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Depolarization Current Analysis for Power Transformers

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Abstract: *One non-invasive test which can be used to assess the condition of insulation in power transformers is depolarization current analysis. Phenomena of polarization within the insulation system may be revealed by the measurement of the residual current via the application and removal of a DC voltage. The study provides an insight into the moisture content of the cellulose and the Oil based materials, the aging effects and dielectric behavior. It offers a reliable and fast means of identifying wear out of the insulation materials without the dismemberment of the machineries. Another aid to standard testing is depolarization current analysis which enhances the condition-based maintenance schedules and increases service life, safety and dependability of power transformers.*

Keywords: *Transformer fault, depolarization current, dielectric response, fault diagnostics, and polarisation current*

I. Introduction

Power transformers play a critical role in electrical power systems and any system can only sustain its energy supply through the reliability of power transformers. The main component of the insulation system made of mineral oil and solid insulation material of cellulose basis to the efficiency and life of transformer. This insulation degrades with thermal, electrical and environmental loads over time, with the probabilities of failure escalating [1]. This necessitates accurate and non-contact measurement technique of diagnosing the condition of the insulation and effective planning on maintenance activities.

One way of measuring the dielectric behavior of transformer insulation today, which is sometimes called a depolarization current analysis or DCA, is an alternative to the oil test. It involves a measurement of current flowing following a direct current (DC) voltage having polarised the insulation of a transformer and following the cutting of a voltage source. The resultant depolarization current is an indicator of the ability of the insulation to store and discharge charge which is influenced by ageing, contamination and moisture content [3-5].

DCA, in addition to other time dependent methods of dielectric response, such as Polarisation and Depolarization Current (PDC) and Frequency Domain Spectroscopy (FDS), provides significant information about the long-term polarisation responses within the insulations system. DCA has been showing itself as the vital tool in evaluating the condition of transformers and managing their life-cycle by being able to detect the beginning of the deterioration of the model and moisture penetration.

II. Current Measures of Polarization and Depolarization

The insulation condition of high-voltage equipment such as power transformers is tested using time-domain dielectric response methods (including current measurements of polarisation and depolarization). Using these methods, a DC voltage across the insulating system is applied and then the current which appears as a result is measured with time. Polarisation The current is measured as the DC voltage is applied to indicate the amount of electric charge which accumulates with the insulation material. This current tends to decline with time due to the polarisation saturation that tends to take place [2].

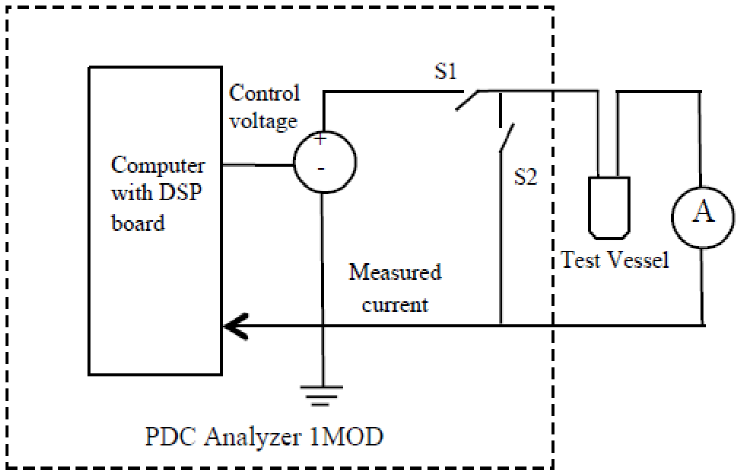

Fig 1: Experimental set-up for polarization and depolarization

Depolarization The current which flows as the stored charges are getting relaxed and regain the control is measured when voltage is removed. Dielectric properties of insulation are revealed by the parameters of this flow. Both the parameters are prone to contamination, ageing as well as moisture content in the insulation materials. These currents can serve as a convenient means of non-destructive transformer diagnostics and predictive maintenance scheduling since engineers can take them to conclude the presence of trapped charges, dielectric absorption and insulation deterioration.

