AC CONDUCTIVITY IN THE COMPOSITE ELECTRICAL PRESSBOARD - SYNTHETIC ESTER MIDEL 7131 - WATER NANOPARTICLES

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Abstract - This paper presents the results of the AC conductivity of electrical pressboard production company Weidman with a water content of 6% by weight, impregnated with MIDEL 7131 synthetic ester. Dependencies on frequency and temperature for AC conductivity were determined. The Arrhenius plots were developed for the whole range of measurement frequencies.

Keywords - Electrical Pressboard, ester MIDEL 7131, AC conductivity.

I. INTRODUCTION

Synthetic esters for almost 40 years have been successfully used as an alternative to mineral oil and their popularity continues to grow. In the past 10 years, the use of synthetic esters in the dielectrics has been revived due to their environmental impact.
Synthetic esters are mainly used in distribution transformers and in transformers where fire safety and environmental protection are very important. Esters are 100% biodegradable compared to mineral oil whose biodegradability is only about 10% [1]. They are increasingly used in transformers exposed to hard working conditions, such as traction, wind farms, on the coasts and underground [2].

During the many years work of transformers in cellulose, the moisture content from the initial approx. 0.8% wt. (after transformer production) to about 6% wt. at the end of its exploitation after about 50 years.The quality of paper-oil insulation is largely determined by the content of water in cellulose. It should be noted that most of the water in the power transformer is located in the solids elements of its insulation and that the concentration of water in the transformer oil is about 1000 times smaller than in the cellulose [3].For diagnostics of the insulation state of power transformers are most often used non-destructive measurements of electrical properties of insulation.In our previous work, measurements of the basic electrical properties of moist cellulose impregnated with insulating oil were performed on the direct current (conductivity) [4] and on the alternating current (conductivity, dielectric permeability, tangent of the loss angle) [5, 6, 7]. Based on a detailed analysis of the dependence of DC conductivity and moisture content [8], it was found that water in cellulose impregnated with insulation oil is in the form of nanoparticles, each containing an average of about 220 molecules of water. This means that the oil-paper insulation should be treated as composite, cellulose – oil – water nanoparticle.

The aim of this work was to examine the AC conductivity the electrical pressboard impregnated with synthetic ester MIDEL 7131 about different moisture content level.
We came out of the premise that the synthetic ester MIDEL 7131, used as a alternative for mineral oil, has physico-chemical properties similar, and in some cases even better than mineral oil. Therefore it was hypothesized that the electrical properties of the electrical pressboard impregnated with syntetic ester MIDEL 7131 with moister content, they may were similar and possibly even more advantageous from the point of view of isolation of transformers than those for pressboard impregnated of mineral oil.

II. DETAILS EXPERIMENTAL

In the study, used one of the world's leading manufacturers, Weidman, with a thickness of 1 mm. The procedure of preparation of pressboard samples impregnated about setpoint moisture content was presented in [9].After preparation, the sample was placed in an hermetic container containing synthetic ester MIDEL 7131 for the purpose of impregnating the pressboard.
In order to perform studying, the sample was placed in a measuring capacitor which was in the thermostat with a keeping the temperature tolerance of ± 0.01 °C.Measurements were made at temperatures from -20 °C to 80 °C. In the study used the Dirana's FDS meter (Frequency Domain Spectroscopy) production company Omikron[10] was used as a standard for power transformer diagnostics.The Diran meter performs basic measurements for AC insulation properties (capacitance, loss tangent) in the frequency range of 10^{-4} Hz to $5*10^{3}$ Hz.

