Polarization Current Measurement of Power Transformer- a Simulation Study

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ABSTRACT: The Polarization and Depolarization Current (PDC) analysis is a non-destructive dielectric testing method for determining the conductivity and moisture content of insulation materials in a transformer. The predominant influence of oil conductivity on the initial amplitudes of polarization / depolarization currents can be used to estimate the oil conductivity of a transformer even without performing direct conductivity measurements on its oil sample. In the same way, an estimation of the conductivity of the pressboard can be obtained from the long term values of the polarization and depolarization currents. Moisture and ageing strongly influence the dielectric properties of oil-pressboard insulation system of power transformer.

Key words—Power transformer, polarization current, Simulink

I. INTRODUCTION

The Demand for reliable electricity supply has significantly increased during the last few decades. Therefore fault free operation of power system has become very important.However due to high cost of power system components, especially transformers, it is not economical to replace them in order to increase reliability, by considering their age. Moisture increases the risk of dielectric failures and has a double function: it accelerates ageing and also agegnerates it. Additional moisture can penetrate from theatmosphere into the tank. Independent of its origin moisture is absorbed into the oil-pressboard insulation system. Hence, measurement of moisture in different stages of transformers life becomes a challenge for transformers experts. A relatively large number of power transformers that are still working in fairly good condition although they have been used longer than their designed life. Therefore correct condition assessment of power transformer is needed beforehand. Any conclusion about replacement and refurbishment. Failures of power transformer mainly occur due to degradation of power transformer insulation, which mainly consist of oil and pressboard. Chemical and electrical measurements are used to monitor the condition of power transformer insulation. Among these, chemical analysis provides direct information on parameters, such as water content, degree of polymerization of paper, sludge content in oil and quantity of different gases dissolved in oil. However, most chemical analysis must be performed under laboratory conditions. On the other hand, electrical measurements are simpler and it is possible to perform them on site. Due to this simplicity, Electrical tests, such as insulation resistance (IR), Polarization index and loss factor (tan δ) provide very little information about the transformer insulation since they are limited to a single value measurement. To overcome this disadvantage, dielectric response measurements, namely return voltage measurements (RVM), polarization and depolarization current measurements (PDC) and frequency domain spectroscopy measurements (FDS), have been introduced for condition monitoring of transformer insulation, especially for the evaluation of water content in transformer pressboard. In the early stages, RVM was introduced because voltage measurements were simpler than measurements of low currents. The other two methods, requiring current measurements, were introduced recently due to improvements provided by the use of sophisticated electronic devices.

The focus of this paper is kept on PDC technique which is a non-destructive testing method for determining the conductivity and moisture content in the insulation materials like oil and pressboard separately. This paper describes the effect of moisture on a prototype model which is similar to that of power transformer insulation.

II. PDC MEASUREMENT

The principle of measurement of polarization and depolarization current is based on application of a dc voltage across a test object for a long time (e.g., 5000 sec). During this time, the current, arising from the activation of the polarization process with different time constants corresponding to different insulation materials and due to the conductivity of the object is measured. Then the voltage is removed and the object is short-circuited. The previously activated polarization process now gives rise to the discharging current in the opposite direction, where no contribution of the conductivity is present. The schematic diagram of the PDC measuring set-up is shown in Figure 4. Figure 5 shows the typical nature of these currents due to step charging.
Charging and discharging currents (i.e., polarization and depolarization currents) are influenced by the properties of the insulating materials as well as by the geometric structure of the insulating system.

### III. Simulink Model

The overall geometric capacitance of the system was 1.00 pF and the applied voltage was 500 V DC. The polarization and depolarization currents were measured for 5000 sec.

In this paper, the Insulation model using Simulink is proposed to study for the practical transformer insulation system. The specifications taken for the study are:

1. For Transformer oil:  
   - Resistance $R_0 = 1 \Omega$, and Capacitance $C_0 = 1 \text{pF}$
2. For Transformer Spacers:  
   - Resistances $R_s = 1 \Omega$, and Capacitances $C_s = 1 \text{nF}$
3. For Transformer Paper:  
   - Resistances $R_p = 1 \text{T} \Omega$, and Capacitance $C_p = 1 \text{pF}$
4. For Transformer Press Boards:  
   - Resistance $R_s = 1 \text{G} \Omega$, and Capacitance $C_s = 1 \text{nF}$
Fig. 3 Polarization and Depolarization Current Waveforms

Fig. 4 Insulation Model using Simulink
IV. SIMULATION RESULTS

1) The simulation results of polarization current obtained using Simulink Software is as follows in fig. 6(a),(b),(c) and (d).

Case1: Simulated Polarization Current Output when oil contains small amount moisture.

Fig. 5 Simulink Model of PDC Measuring Circuit
Case 2: Simulated Polarization Current Output when oil contains large moisture.

Case 3: Simulated Polarization Current Output when Press board contains large moisture.

Case 4: Simulated Polarization Current Output when paper insulation contains large moisture.
V. CONCLUSION

From the simulation results it is observed that the polarization current and depolarization method can be used to find the moisture content of insulation system of a power transformer. And from the above simulated results, it can be concluded that, is the transformer insulation is new then, the moisture content of the composite insulation system i.e., oil-paper (cellulose) is less. If the insulation is aged then, the moisture content is more and accordingly the conductivity of the oil is more and more polarization current value is obtained. Similarly, if the paper is aged, its moisture content is more and its, conductivity is more and therefore the polarization current and depolarization current values will be increasing.

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BIOGRAPHIES

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