Assessment of the Actual State of the Insulation Gaps Larger and Average Electric Motors

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***Abstract*-The report proposes a method to control the condition of the insulation gaps of power equipment. The method uses a representation of a "total polarization index" (tpi) reflecting the main polarization processes, developing in the insulation gap under the influence of an applied electric field. High sensitivity values tpi to change the structure of the insulating gap and ageing processes working material to provide control method the reliability and validity of results of the estimation.**

Keywords- Condition of the Insulation Gaps; the Power Equipment; a Total Polarization Index; a Parameter Control; Quality Assurance

I. INTRODUCTION

Quality as a control parameter of the existing equipment estimated with the level of correspondence to the technical requirements. It known that ensuring of the planned level of quality allows achieving the desired results at minimum cost. Therefore, control and quality assurance of complex electric equipment in stage of its design, manufacture and operation become the actual problem. The solution to this problem connected with the formation of an effective parameter of control, available and simple method of measurement and the reliable base of comparison.

II. CONTROL CONDITION OF INSULATION GAPS BY MEASURING OF THE POLARIZATION CURRENTS

A. The Formation of the Control Parameter

Attempts to assess the condition of the insulation system in order to obtain information about the quality of the product and its degree of reliability continue for more the 50 years. At the same time, it believed that "dielectric" life equipment can approach the deadline for its use rather than its "thermal" life [1]. In fact, 38-40% of equipment failure due to the failure of its insulation system. So today, there is a whole arsenal of methods, each of which uses a wide range of the control parameter and implements specific physical model that provides information value method.

These parameters control today include [2]:

$R_{из.}$ – insulation resistance,

tgδ – tangent angle dielectric loss,

$C_{из.}$ – capacity of insulation gap,

$k_{абс.}$ – Absorption coefficient,

DAR – dielectric absorption ratio,

PI – polarization index,

$I_{ут.}$ – Leakage current,

DD – Dielectric Discharge,

τ – relaxation time insulation construction, etc.

Some of them are classic: $R_{из}$, tgδ, $C_{из}$, $I_{ут}$, usually refers to the latest DAR, PI, DD, etc. However, they have not provided significant success in solving the problem discussed here. This is because energy impact on the dielectric material of the insulation gap is a lot of quotient and its description does not fit with a single, even a well-designed physical model. Condition monitoring in these conditions assumes the character of a multi-level monitoring and multi-parameter [3].

Considering the structure and nature of the control parameters can be seen that their nature substantially determined by the same physical laws describing the decrease of the current flowing in gap from time. Fig. 1a shows that to each control parameter corresponds to a certain value of current measured at specified intervals. In other words, all the information about the state of monitored equipment, which is trying to get through the measurement of a parameter, "encrypted" completely dependent current decrease with time (Fig. 1a).

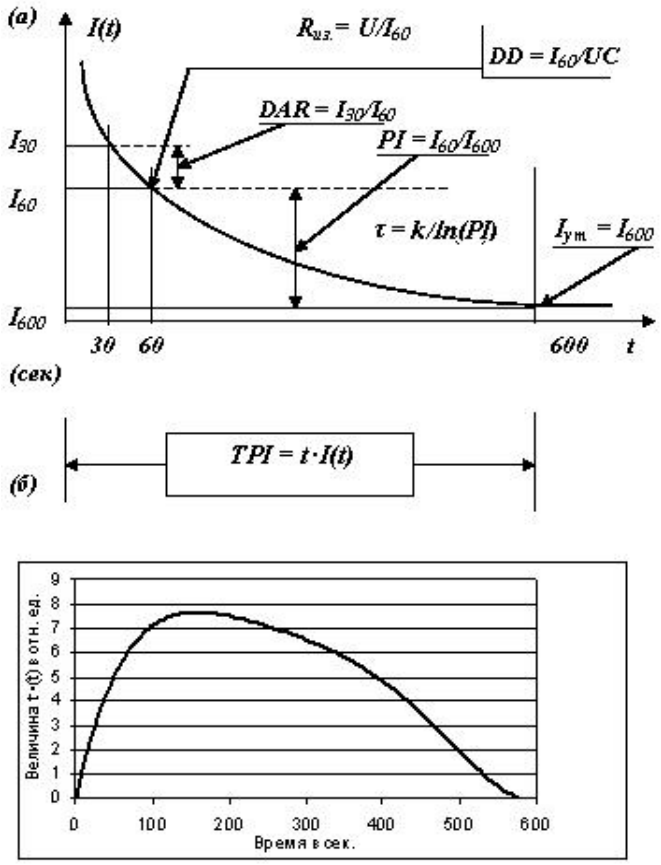

Fig. 1 Physical essence of the basic control parameters used to assess the condition insulation gaps

