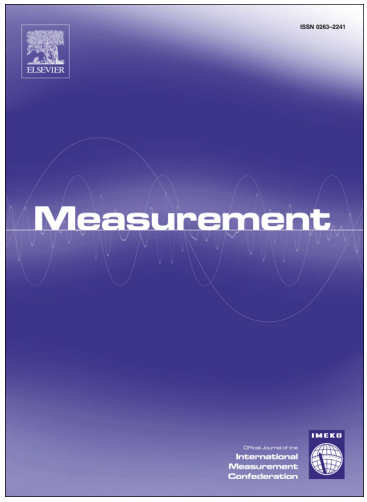

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U. Mohan Rao, Raj Kumar Jarial

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Measurement of Transformer Solid Insulation Degradation Using Dilatometry and X-ray Diffraction Analysis

[1]*U. Mohan Rao and* [2]*Raj Kumar Jarial*

[1]*Research Laboratory, Electrical & Electronics Engineering Dept., LIET, A.P. - 535005, India*

[2]*High Voltage Laboratory, National Institute of Technology Hamirpur, H.P.-177005, India*

Email: mohan13.nith@gmail.com

Abstract

Physical degradation assessment of solid insulation in transformers is a challenge to the condition monitoring engineers. Solid insulation degradation in transformer is accessed indirectly by characterizing insulation oil. The present article describes application of dilatometry and X-ray diffraction (XRD) analysis as direct methods to characterize the degradation of transformer solid insulation. Experimental aging on oil/paper insulation has been simulated in laboratory conditions at elevated temperatures. Thermal expansion and shrinkage behavior of cellulose pressboards aged in mineral oil, synthetic ester, and mixed oil have been reported using dilatometry analysis. Measurement of change in cellulose crystal size and relative crystallinity of cellulose kraft papers have been reported using XRD analysis. The detailed procedure and interpretation of the dilatometry and diffractograph signatures for accessing the degradation of solid insulation are explicitly discussed. It is inferred that, dilatometry and XRD analysis provide a direct physical degradation assessment of transformer solid insulation.

Key words: Dilatometery; Oil; Solid insulation; XRD analysis.

1. Introduction

Cellulose insulation is one of the most important insulating materials for oil-filled transformers. Cellulose insulants are composition of cellulose fibres and lignins (used to harden the insulant). For a transformer insulation system, pressboards and kraft papers are impregnated by insulating oil to increase their dielectric strength and reduce dielectric losses. Thus, an impregnated insulant is a composite dielectric medium (oil-paper or oil-pressboard), whose aging behavior is highly interrelated. Degradation of oil in transformer initiates premature aging of solid insulation and vise-versa.

In oil-filled transformers, impregnated solid insulation will be subjected to variable thermal excursions,