Study of Transformer Oil Purification

On-line Transformer Oil Dehydration With Auto Control

Under The Guidance of,
Prof. [Mrs. Neha Tiwari.]

Presented By, Ms. Asavari Khatri.
Ms. VaishnaviKadam.
Ms. Komal Kadu.

Abstract

Transformer is one of the main assets in the electrical power industry which needs to be maintained for guaranteed uninterrupted power transmission in order to get assured revenue benefits. Transformer's life mainly depends on the quality of its insulating oil i.e. transformer oil. Since transformer oil serves as a dielectric material and as an effective coolant in transformer, to perform these functions effectively the transformer oil must be purified regularly. In this paper, we will discuss about the contamination of transformer oil, why transformer oil needs to be purified and which equipment purifies the transformer oil.

Keywords — Contaminants, Insulating oil, Purification, Transformer.

I. INTRODUCTION

Transformer is a static (or stationary) piece of apparatus by means of which electric power in one circuit is transformed into electric power of the same frequency in another circuit. On-line drying unit was developed in India in the year 1992 by name Oil Conditioner. On-line drying system with the adsorbent that will continually remove the moisture from the oil as well as the insulating paper in a live on load transformer by continuous circulation of oil through the system. Moisture from the core, insulation paper, etc. absorbs more than 97% of water present in transformer, only 3% is left behind in oil. OLDS will adsorb moisture form oil and moisture from paper will travel to oil to maintain nature equilibrium. These in turn OLDS will remove moisture from the insulation paper during on-load condition and will help to extend the life of transformer.

II. TRANSFORMER OIL

Insulating oil in an electrical power transformer is commonly known as transformer oil. It is normally obtained by fractional distillation and subsequent treatment of crude petroleum. That is why this oil is also known as mineral insulating oil. Transformer oil is highly refined mineral oil that is stable at high temperatures and has excellent electrical insulating properties. Transformer oil serves mainly two purposes, one it is liquid insulation in electrical power transformer and the other is it dissipates heat of the transformer i.e. it acts as a coolant. In addition to these, this oil serves other two purposes, it helps to preserve the core and winding as these are fully immersed inside oil and another important purpose of this oil is, it prevents direct contact of atmospheric oxygen with cellulose made paper insulation of windings, which is susceptible to oxidation.

A. Electrical Parameters of Transformer Oil Break down voltage

Dry and clean oil exhibits an inherently high breakdown voltage. Free water and solid particles, the latter particularly in combination with high levels of dissolved water, tend to migrate to regions of high electric stress and reduce breakdown voltage dramatically. The measurement of breakdown voltage, therefore, serves primarily to indicate the presence of contaminants such as water or particles. A low value of breakdown voltage can indicate that one or more of these are present. However, a high breakdown voltage does not necessarily indicate the absence of all contaminants.

Oxidation Stability:

The ability of mineral electrical insulating oil to withstand oxidation under thermal stress and in presence of oxygen and a copper catalyst is called oxidation stability. It gives general information about the life expectancy of the oil under service conditions in electrical equipment. The property is defined as resistance to formation of acidic compounds, sludge and compounds, influencing the dielectric dissipation factor (DDF) under given conditions. For oils complying with IEC 60296 (19) these conditions are detailed in IEC 61125 method C (10) and the limits of acceptable performance in IEC 60296. The common and easy way to monitor the inhibitor consumption is to measure the inhibitor concentration according to IEC 60666 (9)

Dielectric Dissipation Factor:

Dielectric dissipation factor is also known as loss factor or tan delta of transformer oil. These parameters are very sensitive to the presence of soluble polar contaminants, ageing products or colloids in the oil. Changes in the levels of the contaminants can be monitored by measurement of these parameters even when contamination is so slight as to be near the limit of chemical detection. It is normally not necessary to conduct both tests on the same oil and generally DDF is found to be the more common test. Resistivity and DDF are temperature dependent and Figure 3 illustrates typical changes of resistivity with temperature for insulating oils that ar virtually free from solid contamination and water. Useful additional information can be obtained by measuring resistivity or DDF at both ambient temperature and a higher temperature such as 90°C.

