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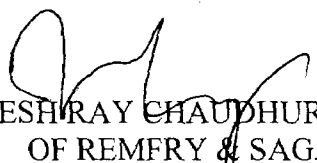
Abstract: The invention relates to a heat exchanger system for transformers or reactors having at least one coil being cooled by gaseous fluids circulating around whereas the arrangement is disposed within an enclosure wherein a flow of cooling gaseous fluid is passing the coil and being heated by the heat of the transformer or reactor which is directed to pass a thermosiphon heat exchanger which dissipates the heat to a cooling media.

Claims

1. Heat exchanger system for transformers or reactors having at least one coil being cooled by gaseous fluids circulating around
whereas the arrangement is disposed within an enclosure wherein a flow of cooling gaseous fluid is passing the coil and being heated by the heat of the transformer or reactor which is directed to pass a thermosiphon heat exchanger which dissipates the heat to a cooling media.
2. System according to claim 1 where the thermosiphon heat exchanger is arranged within a closed loop comprising an evaporator heat exchanger connected to a condenser.
3. System according to claims 1 or 2 whereas said thermosiphon heat exchanger comprises an air heat exchanger which is provided as an evaporator.
4. System according to claim 3 whereat said thermosiphon heat exchanger comprises a water heat exchanger which is provided as a condenser.
5. System according to claim 5 whereat the condenser is located within the enclosure.
6. System according to one of the preceding claims 3 to 5 whereat the evaporator and the condenser are linked together by a first tube and a second tube and work as a thermo-siphon whereas the first tube is a liquid downcomer and the second tube is a vapour riser.
7. System according to one of the preceding claims 3 to 6 where the evaporator heat exchanger is made of an extremely good heat transferring material, e.g. aluminium or copper.
8. System according to one of the preceding claims whereat an automotive type aluminium heat exchanger is being used inside the enclosure.

9. System according to one of the preceding claims whereat the use of a special alloy for the condenser heat exchanger on its liquid coolant side is being significantly reduced due to the use of a liquid coolant being optimized against corrosion.
10. System according to claim 9 whereat the intermediate fluid inside the heat exchanger is a dielectric fluid
11. System according to one of the preceding claims 4 to 10 whereat the condenser side of the thermosiphon heat exchanger is being made of a cupro-nickel alloy.
12. System according to one of the preceding claims 10 or 11 where all surfaces of the system being in contact with water are plated with cupro-nickel alloy or titanium.
13. System according to one of the preceding claims where heat exchanger is being provided with fins being passed by the gas in order to improve the heat transfer by convection.
14. Heat exchanger system according to claim 1, in particular for dry-type transformers which have windings being encased in epoxy resin and wound around a core, having a framework for the transformer made of laminated sheet packages forming the core and the yoke for each transformer coil and being cooled by gas circulating around when being indicated being supported by a fan
whereas the whole transformer is disposed within a container wherein a flow of cooling gas is passing the coils and where the gas heated by the heat of the transformer is being directed to pass a gas-to-water thermosiphon heat exchanger which is connected to an external water circulation.
15. System according to claim 1 whereas the evaporator heat exchanger is arranged within the enclosure while the water condenser is located outside of the container.
16. System according to claim 1 or 2 whereas a fan is provided for making the gas flow pass through the transformer.

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[HRISHIKESH RAY CHAUDHURY]
OF REMFRY & SAGAR
ATTORNEY FOR THE APPLICANT(S)

