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Low temperature and moisture effects on polarization and depolarization currents of oil-paper insulation

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ABSTRACT

In the last decades, dielectric testing techniques are being used and investigated as potential tools for condition assessment of oil-paper insulation. From fields and laboratory investigations these techniques were found to be highly operating conditions (moisture, ageing, temperature, etc.) dependant. Because field measurements (generally performed after de-energizing the transformer), last hours after de-energizing the transformer, the ambient temperature may affect the results. Especially in cold regions of the world, extreme care is required to interpret the results when performing tests at surrounding low temperatures. A better understanding and analysis of the dielectric test results are therefore only possible with a clear understanding of the physical behaviour of the insulation system in response to the ambient conditions. In the current research project, a series of experiments have been performed under controlled laboratory conditions with preset moisture content inside the insulation. This paper reports the effects of low temperature on the time domain dielectric response of oil impregnated paper insulation.

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1. Introduction

Power transformers are the single largest capital item in substations, comprising almost 60% of the total investment [1]. It is therefore crucial that they function properly for many years. This importance is raised due to the increasing demand of electric energy.

A large number of power transformers around the world are approaching the end of their design life. Replacing them with new ones – only because of their age – is clearly uneconomical, since some of these transformers are still in good condition and could be used for many more years. For these reasons, transformer life management gained the past decade an ever increasing interest, due to both economic and technical reasons.

Because the lifetime of a transformer is directly related to the quality of the insulation, condition monitoring of the insulation of transformers appeared to be an important issue. Indeed, condition monitoring can be utilized to attempt the prediction of the insulation condition and the remaining lifetime of a transformer. In this context, the adequacy of existing and the application of new diagnostic tools and monitoring techniques, have gained increasing importance.

Numbers of modern diagnostic techniques used to assess the insulation condition of transformers include, but are not limited to, dissolved gas analysis (DGA), degree of polymerization (DP) measurement, and high performance liquid chromatography (HPLC), the classical insulation resistance, power frequency dissipation factor, and polarization index measurements [2–9]. Over the last decades, increasing requirements for appropriate tools to diagnose power systems insulation non-destructively and reliably in the field drove the development of diagnostic tools based on changes of the dielectric properties of the insulation. Some of these modern diagnostic methods include the recovery voltage measurement (RVM), frequency domain spectroscopy (FDS) and polarization and depolarization current measurements (PDC) [2–9]. These studies have shown that dielectric response measurements could be used as an effective tool for insulation condition assessment.

Polarization and depolarization current (PDC) [3–9] measurement techniques provide indication of the general ageing status and moisture content of the oil-paper insulation of transformer. However, the results of these tests are severely influenced by several environmental factors, predominantly the temperature [3,4,9,10].

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