



**INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS**

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SHORT ABSTRACT

This thesis presents a high frequency signal based condition assessment technique that can detect and estimate the moisture content (MC) and total acid number (TAN) in insulating oil samples. It addresses the applicability of the developed technique to alternate insulating oils such as nanofluids (NFs), ester oil (EO), and blended oils (BO). A non-intrusive and non-destructive technique (NINDT) which uses an S-band horn antenna to radiate the signals onto the oil samples for detecting and estimating the MC and TAN in mineral oil (MO) is developed. The reflected signal from the samples is analyzed to study the resonant frequency corresponding to MC and TAN. Electromagnetic interference on the measurements is avoided by placing the test setup in an anechoic chamber. Undesired reflections from the oil-test vessel boundaries are avoided by making the test cell with a material having impedance and relative permittivity close to that of the oil. The technique is applied to various laboratory-aged samples and linear prediction graphs are deduced from the obtained reflection coefficient. These linear prediction graphs are used to predict the MC and TAN in service-aged MO samples to evaluate the effectiveness of the developed technique. The alternative insulation such as EO, BO, and NFs are studied extensively to support the fact that the proposed technique is being used on validated insulation rather than arbitrarily selected samples. MO and a commercial EO (FR3) are mixed in various ratios to prepare BOs. The electrical and physiochemical properties such as MC, AC breakdown voltage, dissipation factor, relative permittivity, specific resistance, flash points, interfacial tension and density of the BOs are studied. The long term performance of the BOs is also studied by oxidative aging them according to ASTM D1934.

The partial discharge in the fresh and aged oils is studied according to the IEC 60270 standard and the inception, extinction voltages, phase resolved partial discharge patterns are presented. Further, the fresh and oxidative aged MO, EO, and BOs are subjected to multiple electrical sparks and the gases produced are noted. The classical ratio methods such as Rogers, IEC, and Dornenburg ratios are used to predict the type and intensity of fault in the BOs from the collected data. Further, the prediction of the type and intensity of fault is attempted by using graphical methods such as Duval's triangles and pentagons. The total dissolved combustible gases produced in the oils are also presented. Further, solid insulation is aged in the EO to study the gelling phenomenon and the surface profile of the insulation. Although extensive literature is available on the physiochemical and electrical properties of NFs, their magnetic behavior is unclear. Therefore, the magnetic response of the NPs, base oils, and NFs to the quasi-static and dynamic magnetic fields is studied at room temperature conditions and various magnetic parameters of the NPs and NFs are extracted. After the extensive investigation and substantiation of the insulation, the NINDT and the linear graphs are investigated for their applicability to detect and estimate the MC and TAN in the NFs and BOs. The percentage error between the predicted and actual value is reported and the applicability of the NINDT for the BOs and NFs is commented upon.