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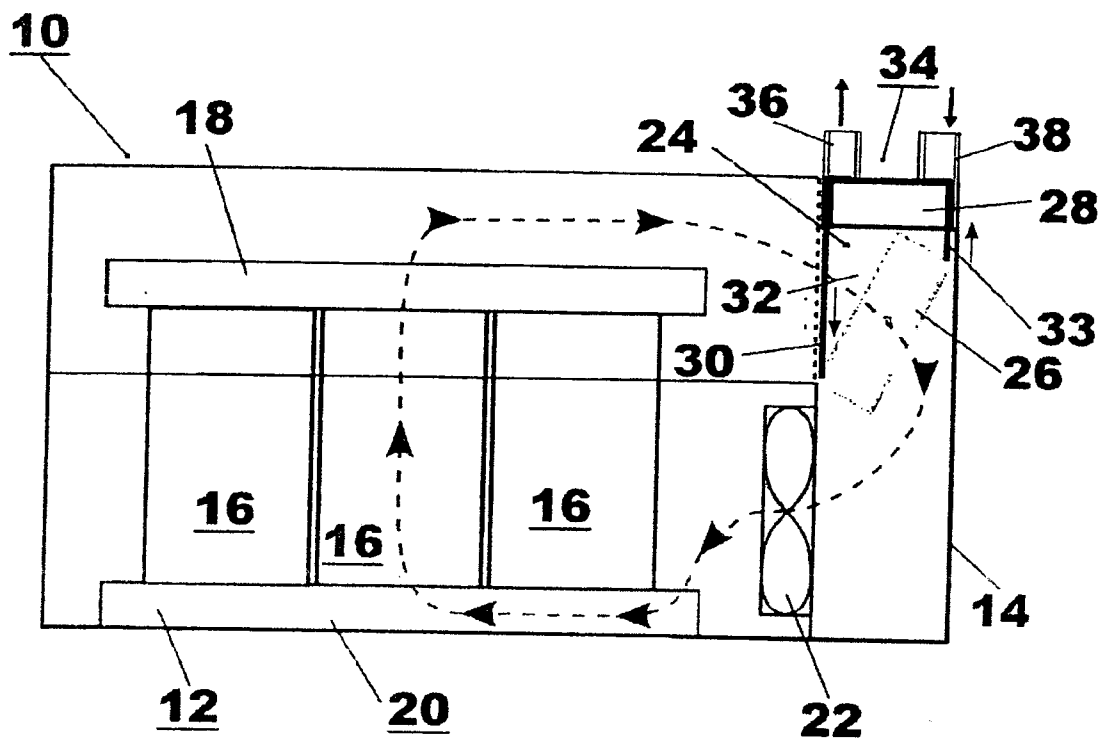


Fig. 1

[Signature]
[HRISHIKESH RAY CHAUDHURY]
OF REMFRY & SAGAR
ATTORNEY FOR THE APPLICANTS

Heat Exchanger System for Dry-Type Transformers

Description

The invention relates to a heat exchanger system for transformers or reactors having at least one coil being cooled by gaseous fluids circulating around.

Transformers or any other electromagnetic apparatuses which dissipate heat during operation have to be cooled by means of a coolant which absorbs the heat resulting from losses and transfers the heat to a heat sink. Such coolant may be liquid fluids, e.g. oil in case of oil transformers, or gaseous fluids, e.g. gas in case of dry-type transformers.

Dry type transformers have generally been constructed using one of three types of techniques: conventional dry, resin encapsulated, or solid cast. The conventional dry method uses some form of vacuum impregnation with a solvent type varnish on a completed assembly consisting of the core and the coils or individual primary and secondary coils. A problem with all kind of these transformers is the removal of heat generated by power dissipation in the windings.

From US 5656984 A a solid insulation transformer is known which has a rectangular core covered with a compressible closed-cell foam to eliminate stress during curing of the cast dielectric material surrounding the core and during operation. Heat pipes are placed between the inner coil and the core to extract heat before the temperature builds up. For safety and to eliminate the need for a separate enclosure, an outer multi-layer casing having an incorporated grounded conductive layer is provided to cover the sides of the cast body. The outer casing prevents explosion if dielectric break down and arcing occur, and reduces the danger of electric shock. There are not any further provisions for cooling the transformer.

In EP 1787304 A1 a compact dry transformer has been disclosed which is consisting of a magnetic material core provided with a first heat sink consisting of covers having cooling fins on the outer surface thereof. The transformer also consists of a coil assembly provided with a second heat sink consisting of enclosures having cooling fins on the outer surface thereof. The second heat sink further consists of jackets with heat pipes containing a thermo fluid having low boiling point at vacuum such as water. The heat pipes consist of evaporator portions and condenser portions having cooling fins on the outer surface thereof. Due to the heat sinks heat dissipation efficiency of the transformer is improved.

