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Influence of the Oxygen Aging on Dielectric Characteristics of Oils on the Vegetable Basis

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Abstract: Now as the isolating environment, an alternative to a mineral oil, oils on a vegetable basis are considered. Quality of the electroisolating environment is defined by its dielectric indicators, the most important of which are the inductivity, dielectric loss, specific volume resistance. In work changes of dielectric oil indexes on a vegetable basis in the course of the artificial accelerated oxygen aging are investigated. Dielectric indexes were measured: inductivity, dielectric loss, specific volume resistance. The analysis of the received results is carried out, analytical dependences are received.

Key words: Inductivity, dielectric loss, specific volume resistance, oil on a vegetable basis, volume

INTRODUCTION

Oil-filled inventories are as a rule, the main elements in network of transfer and distribution of the electric power. Reliability of operation of the oil-filled equipment depends on dielectric properties of insulating oil. Now on a row with the improvement of designs of an inventory urgent transition to use of pollution-free biodegradable insulation liquids on the basis of vegetable oils is. There is a number of works in which dielectric properties of various oils such as rape, cotton, coconut and peanut (Oommen, 2002; Sankarappa and Prashantkumar, 2014; Semancik *et al*., 2007; Hemmer *et al*., 2002; Amanullah *et al*., 2005; Arazoe, 2011) are considered. These researches are as a rule, concentrated on a research of dielectric properties of fresh vegetable oils not subject to an aging. In the real work two exemplars were investigated; the first: initial "is fresher" also the second: after the artificial accelerated oxygen aging. The purpose of this research is the research of dielectric properties of oil on a vegetable basis before artificially accelerated oxygen aging.

MATERIALS AND METHODS

Technique: In a research sunflower-seed oil of the premium in accordance with GOST 1129-2013 was used. Characteristics are provided in Table 1.

Table 1: Physical and chemical indexes of vegetable oil

Indicator name	Value of an index of sunflower-seed oil refined, deodorized, the premium
Color number, iodine mg, no more	6
Acid number, mg KON/g, no more	0.30
Mass fraction of not fatty impurity, %, no more	NA
Mass fraction phosphoric substances, %, no more:	
in terms of stearo-oleo-lecithin	
in terms of P_2O_5	NA
Soap (qualitative test)	NA
Mass fraction of moisture and volatile matters, %, no more	0.10
Flash point	
extraction oil, °C, no lower	Not normalized
Cold test	Passes tests

The installation presented in the Fig. 1, consisting of an air compressor, an air duct, the heater and a vessel with oil was applied to receiving the exemplar which underwent quick-aging. The technology of quick-aging consisted in aeration by air oxygen at a temperature of 50°C within 720 clocks without light influence.

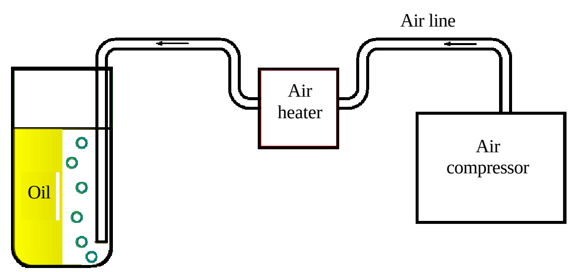

Fig. 1: Block diagram of installation of oxygen oil aging

Definition of electric characteristics of oil was carried out on the principle of measurement of a component of a vector of the current which is in a phase with the operating tension (Fig. 2).

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Values of current and tension by means of system of acquisition L-Card E-502 are transmitted to the personal computer where processing by the principle of a synchronous rectification is carried out. If current, is in a phase with tension on an object, then mean value of current, will be in proportion to the fissile component of current through an object of Ia = Ixcosϕ where Ix: is current through the object of measurement. At a current phase displacement on 90° concerning tension on subject of the indication will correspond to a jet component: Ir = Ixcos (90°-ϕ) = Ixsinϕ. The relation of these sizes allows to define the loss angle which is subject to measurement: Ia/Ir = tgϕ. At measurement of a jet component of current the received values will be proportional to the capacity of an object.