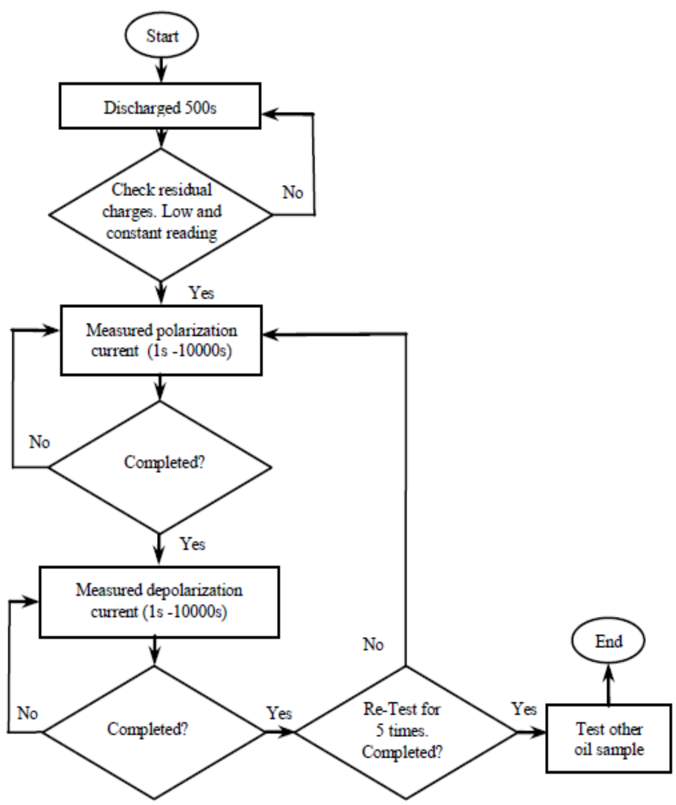

Fig 2: Experimental set-up flow chart

III. Results and Discussion

Depolarization Current Analysis (DCA) of old and new power transformers displayed significant deviation in current decay characteristics. Transformers with good condition showed a rapid decrease in depolarization current which implied minimal charge trapping and healthy insulating [2-5]. Older and moisturized polluted insulation on the other hand was more likely to deteriorate more slowly and ultimately possess higher residual current. This behavior is due to increased polarisation losses and moisture induced conductivity in cellulose insulation.

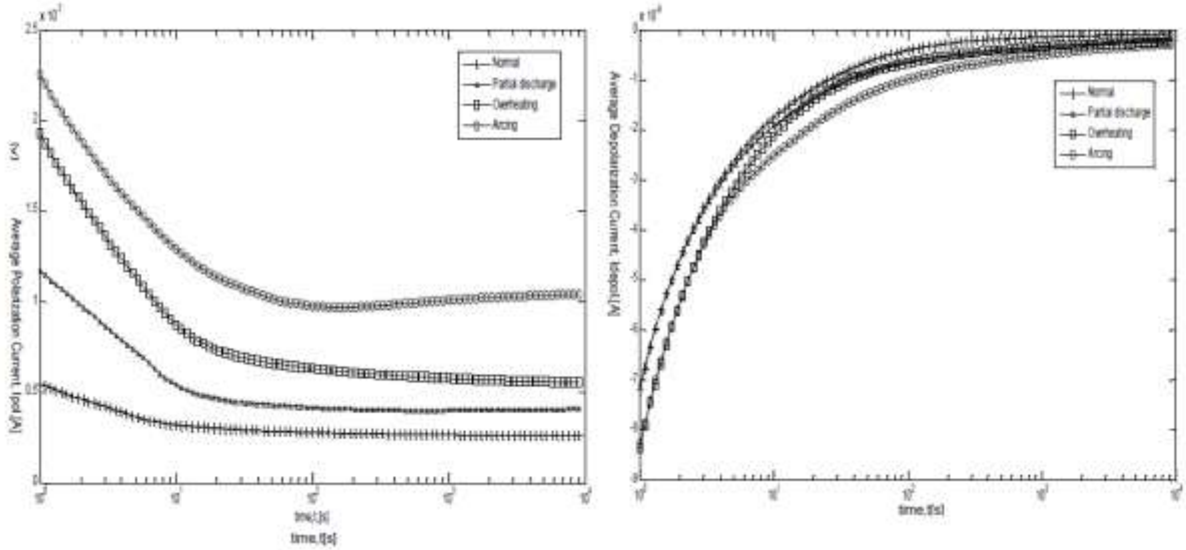

Fig 3: Polarization and Depolarization currents

The time constant and slope of the current decay curve have been analysed to get the moisture content and determine the degree of ageing. The accuracy of DCA was established by the high-level correlation in the results of the method with other diagnostic methods such as the insulation resistance test and frequency domain spectroscopy (FDS). Also, the relative simplicity of DCA and the relative test length compared with more traditional techniques of measuring dielectric response made DCA field-friendly. Altogether, the findings indicate DCA is an effective, non-destructive approach to locating insulation degradation that assists in predictive outlooks and enhancing the reliability of transformers.