Therefore, as an effective indicator of performance insulating gap is advisable to use the dependence of *I(t)* completely. For this paper was used parameter *t*I(t)*, the time dependence of which seems to curve passing through a maximum (Fig. 1b). The maximum value of *[t*I(t)]max*, playing the role of the main parameter control, formed (in contrast to the commonly used parameters) behavior of the function *f(t)= [t*I(t)]* for the entire time interval and therefore perceived as a complex indicator of performance insulating gap. To emphasize this feature of the discussed indicator, it was abbreviated by *tpi* or total polarization index. It has been found that the values *tpi* correlate well with the majority of the parameters listed above.

B. Measurement Method, Results and Discussion

Physical nature of the function *f(t)= [t*I(t)]* defined physical entity spectrum polarization currents, the form of which is usually poorly structured. However, you can use the method of isolation of the main bands poorly structured a spectrum proposed in H. Matsuura and T. Hose [4]. Then from the experimentally obtained spectrum polarization current fails in the investigated time interval divided into two major bands. Each defined by its own mechanism of the current decrease with time, characterizing the degree of homogeneity of the structure and nature of the insulating gap (Fig. 2).

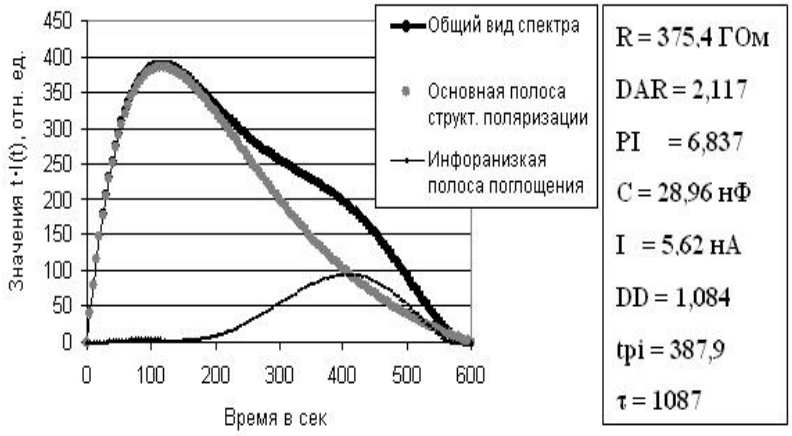

Fig. 2 General view of the spectrum and its individual bands

At a predetermined time interval, the main type of polarization is the structural polarization, so the nature of the first peak determined by the degree of homogeneity of the structure under study. It characterized by the presence of whole system distribution over the volume of structural defects, which act as traps of electric charge carriers. Nature of the second peak is associated with the presence of major structural defects, which are deeper traps that can locate many electric charge carriers. This causes a strong polarization effect. Moreover, this spectrum of polarization is sensitive not only to the meaning structural defects (the position of the maxima in the time axis), but their intensity (maximum amplitude). Effectiveness of condition monitoring of insulation gaps using considered in this paper approaches demonstrated by the large amount of experimental results presented in Fig. 3.

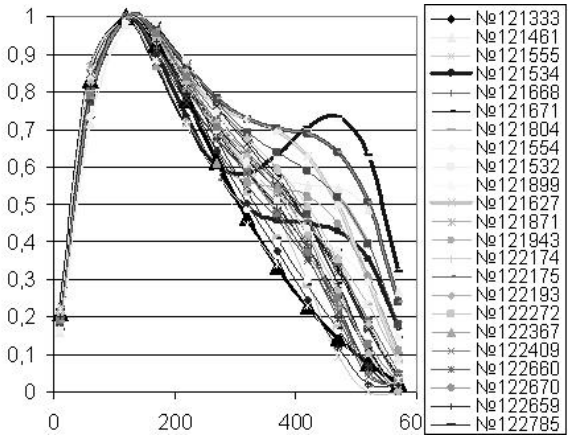

Fig. 3 Degree of compliance with current polarization spectra studied in the work of engines tore analogue