The inductivity is determined by a formula $\varepsilon = C/C_0$ where, C_0: the capacity of an empty cell, F, cell C: capacity with the studied oil exemplar.

For these exemplars the loss angle, an inductivity, specific volume resistance were measured. Measurement of a loss angle was carried out in the heating mode in temperature range from 25°-100°C with the subsequent measurement of a loss angle in the cooling mode from 100°-25°C. The received experimental results were exposed to approximation.

For an interval of temperatures 25°-100°C specific volume resistance of oil were approximated by a Eq. 1 :

$$\rho = \rho_0 \times \exp(-\alpha \cdot t) \quad (1)$$

Where:

ρ = Specific volume resistance at a temperature of t, °C

ρ_0 = Specific volume resistance at a temperature of 0°C

α = The coefficient depending on properties of oil

Data were used for creation of dependences and definition of the analytical expressions connecting the measured parameters. The comparative analysis of results for an initial exemplar of oil and an exemplar subject to an oxygen aging is carried out.

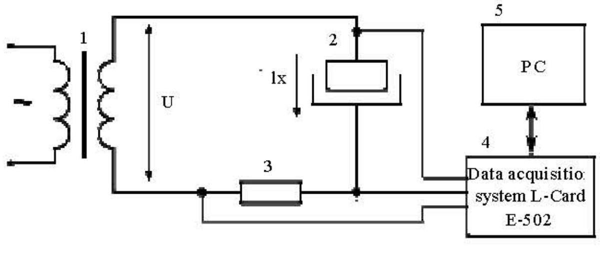

Fig. 2: Block diagram of measuring installation; 1: exploring transformer; 2: reference measuring cell (State standard specification 6581-75); 3: the shunt measuring; 4: systems of acquisition L-Card E-502; 5: personal computer

RESULTS AND DISCUSSION

Dependence of an inductivity on temperature for initial and an exemplar subject to an oxygen aging is presented in Fig. 3.

The inductivity of both exemplars decreases with body height of temperature. This decrease happens because of decrease of density which is directly bound to density of dipoles in an exemplar. Temperature increase of an exemplar of oil also leads to strengthening of chaotic thermal agitation which prevents streamlining of an arrangement of molecules that follow-up leads to decrease in an inductivity.

Dependence of an inductivity of exemplars in the considered temperature range can be described the look equation:

$$\varepsilon(t) = \varepsilon_0 - k \cdot t$$

Where:

ε = An inductivity at a temperature of t, °C

ε_0 = An inductivity at a temperature of 0°C

k = Temperature coefficient of an inductivity

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Values of coefficients ε_0 and k for initial and subject to oxygen oil aging are presented in Table 2. Follows from Table 2 that the inductivity at a temperature of 0°C of an

Table 2: Value of coefficients of approximation of an inductivity of the studied exemplars of oils

Samples	ε_0	k (1/deg)
Initial	3.22962	0.00721
Aged	3.32964	0.00677

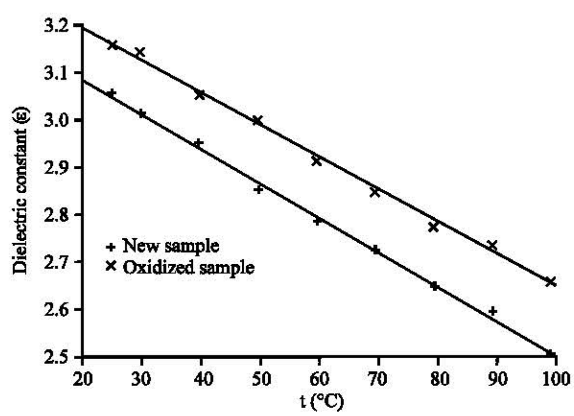

Fig. 3: Dependence of an inductivity initial and an exemplar subject to an oxygen aging from temperature