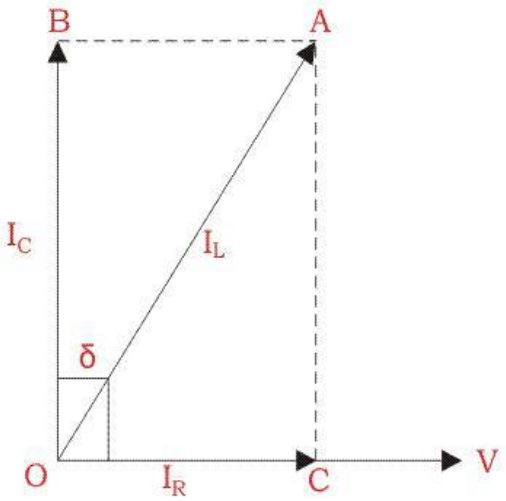

Fig 1: Loss Angle

But in reality no insulating materials are perfect dielectric in nature. Hence current through the insulator will lead the voltage with an angle little bit shorter than 90°. Tangent of the angle by which it is short of 90° is called dielectric dissipation factor or simply tan delta of transformer oil. More clearly, the leakage current through an insulation does have two components, one is capacitive or reactive and the other one is resistive or active. Again it is clear in Fig 1, the value of ′δ′ which is also known as loss angle, is smaller, means resistive component of the current I_R is smaller which indicates high resistive property of the insulating material. High resistive insulation is good insulator. Hence it is desirable to have loss angle as small as possible. So we should try to keep the value of tanδ as small as possible. High value of this tanδ is an indication of presence of contaminants in transformer oil. Hence there is a clear relationship between tanδ and resistivity of insulating oil. If resistivity of the insulating oil is decreased, the value of tan-delta increases and vice versa. So both resistivity test and tan delta test of transformer oil are not normally required for same piece of insulator or insulating oil. In one sentence it can be said that, tanδ is measure of imperfection of dielectric nature of insulation materials like oil.

III. CONTAMINANTS OF TRANSFORMER OIL

The power transformer insulation gets degraded under a combination of thermal, electrical, chemical, mechanical, environmental stresses, etc. during its operation. These stresses reduce the dielectric capability of a transformer and increase the probability of failure. Principal causes of oil contamination are electrical disturbance and thermal decomposition. Contaminants commonly found in transformer oil are moisture, sludge contents, dissolved gases and acids.

A. Moisture

Oil serves as a water-transferring medium within a transformer. In a transformer the total mass of water is distributed between the paper and the oil such that the bulk of water is in the paper. Small changes in temperature significantly modify the dissolved water content of the oil but only slightly modify the water content of the paper.

Thus, for the proper interpretation of moisture content the analytical results need to correct the water content of the oil at a given sampling temperature to the content at a defined temperature. For practical reasons, the defined temperature is set at 20oC, since below 20oC the rate of diffusion of water is too slow to achieve equilibrium in operational equipment

Moisture content in transformer oil is a life shortening parameter and has following effect on the insulation system:

1. It can weaken the breakdown capacity of the insulation system.
2. It promotes local heating
3. It reduces the overload capability of transformer in emergency conditions.

B. Acidity

The acidity of a used oil is due to the formation of acidic oxidation products. Acids and other oxidation products will, in conjunction with water and solid contaminants, affect the dielectric and other properties of the oil. Acids have an impact on the degradation of cellulosic materials and may also be responsible for the corrosion of metal parts in a transformer. The acidity of oil in a transformer should never be allowed to exceed 0.25mg KOH/g oil. This is

The rate of increase of acidity of oil in service is a good indicator of the ageing rate. The acidity level is used as a general guide for determining when the oil should be replaced or reclaimed.

C. Sludge Contents

Sediment is insoluble material present in the oil. Sediment– includes:

- Insoluble oxidation or degradation products of solid or liquid insulating materials;
- Solid products arising from the conditions of service of the equipment; carbon, metal, metallic oxides;
- Fibers, and other foreign matter, of diverse origins.

