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The effect of thermal aging process on dielectric response of bushings with RBP and RIP insulation

***Abstract**. The article presents the impact of the thermal aging on frequency characteristics of the dissipation factor and the capacity (FDS) and voltage-time characteristics of the charging current SVM in the transformer bushings RBP insulation. The tests were conducted in operating conditions taking into account temperature distribution inside the insulation for the most unfavorable working conditions. The analysis of the characteristics FDS and SVM has shown that the correlation between the time of the aging and the dielectric response in the LF range and the absorption coefficient Ka exists.*

Keywords: diagnostic, relaxation, FDS, SVM

Introduction

Bushings are the extremely important elements of the transformers since they enable the introduction of the high-voltage circuits outside the transformer tanks. The operating experiments demonstrate that they are characterized by high failure rate resulted mainly from accumulation of thermos-mechanical and electrical exposures. The statistics indicate that in the case of the transformers produced after 1980 the windings are the main cause of the failure, however, 18% of the catastrophic failures were caused by the damage of the bushings [1,2]. The high share of the bushings in the unexpected catastrophic failures, according to the authors, indicates the imperfection of the currently applied operating tests which, first and foremost, are based on the measurement of the dissipation factor tanδ and the capacity at the frequency 50 Hz. The small effectiveness of the test results from the small sensitivity of $\tan\delta_{50Hz}$ to structural changes in the insulation with the use of the following methods: FDS - Frequency Domain Spectroscopy and SVM - Step Voltage Measurement.

Design of the measuring stands

The research has been conducted with two transformer bushings Micafil CTKF 145 kV and Haefely CRPT 52kV. In order to present their functioning in the operating conditions, the inner parts of the current path of the bushings were filled in with the transformer oil and the regulated source of the heat was placed, it allowed to create the temperature up to 130^0C. The measuring stands are presented in the figure 1. The thermal aging for the temperature of the current core T=110^0C lasted 720 hours.

Experimental results

The exemplary results of the measurements of the bushing CTKF with FDS method were presented in the figure 2. On the basis of the received characteristics it is concluded that the time of the thermal aging has the significant impact on the values of the dissipation factor tanδ especially in the low frequency range. Such relationships were not observed in the high frequency range, including f= 50hz. The analysis of the FDS characteristics also revealed that in the initial period of operation of the elevated temperature the decrease in tanδ value in the LF range occurred, what probably results from physico-chemical relaxation of the composite structure used in the construction of the insulation including possible curing processes.

Fig.1. The research stand of the bushing CRTP (a) and the bushing CTFK (b).

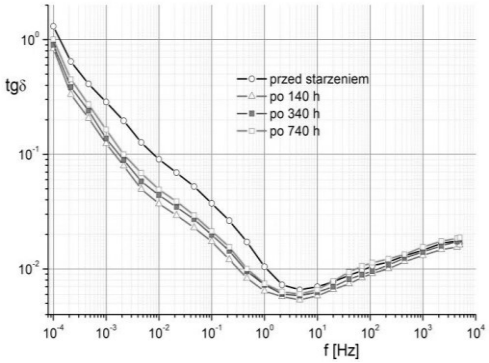

Fig.2. FDS characteristics of the CTKF 145 kV bushing after 10 years of operating and after additional thermal aging.

The relaxation effect with the time constant of 10 seconds was also observed. It is the typical effect of the presence of the spatial charge of RBP insulation which is connected with the morphology of the composite.

In the following aging cycles the initial phase of the development of the aging process was observed. It manifested itself with the increase in the electrical conductivity of the composite and slight shortening of the relaxation time constant in the LF range.

The analysis of the time dependencies of the charging currents (SVM measurements) indicated that there is the dependence between so called absorption coefficient Ka and the development of the aging processes.

Conclusion

The tests have shown that there is the dependence between the changes of the dissipation factor tanδ values in the low frequency and morphological changes of the composite used in the construction of the bushing with RBP insulation. Such correlations were not observed in the high frequency range including f=50 Hz.

As a result, the analysis of the dielectric response in the LF range may be used to assess the development of the aging process. However, in order to develop descriptors of the assessment of the insulation condition, it is necessary to conduct further tests. Similar conclusions may be presented after the analysis of the SVM measurements.

References

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