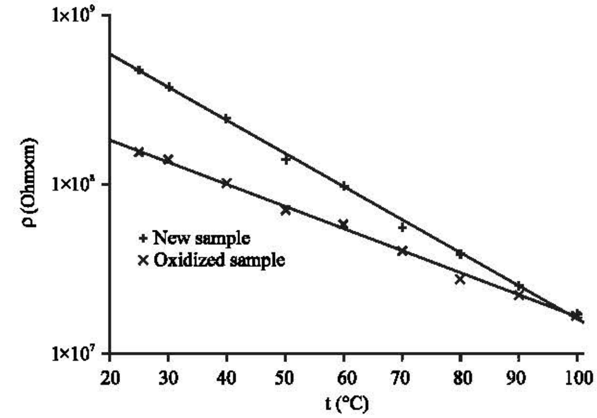

Fig. 4: Dependence of specific volume resistance of exemplars initial and subject to oxygen oil aging from temperature

Table 3: Value of coefficients of approximation of specific volume resistance of the studied exemplars of oils

Samples	ρ_0 (Om·m)	α
Initial	1.45938E+09	4.508E-02
Apt to aging	3.37858E+08	3.043E-02

exemplar of oil subject to an aging increased by 3% in comparison with initial oil. It is explained by emergence as a part of oil of oxidates. The temperature coefficient of an inductivity of an exemplar of oil subject to an aging decreased by 6% in comparison with initial oil that is bound to decrease of a coefficient of volume expansion of oil because of influence of oxidates.

In Fig. 4, dependences of specific volume resistance of exemplars initial and subject to oxygen oil aging from temperature are shown. Decrease of specific volume resistance with body height of temperature is bound to sharp increase of an ionic conduction of oil. This regularity has a talk strengthening of dissociation with increase in temperature and increase in ionic mobility. With increase in temperature the specific volume resistance caused by molionic conduction due to increase in mobility of particles owing to decrease in viscosity of liquid also decreases.

The received results of dependence of specific volume resistance on temperature are approximated by a Eq. 1, approximation coefficients for initial and subject to oxygen oil aging are presented in Table 3.

Specific volume resistance of an exemplar subject to an oxygen aging decreased at 4.32 time in comparison with an initial exemplar. It is bound to increase in strongly dissociating impurity which are loaded in an electric field and become carriers of current. At the same time the exponent of the exponential law decreased at 1.48 time in connection with the increased dominance of molionic conduction.

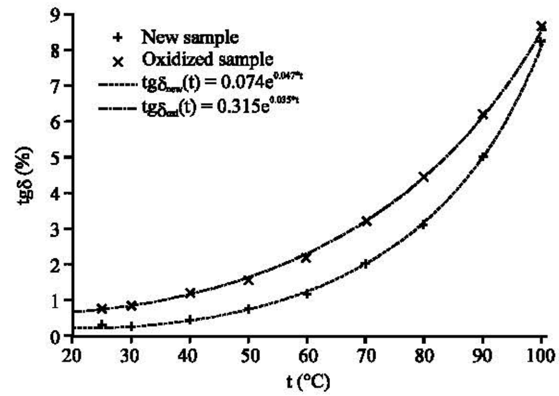

Fig. 5: Dependence of a loss angle on temperature initial and subject to oxygen oil aging when heating

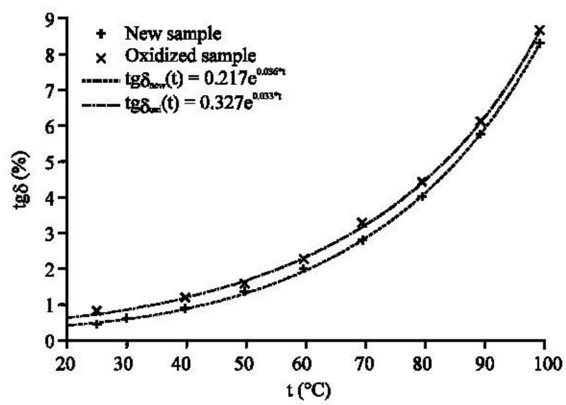

Fig. 6: Dependence of a loss angle on temperature initial and subject to oxygen oil aging when cooling

In Fig. 5 dependences of a loss angle initial and subject to oxygen oil aging when heating are shown. Similar dependences in Fig. 6 correspond to cooling process.