Sludge is a polymrised degradation product of solid and liquid insulating material. Sludge is soluble in oil up to a certain limit, depending on the oil solubility characteristics and temperature. At sludge levels above this, the sludge is precipitated, contributing an additional component to the sediment. The presence of sediment and/or sludge may change the electrical properties of the oil, and in addition, deposits may hinder heat-exchange, thus encouraging thermal degradation of the insulating materials. Sediment and sludge should be measured according to the method described in IEC 61125 method C without submitting the oil sample to the oxidation process, by filtration of the oil for sediment content and by adding n-hepatne and filtration of sludge.

D. Dissolved Gases

Gases produced due to oil decompositions are hydrogen (H2), methane (CH4), acetylene (C2H2), ethylene (C2H4) and ethane (C2H6). On the other hand paper decomposition produces carbon monoxide (CO) and carbon dioxide (CO2). The gases listed above are considered key gases and are generally considered combustible (note that CO2 is not a combustible gas). The total of all combustible gases may indicate the existence of any one or a combination of thermal & electrical.

At high temperature, sulphur compounds may decomposes on hot metal surfaces to produce metal sulphides that can affect the electrical properties of the oil and provide nuclei for discharge and gas inception if they become detachable and dispersed in the oil. After an event with such temperatures a corrosive sulphur test may be used to ensure freedom from corrosive attack under continued service. Considering all the adverse effects of the contaminants present in the transformer oil, it is cleared that transformer oil should be absolutely free from acids, sludge, dissolved gases and particularly from the moisture, to avoid catastrophic failure of transformer which leads to failure of power system network.

A good oil purification system is able to deliver filtered oil with parameters as per the standard specification. To purify the transformer oil, transformer oil filtration machine is used. The revival of the transformer oil by oil filtration machine to standard oil parameters is based on the quality of unprocessed oil and its initial process. In case the unprocessed oil does not match the standard oil parameters, then the effort of transformer oil filtration is all in vain. Alternate method of regeneration of transformer oil should be adopted in this case.

A. Transformer oil filtration machine

Transformer oil filtration machine consists of inlet pump, filters, heaters, ionic reaction column, degassing and dehydration chamber, discharge pump, vacuum pumps etc. Inlet pump pumps the contaminated oil from transformer to oil filtration machine. Heaters heats the oil up to 60 to 70 degree Celsius. Oil is heated to make the purification process faster. An ionic reaction column is provided to reduce the acidity in the oil. Filters are provided for the removal of suspended particles, sludge content in the oil. The degassing and dehydration chamber is provided for removal of dissolved gases and moisture from the oil. Vacuum pumps are provided for evacuation of degassing and dehydration chamber. After three to five passes in transformer oil filtration machine the contaminated transformer oil is purified.

IV. PURIFICATION OF TRANSFORMER OIL

The tests for in-service oil are divided into three groups as:

Group 1: minimum tests require to monitor the oil and to ensure that it is suitable for continued service.

Group 2: These are additional tests which may be used to obtain further specific information about the quality of the oil and may be used to assist in the evaluation of the oil for continued use

Group 3: These tests are used mainly to determine the suitability of the oil for the type of equipment in use and to ensure compliance with environmental and operational considerations.

