The assessment of oil impregnated paper condition by electrical conductivity and permittivity

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The assessment of conditions and life time reserves of power transformers is generally done based on the analysis of characteristics of main components of insulation systems, namely oil and paper [1].

This paper shows the results of a study concerning thermal ageing of some pressboard samples 0.5 mm thick impregnated with NYNAS transformer oil subjected to accelerated thermal stresses at the temperature $T_s$ which takes values between 115 and 155 °C for time intervals $\tau$ which also takes values between 0 and 800 h. For certain values of $\tau$, the real parts ($\varepsilon_r'$ and $\sigma_r'$) and the imaginary parts ($\varepsilon_r''$ and $\sigma_r''$) of complex conductivity and relative permittivity, and the loss factor $tg\delta$ were measured (using a NOVOCONTROL dielectric spectrometer) for different values of measurement temperature $T_m$ ($T_m = 30...90$ °C) and frequency $f$ ($f = 10^3...10^7$ Hz). Variation curves of these quantities depending on ageing time $\tau$ were drawn (fig. 1 and 2).

By analyzing the results, it can be seen that, the increase of temperature and ageing time determines the increases of the $\varepsilon_r'$ and $\sigma_r'$ quantities [2] and these increases are more important in the case of low electric field frequencies. On the other hand, considering certain boundary values of $\varepsilon_r'$, $\varepsilon_r''$, $\sigma_r'$ and $\sigma_r''$ and $tg\delta$ quantities the life time of the pressboard can be obtained through the ageing curves. Using these results and carrying out tests on samples taken from transformers in service, their life time reserves can be estimated.

Figure 1 Variation of the real part of relative permittivity $\varepsilon_r'$ with frequency $f$ and temperature $T_m$ for oil impregnated paper ($T_s = 155$ °C, $\tau = 750$ h):
1 – $T_m = 30$ °C, 2 – $T_m = 50$ °C, 3 – $T_m = 90$ °C

Figure 2 Variation with ageing time $\tau$ for oil impregnated paper: 1 - the real part of relative permittivity, 2 - the real part of electrical conductivity ($T = 155$ °C, $f = 1$ mHz).

References