed, whereby the dissipation of heat of the core 2 is inhibited. Thus, it is possible to control the raising of the temperature of the core 2 with a good efficiency. It is also possible to decrease the core loss of the core 2 and to further increase the transforming efficiency.

According to this embodiment, it is possible to improve the difficulty to increase the flux density due to the essential problem of the amorphous alloy core 2 as in the previously described embodiment to increase the capacity of the transformer. It is also possible to improve the reductions in size and weight of the entire transformer, as compared with the conventional transformer having the same capacity.

Figs. 8 and 9 show a further embodiment of a

transformer with an amorphous alloy core according to the present invention. In these figures, the same reference characters as in Fig. 6 and 7 designate portions similar to or corresponding to those indicated by the same reference characters as in Figs. 6 and 7 and hence, the description of them is omitted. This embodiment comprises an arrangement in which the openings 18 provided in the upper fastener 15 and the lower fastener 7 have been eliminated, and in which the lower and upper sides of a core 2 are covered with the lower fastener 7 and the upper fastener 15, respectively, and the intermediate portion of the core 2 is covered with a winding 3, so that the flowing of the silicone liquid 14 toward the core 2 is further suppressed.

Thus, the dissipation of heat of the core 2 is further inhibited. This makes it possible to control the raising of the temperature of the core 2 further efficiently. As a result, it is possible to further decrease the core loss of the core 2 and to further increase the transforming effect.

According to this embodiment, it is possible to improve the difficulty to increase the flux density due to the essential problem of the amorphous alloy core 2 to increase the capacity, as in the previously-described embodiment. It is also possible to further improve the reductions in size and weight of the entire transformer, as compared with the conventional

transformer having the same capacity.

If the inhibition of the dissipation of the heat of the core 2 by the silicone liquid 14 cannot be insufficiently exhibited in the above-described
5 embodiment, for example, an insulating paper such as kraft paper can be used without use the plastic-based coating insulating material 3d on the winding 3 of the transformer with the amorphous alloy core.

In the above-described embodiment, the liquid
10 for performing the function of inhibiting the dissipation of heat of the core may be the silicone liquid having the lower viscosity. Thus, if the silicone liquid is vaporized and burned, a silica layer is formed, and a silicone gel layer is further formed
15 under the silica layer, leading to a higher self-flameproofing property by which the supplying of oxygen is cut off to inhibit the burning. As a result, the transformer is optimal to be used outdoors and indoors, which also contributes to the simplification of a fire
20 extinguishing equipment.

Further, the silicone liquid having the lower viscosity is hydrolyzed in the atmosphere to change back into silica, which is soft to an ecosystem, re-utilizable and excellent in economy.

25 It should be further understood by those skilled in the art that although the foregoing description has been made on embodiments of the invention, the invention is not limited thereto and

various changes and modifications may be made without departing from the spirit of the invention and the scope of the appended claims.

CLAIMS:

1. A power transformer with an amorphous alloy core, comprising transformer contents including an amorphous alloy core made using a plurality of amorphous magnetic ribbons as laminated, and a winding mounted on said core, and a tank in which said transformer contents are contained, an insulation cooling medium for cooling said transformer contents being encapsulated in said tank, characterized in that

said winding is made of a layer insulation disposed between each layers of a plurality of windings, and a plastic-based coating insulation material or a sheet-like coated insulation material, said material coating a periphery of said windings and in contact with said amorphous alloy core to perform heat-radiation restriction function of said alloy core, and

said insulation cooling medium is a silicone liquid in contact with said amorphous alloy core to inhibit a function of heat-dissipation of said core so as to increase a temperature of said alloy core.

2. A power transformer with an amorphous alloy core according to claim 1, characterized in that said silicone liquid has a temperature of flash point in a range of 180°C to 320°C.

3. A power transformer with an amorphous alloy core according to claim 1, characterized in that said silicone liquid has a dynamic viscosity coefficient in a range of from 20 cSt to 50 cSt.

4. A power transformer with an amorphous alloy core according to claim 1, characterized in that said silicone liquid has a temperature of flash point in a range of 180°C to 320°C and a dynamic viscosity coefficient in a range of from 20 cSt to 50 cSt.