Fig 2: Transformer Oil Before and After

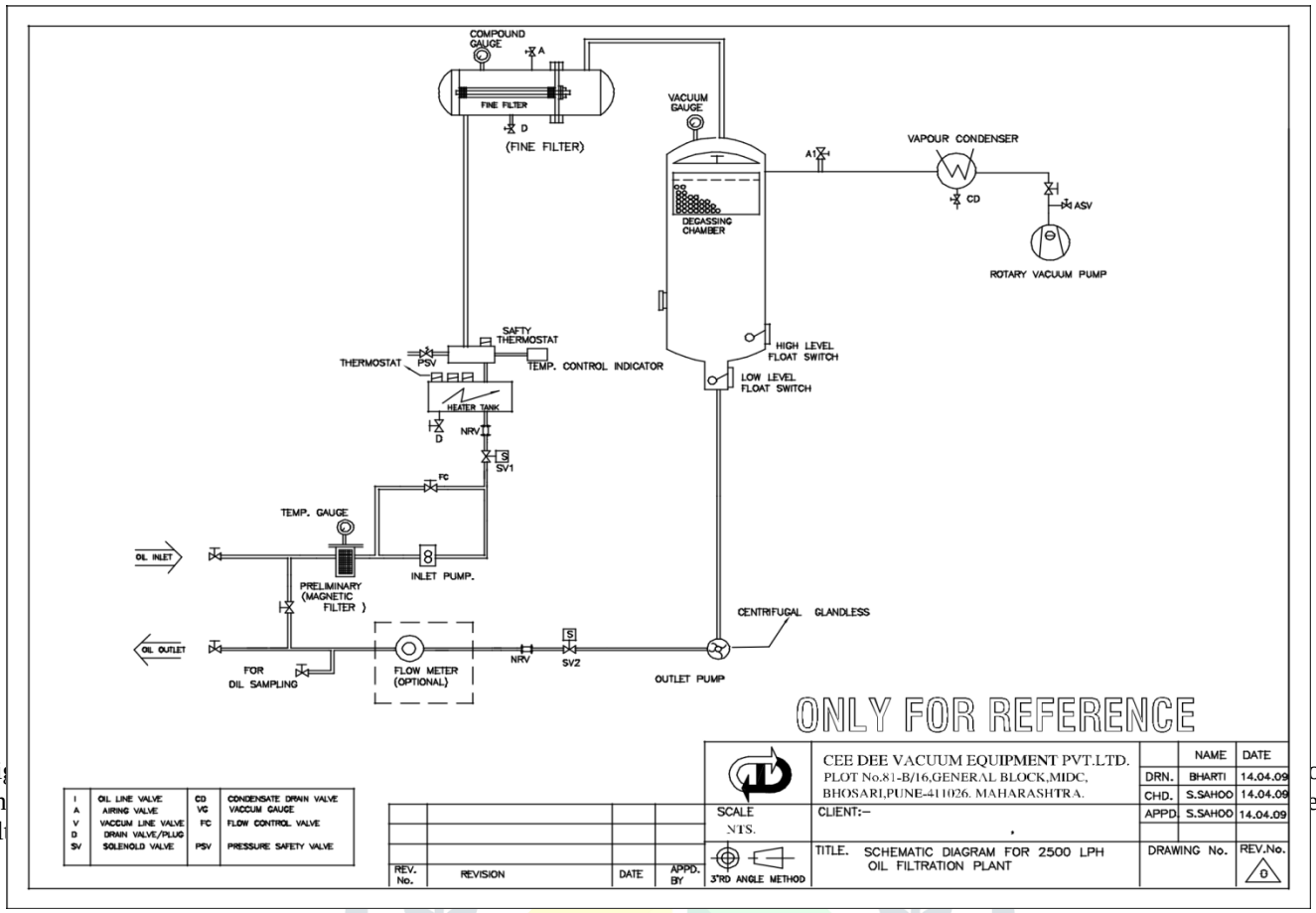

Fig oil is
un er oil
fil

V. CONCLUSIONS

In this paper, we have discussed about the transformer oil, the contaminant present in the transformer oil, why transformer oil needs to be purified and how transformer oil filtration machine purifies the transformer oil.

REFERENCES

[1] [1] IEEE : Kapila Bandara, Chandima Ekanayake, Tapan Kumar
[2] Saha,' Modelling the Dielectric Response Measurements of
[3] Transformer oil ',IEEE Transactions on Dielectrics and
[4] Electrical Insulation,Vol. 22, No. 2; April 2015
[5] [2] IEEE : A. Abu – Siada, S. Islam,' A New Approach to
[6] Identify Power Transformer Critically and Asset