In the field of positive temperatures the main size of losses is caused by an electrical conductivity of oil, and dependence of a loss angle of oil on temperature is well described by the following equation:

$$tg\delta = tg\delta_0 \times \exp(b \cdot t)$$

Where:

$tg\delta$ = An oil loss angle at a temperature of t, °C
$tg\delta_0$ = An oil loss angle at a temperature of 0°C
b = The coefficient depending on properties of oil

Approximating coefficients of the offered equation for initial and subject to oxygen oil aging are presented in Table 4.

The loss angle of oil subject to an oxygen aging is much higher, in comparison with initial oil. At the same

Table 4: Value of coefficients of approximation of a loss angle of the studied exemplars of oils

	Heating		Cooling	
Samples	$tg\delta_0$ (%)	b	$tg\delta_0$ (%)	b
Initial	0.07387	0.04694	0.21681	0.03638
Apt to aging	0.31528	0.03293	0.32710	0.03258

time the size of an exponent of the exponential law of b has lower values. When heating the exponent of the exponential law of b of initial oil is more at 1.42, than oils subject to an oxygen aging. When cooling the exponent of the exponential law differs at 1.12 time.

Change is bound to change of an inductivity and electrical conductance of oil as a result of an aging. Aging products along with decrease of a specific resistance, increase activation energy of ions that leads to decrease in extent of temperature effect at a size of losses that is reflected in the size of an exponent of the exponential law of b. B exponent for an exemplar of oil subject to an oxygen aging for the modes of heating and cooling practically do not differ.

CONCLUSION

In work influence of an oxygen aging on dielectric characteristics of oil on a vegetable basis is investigated. Were measured at various temperatures an inductivity, specific volume resistance and a loss angle for an initial exemplar of oil and subjected within 720 clocks to an oxygen aging.

The analysis of the received results is carried out, analytical dependences of the studied sizes on temperature are defined. The inductivity of an exemplar of oil subject to an oxygen aging increases. At the same time dielectric loss significantly increase. Oxidates lead to decrease of specific volume resistance of oil. The received results and formulas of approximating dependences can be used at further researches of characteristics and properties of oils on a vegetable basis.

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REFERENCES

Amanullah, M., S.M. Islam, S. Chami and G. Ienco, 2005. Analyses of physical characteristics of vegetable oils as an alternative source to mineral oil-based dielectric fluid. Proceedings of the IEEE International Conference on Dielectric Liquids ICDL, June 26-July 1, 2005, IEEE, New York, USA., ISBN:0-7803-8954-9, pp: 397-400.

Arazoe, S., D. Saruhashi, Y. Sato, S. Yanabu and G. Ueta *et al.*, 2011. Electrical characteristics of natural and synthetic insulating fluids. IEEE. Trans. Dielectr. Electr. Insul., 18: 506-512.

Hemmer, M., R. Badent and A.J. Schwab, 2002. Electrical properties of rape-seed oil. Proceedings of the 2002 Annual Report Conference on Electrical Insulation and Dielectric Phenomena, October 20-24, 2002, IEEE, New York, USA., ISBN:0-7803-7502-5, pp: 83-86.

Oommen, T.V., 2002. Vegetable oils for liquid-filled transformers. IEEE. Electr. Insul. Mag., 18: 6-11.

Sankarappa, T. and M. Prashantkumar, 2014. Dielectric properties and AC conductivity in some refined and unrefined edible oils. Int. J. Adv. Res. Phys. Sci., 1: 1-7.

Semancik, P., R. Cimbala and I. Kolcunova, 2007. Dielectric analysis of natural oils. Acta Electr. Inf., 7: 1-5.