III. RESULTS AND DISCUSSION

Figure 1 shows as an example the frequency dependence of conductivity for pressboard with a moisture content of 6% wt. impregnated with ester

MIDEL 7131 for selected measurement temperatures: -20 °C, 10 °C and 50 °C.As shown in Figure 1, especially for higher measuring temperatures, in the low frequency area, the conductivity value is practically does not depend of the frequency. Only at higher frequencies is the increase observed. The transition from steady values to segment of growth moves to higher frequencies area with increasing temperatures. This is compatible with the a model of hopping conductivity on the direct and alternating current, developed in work [11]. Based on the waveforms shown in Figure 1, Arrhenius plots performed (Figure 2) were used to describe the temperature dependence of the conductivity.

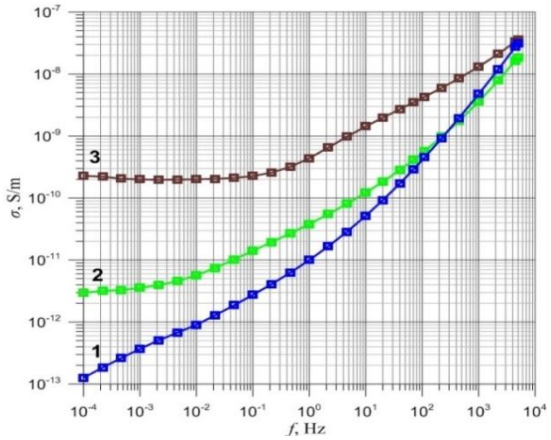


Fig.1. Frequency dependences on conductivity for the pressboard containing a water nanoparticles about content of 6% by weight impregnated with synthetic ester for measuring temperature: -20 °C – *1*; 10 °C – *2*; 50 °C – *3*

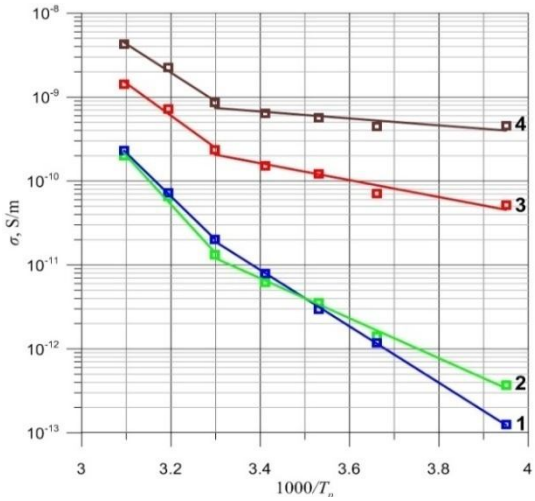


Fig.2. The Arrhenius plots for the pressboard containing a water nanoparticles about content of 6% by weight impregnated with synthetic ester, frequency: 1 – 10^{-4} Hz; 2 – 10^{-3} Hz;3 – 10 Hz; 4 – 100 Hz

As you can see in Figure 2, the Arrhenius plots for the full frequency range can be presented as two straight lines. The first one concerns low temperature areas from -20 °C to +30 °C. This area is characterized by a smaller slope. In the second area, from 30 °C to 50 °C, the slope is much higher. This means that the material is characterized by the occurrence of two activation energy of the conductivity. This may mean that the water nanoparticles in the pressboard they have different properties. For example, part of them may be are located in the environment cellulose material, while the second part - in the environment the MIDEL 7131 ester.

CONCLUSIONS

In this paper presented results of AC electrical parameters cellulose in the form of electrical pressboard manufactured by Weidman, with a water nanoparticles about content 6% wt. impregnated with synthetic ester MIDEL 7131.The studying were performed with Omikron'sDiran meter in the frequency range of 10^{-4} Hz to 5000Hz and temperatures from -20 °C to 80 °C. Frequency and temperature dependencies of AC conductivity were determined. Based on them, Arrhenius plots have been developed for the full range of measurement frequencies. It was found that Arrhenius plots show that changes in AC conductivity can be described by two activation energies.This may mean, in our view, that these differences are due to changes the environment occurring water nanoparticles in pressboard. Part of them may be are located in the environment cellulose material, while the second part - in the environment the MIDEL 7131 ester.

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