As one can realize all these methods and arrangements for heat removal is either affiliated with great efforts for instalment of heat pipes and the like or it is rather inefficient as to the amount of removed heat.

Hence it is an object of the present invention to allow a totally enclosed dry transformer to be cooled by gas more efficient than now whereas the efforts with the construction of such transformer accomplishing this goal and to achieve the desired heat reduction shall be low.

According to the present invention it is provided that the whole transformer is disposed within a container as an gas tight enclosure wherein a flow of cooling gas is passing the coils and the gas heated by the heat of the transformer is being directed to pass a gas to water thermosiphon heat exchanger being thermally connected to an external water circulation.

Inside the transformer is flowing gaseous fluid as a coolant which dissipates its received heat to an intermediate dielectric fluid. The intermediate dielectric fluid which is contained in a closed loop transfers its heat to cooling water outside the transformer to carry away the heat taken from the intermediate dielectric fluid. This intermediate fluid is circulating naturally with gravity and evaporating inside the enclosure in a gas evaporator and condensing in a water condenser. Thus a gas to water heat exchanger is formed with an arbitrary distance possible between the hot gas and the cold water thanks to the transport of heat with the phase change of the dielectric fluid. This is basically a gas to water thermo-siphon.

According to a preferred embodiment of the invention the evaporator heat exchanger is arranged within the container and the water condenser is located outside of the container.

Furthermore a fan can be provided for causing the gas flow pass through the transformer. If need be gas ducts can be arranged within the container to direct the gas flow to the coils at their lower end in order to make use of fluid physics where due to gravity cool gas is heavier than heated gas which rises up.

As a result of this configuration the unity formed by the evaporator heat exchanger and the condenser heat exchanger a specific embodiment of the present invention is achieved which is a gas to water thermo-siphon. A thermo siphon uses the method of passive heat exchange based on natural convection which circulates liquid in a closed loop without the necessity of a mechanical pump. To this end the so-called thermosiphon principle can be used whereat an intermediate fluid evaporating at the gas side and condensing at the water side circulates naturally by gravity. Its intended purpose is to simplify the transport of liquid as a heat-carrier and/or heat transfer, by avoiding the cost and complexity of a conventional liquid pump.

According to a preferred embodiment of the invention the gas-to-water heat exchanger is made of an extremely good heat transferring material, e.g. aluminium or copper, having a thermal conductivity of $\alpha > 150 \text{ W/mK}$. Hence it is possible according to the invention to employ an automotive type aluminium heat exchanger which is being used on the gas side inside the container.

Advantageously it is provided the use of a special alloy for the gas-to-water heat exchanger on its water side is being significantly reduced or not required by use of optimized water i.e. preferably ultrapure water which is usually deionized in order to prevent the respective components from corrosion and the like.

Accordingly as an appropriate material for the waterside of the thermosiphon heat exchanger a cupro-nickel alloy is being provided where according to a further em-

bodiment of the invention preferably all surfaces of the system being in contact with water are plated with the cupro-nickel alloy. In some cases, e.g. if sea water is used, some corrugated plate condensers will rather be made from titanium.

In order to improve or optimize the thermal flux from the heated gas to the heat exchanger this is being provided with fins which are being passed by the gas in order to improve the heat transfer by convection.

According to the core idea of the invention to cut down any efforts for accomplishing the set goal a more improved system is being provided where the measures for optimization of the gas side and the water side are taken separately. In this system using an intermediate phase change fluid, the heat is transferred to the water by condensation, e.g. by using a plate type heat exchanger. Since the heat capacity on the water and condensing sides are similar this heat exchanger can be very compact, for example compared to a customary heat exchanger according to the state of the art the compact heat exchanger according to the invention has a weight of only about 29 kg for 97 kW of heat duty which results in less need of alloy by about 69%. On the evaporation side where a large heat transfer area is needed due to the poor heat capacity of gas a cheap standard technology can be used such as automotive type heat exchangers made from aluminium. When clean internal gas and clean dielectric fluid only are in contact with this heat exchanger, no specific and expensive alloy is needed.

