

Abstract - Analysis of OIP bushing ageing using FDS method and results of oil tests

The ageing of the OIP bushings population, which most power transformers with a voltage of 220kV and higher are equipped with, and an increase in their failure frequency in recent years led to an interest in improving defect detection at an early stage of development. It became an impulse to start research on a new way of using proven methods of paper-oil insulation systems diagnostics, taking into account the specifics of bushings design. In particular, it concerns the frequency domain spectroscopy (FDS), used until now mainly to assess moisture level in a bushing and to connect it with the analysis of oil tests results.

In order to investigate a possibility of evaluating the condition and ageing of an insulation system and detecting short circuits between conductive foils in the bushing capacitor core by the FDS method and oil tests, the author has designed and made his own model of the OIP bushing and studied the impact of ageing and defect development within the bushing on the obtained results.

The influence of the dielectric layer resistance on the frequency characteristics of capacitance and dissipation factor $\text{tg}\delta$ was checked by simulating resistance change in the calculation model (procedure in Matlab) and in the physical model of a bushing. On the basis of calculations and measurements, it has been demonstrated that the FDS method enables an early detection of paper layer degradation, resulting in a decrease in its resistance. Based on the shift of $\text{tg}\delta$ characteristics obtained at different temperatures, the activation energy was calculated.

Furthermore, the influence of the axial temperature distribution in a bushing on the characteristics of $\text{tg}\delta(f)$ was experimentally tested (using the model of the OIP bushing), and a method of determining the substitute temperature was discussed. What was also analysed was the possibility of indirect determination of moisture in a bushing on the basis of water content in the oil measurements using the Karl Fischer method and its correlation with the results obtained by FDS. The values of gas concentrations in oils sampled from the bushings were approximated with Weibull distribution, and, based on this distribution, the limit values for the individual gas components were calculated and compared with the values given by the bushing manufacturers' standards and recommendations.

Finally, cases of real bushings were presented; ones whose damages were detected by means of the combined study of the FDS and DGA results and also determined their character.