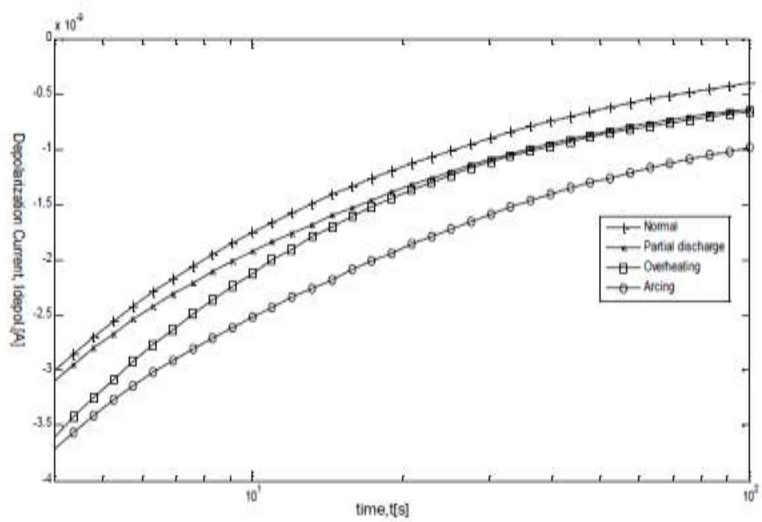

Fig 4: Oil samples for depolarization currents

IV. ANN for Power Transformers

Artificial neural networks, ANNs, are increasingly being used to analyze data on the depolarization current of power transformers in order to diagnose transformers. The ANN models can be trained on complex nonlinear relationships between the output markers e.g. moisture content, insulation ageing, and dielectric health with the changing values of input parameters e.g. the values of the depolarization current over time. Transformer analysis uses the data on the depolarization current that is initially pre-processed and normalized. Then the ANN is then trained using historical test data on known insulation settings. Having been trained, the model can then use the depolarization current profiles of new scripts to estimate the insulation characteristics.

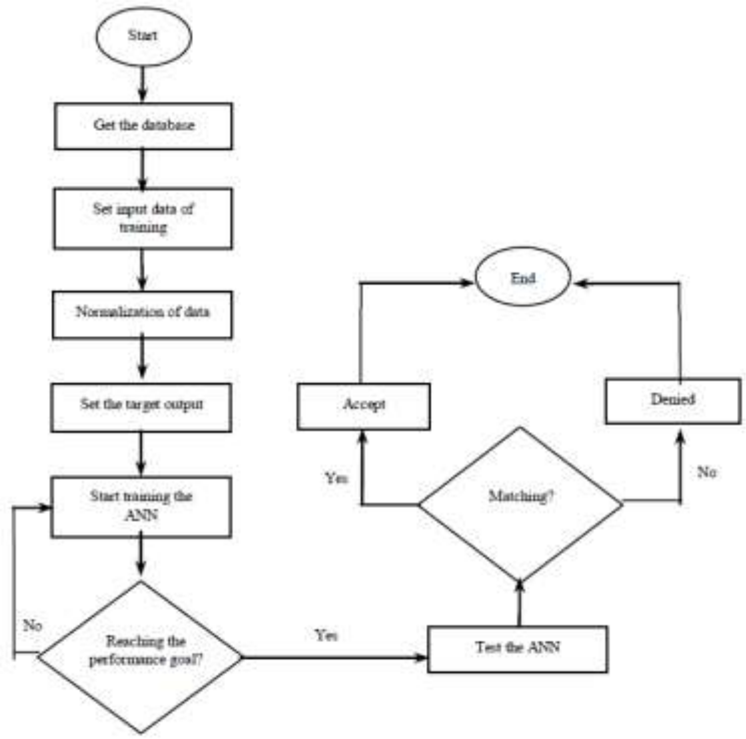

Fig 5: Training procedure based on ANN

The ANNs enhance the speed and accuracy at which the information is interpreted by eliminating the human curve-fitting thus reducing the interpretation time and also comparison with the reference databases. They also improve decisions relating to maintenance by providing real-time information regarding the health of the insulation. All in all, ANN and depolarization current analysis combination significantly enhances diagnostic power resulting in a much longer life of the transformer and enabling condition-based maintenance [1-3].

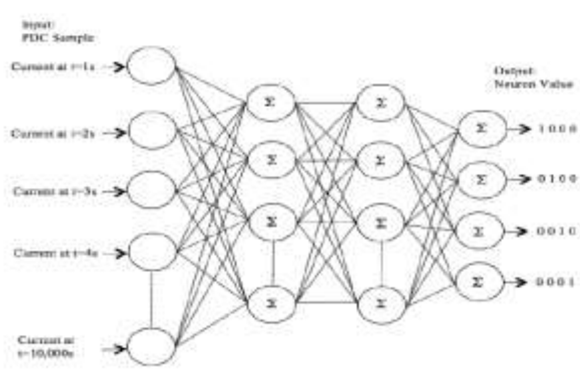

Fig 6: ANN schematic diagram

V. Conclusion

This paper discussed the increased application of PDC measurement in the characterization of different in-service failure scenarios of power transformers. Oil samples that had been taken out of the suitable units were analysed under normal conditions, and partial discharge, overheating and arcing conditions to check the presence of flammable fault gases. It was observed that, the first-time response of the two measured current is affected by fluctuations in the molecule related properties of the insulating oil substance caused by different fault conditions. Approach to sensitivity of Artificial Neural Network (ANN) indicates that depolarization current is more precise in the key of identifying and also classifying different transformer conditions in comparison to polarisation current.

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