This figure shows the spectra of 20 electric motors brand ДАВ 315-4у2, which issued by ОАО «Сафоновский электромашиностроительный завод». Studies conducted monthly at 2-3 motors per month. For ease of reading useful information of the given family, spectra polarization current is compared with the reference spectrum (black solid line), playing the role of analog. It clearly seen that the submitted spectra studied engines correspond spectrum tear as analog. Note that about 30% of the totality of the engines have problems with the degree of homogeneity of the structure of insulation gaps, and some of them can be observed discontinuities materials working at intervals. Interestingly, the observed the change in electrical parameters of controlled items is not enough to recognize it is defective, and it passes final inspection, statutory.

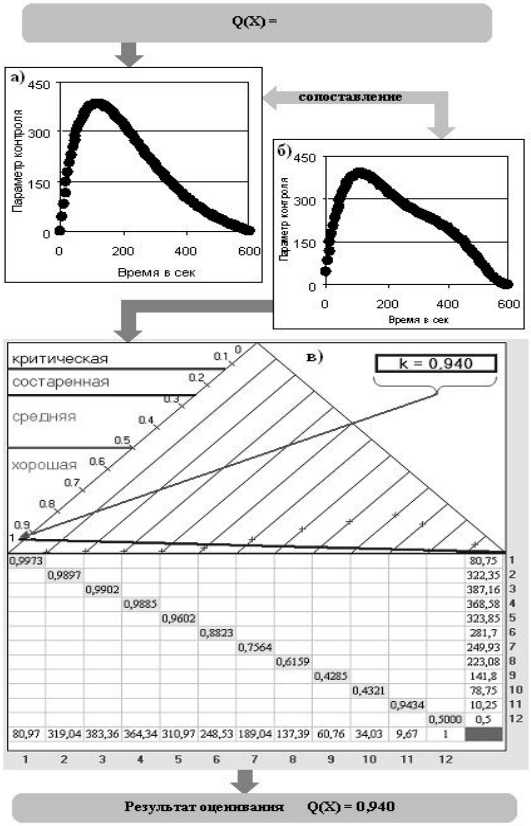

Fig. 4 Algorithm and evaluation tools of insulation gap: а – reference spectrum; б – spectrum controlled gap; в – module evaluation

If the spectra polarization current sensitive to even the slightest disruption of the structure, it can be used as a parameter to monitor the status of the insulating gap. However, you must be able to obtain quantitative estimates, due to the formation of a reliable basis for comparison. Numerical parameter thus obtained reflects the degree of proximity to the base of its range.

Algorithm and evaluation tools are shown in Fig. 4. In this figure shows a master curve (Fig. 4a), representing a spectrum of polarization currents insulating gap, meeting the requirements of technical specification and providing the minimum cost is not only the producer, but also the consumer. Spectrum of polarization currents gap under the control shown in Fig. 4б. Finally, program module estimation presented in the form of an information matrix, intended to match the spectra of both portion in numerical form, is depicted in Fig. 4.в. Program module evaluation in principle is modernized matrix method QFD (Quality Function Deployment). The method developed in the late 20^{th} century in Japan and used to determine the points of promotional product preferences, the forthcoming with respect to products already available on the market.

Downstairs information matrix horizontally given 12 supervised parameter values [t*I(t)], spaced at equal interval time (50 s) for master curve (the reference curve). This will create a base of comparison, in which the control parameter values ranked in descending order of importance. Similar values given in the module in vertical column to the right of the spectrum for the test gap. Diagonal matrix arranged results representing the relationship:

$$q_i(X) = X_{i,1}/X_{i,0} \text{ or } q_i(X) = X_{i,0}/X_{i,1},\ i = 1,2,\ldots,n$$

The index "0" indicates, that the comparison value belongs base (master curve), and the index "1" – an array of experimental data.

Values $q_i(X)$ deferred to coordinate field [n, $q_i(X)$] form a set of experimental point uniquely determined by the position of the straight line. The point intersection of this line with the y-axis and is the result of evaluation Q(X). This result determines the degree of approximation of structure of insulating materials controlled gap to gap structure materials selected as a basis for comparison and can act as an effective monitoring parameter.

III. CONCLUSIONS

Proposed in the article testing method have increased sensitivity to changes to the structure and condition of the electrical insulation. There, they can be integrated in to the process of service of power equipment.

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