Mathematical Modelling on Bridge Formation in Contaminated Transformer Oil

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Oil is an essential insulating and cooling medium used in a vast range of high voltage equipment from cables to transformers and switchgears. Analysis on power transformer failures has revealed that insulation/oil contamination is a major factor, accounting for nearly 30% of the total failures. As a result there is a great deal of research interest in understanding the composition, insulating performance, ageing processes and breakdown mechanisms in such oils. In the present project we are focussing on the effect of particle contamination of transformer oil on electrical performance of the power transformer using mathematical modelling.

The model is based on the current knowledge of dielectrophoresis (DEP) whereby a neutral body placed in an electric field becomes polarized and is equivalent to an electric dipole with an excess of positive charge on one end and negative charge on the other. The forces acting on the two ends do not balance in non-uniform electric field region and the particle moves. This phenomenon was first described by Pohl [1].

Our initial model is based on fibrous particles using equation derived by Lipowicz et al [2]. On comparison with the experimental data, the model is a successful means of predicting bridge formation rate. The electric current does not match with that observed in the experiment as the contamination level used in experiment is by weight rather than volume as for simulation. Furthermore, the simulation model is based on several assumptions of unknown variables in our initial attempt. Nevertheless, the rate of change in terms of current increase is similar to the experiment. Continual improvements to the model will allow us to make more accurate predictions regarding the current.

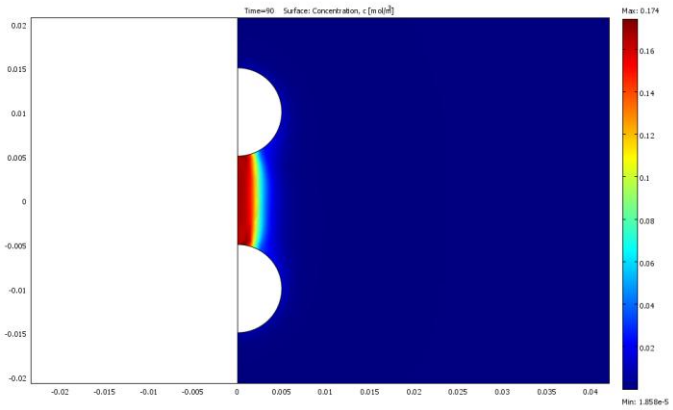

Figure 1: COMSOL Image showing pressboard fibre concentration of bridge formation in transformer oil after 90s at 15kV. Contamination level is 0.0003% by volume.

[1] Phol, H.A., "The motion and precipitation of suspensoids in divergent electric fields", *Journal of Applied Physics*, 1951. **22**(7): p. 869-871.

[2] Lipowicz, P.J. and H.C. Yeh, "Fiber Dielectrophoresis", *Aerosol Science and Technology*, 1989. **11**(3): p. 206-212.