Finally the invention is based on using a thermosiphon gas to water heat exchanger in a dry transformer in the way in order to transfer the heat from the enclosure wherein the transformer is located and cooled by clean gas, to tap water. The use of a thermosiphon has the following advantages:

Improved reliability since there is not any water running inside the transformer. In case of leak only dielectric fluid will be discharged. The separation of gas and water sides allows better optimizing of each side. Consequently the use of special alloy on the water side can be significantly reduced, e.g. by about 69%, because the water condenser is optimized for water.

Likewise the utilization of customary automotive type aluminium heat exchanger

reduces essentially the efforts for development and construction of specific heat exchangers to be used on the gas side inside the transformer.

Due to the fact that the design of the system is flexible the condenser can be positioned anywhere, as far as it is above the evaporator which position is needed for the gravity driven natural circulation of the intermediate fluid.

These features and further advantageous embodiments are contained in the claims and shall be illustrated by means of an example in the figure contained in a drawing attached to this specification.

The attached drawing shows in

Fig. 1 a schematic view in side elevation of an arrangement of a dry-type transformer according to the invention.

Fig. 1 shows a schematic view in side elevation of an arrangement of a transformer 10 according to the invention, where a dry-type transformer 12 is being arranged in a container 14.

The dry-type transformer 12 comprises three coils 16 which are encompassed by an upper yoke 18 and a lower yoke 20 whereat each coil 16 is attached to a core (being not visible in this drawing) which cores are joint with the yokes 18, 20 in order to close the magnetic circuit. Each coil consists of at least two windings which are encased in epoxy resin.

For cooling purposes of the dry-type transformer 14 it is circulated by cooling gas while being encapsulated in the container 14. Additionally this gas flow – shown by a dashed line with large arrows – is being supported by a fan 22 which blows the cooling gas from below against the dry-type transformer 12.

The fan 22 is arranged at a wall which separates the space wherein the dry-type transformer 12 is positioned from a compartment in which a so-called thermosiphon 24 is being located. This thermosiphon 24 has a vaporizer 26 and a condenser 28

which is positioned above the vaporizer 26 due to flow-physics and gravity. The connection between the vaporizer 26 and the condenser 28 is done on one side by a liquid downcomer 30 and on the other side by the vapor riser 33. Hence the thermosiphon 24 consists of the vaporizer 26, the condenser 28, the liquid downcomer 30, and the vapor riser 33 and forms a closed loop accordingly.

As can be seen from Fig. 1 cooling gas passes the coils 16 and receives the heat generated therein and flows to the upper region of the dry-type transformer 12 where the gas flux passes the vaporizer 26 which advantageously can be a customary automotive heat exchanger.

As for the gas it is all the same since the enclosure 14 is provided to be gas tight wherein the circulation of gas is supported by the fan 22 takes place. As for the water there is one circuit of flow, an open circuit which is not shown in detail but indicated by two pipe ends 36 and 38 respectively by arrows for outflow and inflow.

As for the circulation of the gas after leaving the dry-type transformer 12 enriched with heat the gas passes through the vaporizer 26 and transfers its affiliated heat to the vaporizer 26 respectively to the intermediate fluid flowing in the closed loop 32. After having passed the vaporizer 26 the intermediate fluid vaporised by the affiliated heat from the gas flows towards the condenser 28 through the vapor riser 33.

Subsequently it flows through the pipe 33 belonging to the closed loop 32 to the condenser 28 which actually is a heat exchanger, too. In the condenser 28 the vaporized intermediate fluid is condensed by dissipating its heat to the fluid of the open circle 34 which is usually water, e.g. tap water.

After condensation of the intermediate fluid it reaches the liquid downcomer 30 again and the cooling procedure restarts.

As a media for the intermediate fluid of the closed loop preferably Halocarbon compounds or the like are provided which change the physical condition due to thermal impact e.g. from liquid phase to gaseous phase and reverse.

List of references

- 10 transformer
- 12 dry-type transformer
- 14 Container, enclosure
- 16 coil
- 18 upper yoke
- 20 lower yoke
- 22 fan
- 24 thermo-siphon
- 26 vaporizer
- 28 condenser
- 30 liquid downcomer
- 32 closed loop
- 33 vapor riser
- 34 open circuit
- 36 outflow pipe
- 38 influx pipe