Modelling PD in Cavities and PD-based Degradation Mechanisms

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Micro cavities are considered to be unavoidable during manufacturing processes of polymeric insulation materials. Partial discharge initiated by micro cavities can induce various levels of damage and degradation, sometimes leading to global breakdown. Thus, developing an understanding of PD activities in such cavities and damage caused is essential. This project commenced in May 2012 and contains experimental validation and development of simulation models. The focus is on PD activities in micro cavities, damage and degradation resulted, and final breakdown mechanisms. Experimental work aims to observe degradation process by stressing five identical samples simultaneously until one fails, so that the different levels of degradation of the other samples that have yet to suffer catastrophic breakdown can be studied. Different insulation materials will be involved, such as epoxy resin, LDPE, and XLPE. Moreover, three types of methods are used to create cavities inside the samples, including the traditional sandwich structure, syringe injection, and use of a foaming agent.

Predicted experimental results are the initiation and growth conditions of degradation and final breakdown mechanisms. Among all mechanisms, thermal ageing and breakdown, pitting, and treeing are the major interests of this work. The experimental results will be simulated, based on some existing models and theories, the major ones are Niemeyer's PD model, and its Matlab version by Illias that uses COMSOL for field simulation [1]; Sanche's hot electron theory [2], and its Matlab version by Testa to analyse energy and speed spectrums of PD avalanches and the resultant damage caused [3]. Please note that throughout the experiments, PD data will be recorded to study possible relationships between PD pattern and degradation status, as well as to prove that the experimental method is valid against multiple sample data superposition and interaction. A typical superposition of five samples as below:

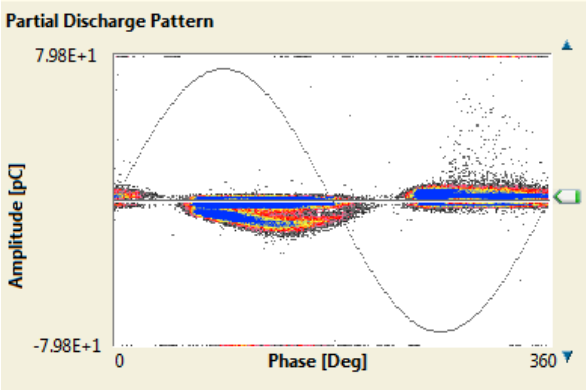

Figure 1. PD pattern superposition of five identical samples

To conclude, this project aims to provide more complete knowledge for PD and related degradation process, by distinguishing the major damage type, identifying the conditions for it to initiate and grow in different insulating materials, and providing simulation models as a conclusion of experimental results and theories.

[1] H Illias, G Chen and P L Lewin, "Comparison of Partial Discharge Measurement and Simulation Results for Spherical Cavities within Solid Dielectric Materials as a Function of Frequency using Finite Element Analysis Method", *Proc. Electrical Insulation (ISEI) Conference*, pp. 1-5, June 2010

[2] L Sanche, "Nanoscopic Aspects of Electronic Aging in Dielectrics", *IEEE Transactions on Dielectrics and Electrical Insulation*, Vol. 4, Issue 5, pp. 507-543, Oct 1997

[3] G C Montanari, A Cavallini, L Testa, S Serra and L A Dissado, "Model of Ageing Inception and Growth from Microvoids in Polyethylene-based Materials under AC Voltage", *Proc. Electrical Insulation and Dielectric Phenomena CEIDP Conference*, pp. 29-32, Oct 2008