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التوثيق الالكتروني والميكروفيلم

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قسم

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تحفظ هذه الأقراص المدمجة بعيدا عن الغبار

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Transformer Insulation Deterioration as Influenced by Various Voltage Stresses and Effects of Using Nanofluids

A Thesis
Submitted in Partial Fulfillment for the Requirement of the Degree of **Doctor of Philosophy** in Electrical Engineering

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Dedication

To all who has been a great support for me,

I dedicate this work

Statement

This thesis is submitted to Ain Shams University in partial fulfillment of the requirements for the award of Doctor of Philosophy degree in Electrical Engineering.

The author declares that no part of the work included in this thesis has been submitted to any other university / scientific entity for the award of any Degree or Diploma.

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Abstract

With the tendency of the power system to increase the generating capacities and transmission voltage levels to meet the rapidly growing worldwide energy demands, associated problems with additional stresses on conventional insulation systems of high voltage equipment such as power transformer insulations have become an expected concern. Additional stresses will affect the lifetime of transformer insulations. Consequently, there is a critical need to develop new reliable transformer insulation materials to meet these worldwide challenges and resist the faster the deterioration effect.

As nanotechnology moves forward, nanofluids represent very promising fluids for applications as transformer insulating liquids, from the viewpoint of their excellent dielectric and thermal properties. Where there are many research papers stated that nanofluids provide better heat transfer and dielectric properties than those of base liquids. Nevertheless, it is still a significant step to move these fluids from the lab domain to high voltage power transformers. This step still requires more comprehensive studies of dielectric performance of nanofluids.

In this thesis, the dielectric performance of the transformer mineral oil (MO) based on these nanofluids developed using conductive Zinc Oxide (ZnO), semi-conductive Titanium Dioxide (TiO2) and Insulating Silicon Oxide (SiO2) nanoparticles have been researched. Nanofluids (NFs) were prepared with various concentrations ranging from 0.01 to 0.1 wt. %. The experiments have been designed and performed on prepared samples for study of: AC breakdown voltage, relative permittivity, DC conductivity, lightning impulse breakdown voltage, acceleration voltage and breakdown time. Studies on the analysis of the dissolved gas in the presence of nanoparticles under impulse faults have also been put forward. The experimental results demonstrated improvement of the AC breakdown strength with ~30 % enhancement for ZnO concentration of 0.06 wt. %, ~22 % for TiO2 concentration of 0.1 wt. % and~15% for SiO2 at relatively low concentration of 0.01 wt. %. Positive effects on relative permittivity and the opposite ones on DC conductivity have been obtained for

tested nanofluids. For positive impulse voltage, the breakdown voltage of ZnO nanofluid achieved ~9% enhancement under quasi-uniform field and ~32% under non-uniform field. For negative impulse voltage, ZnO nanofluid achieved slight worsening of breakdown voltage by ~9%. Potential mechanisms behind nanoparticle influence on the dielectric properties of nanofluid have been discussed and analyzed by using thermally stimulated current technique.

Moreover, the deterioration behavior of nanofluid in combination with cellulose insulation has been investigated and compared with that of mineral oil-cellulose system. Accelerated thermal aging experiments of cellulosic insulations impregnated in nanofluid and mineral oil were conducted under laboratory conditions at 120ºC for aging period up to 20 days. Different aging properties such as tensile strength, breakdown voltage, and dielectric dissipation factor of impregnated paper/pressboards were monitored and analyzed throughout the aging period. In addition, properties of oils related deterioration rate such as breakdown voltage, acidity value, interfacial tension, viscosity and color are thoroughly investigated in this research work to assess the degree of deterioration of both nanofluid and mineral oil. It is found that paper/pressboards aged in nanofluid possessed higher mechanical and dielectric properties than those in mineral oil. Regarding aged oils, nanofluid exhibited higher values of aging indicators such as interfacial tension, acidity and viscosity than mineral oil. The breakdown voltage of nanofluid was superior to that of mineral oil in the initial aging period, thereafter, showed a lesser reduction tendency with increasing age.

Keywords: Power transformer, Mineral oil, Nanofluid, lightning impulse voltage, Aging.

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