EVALUATION OF TRANSFORMER RESOURCES BY VIBRATION TEST METHODS

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Аннотация: *Возникает необходимость обеспечения надежной работы масляных силовых трансформаторов, являющихся основным элементом системы электроснабжения. В первую очередь целесообразно оценивать процесс развития возникающих и существующих отказов.*

Ключевые слова: *Трансформатор, диагностика, вибрация, катушка.*

Abstract: *There is a need to ensure the reliable operation of oil power transformers, which are the main element of the power supply system. First of all, it is appropriate to assess the development process of emerging and existing failures.*

Key words: *Transformer, diagnostics, vibration, coil.*

If the diagnostic system installed to monitor each element of the transformer is clean and perfect, the information about the current state of the controlled transformer is obtained and processed as quickly as the information is more reliable and its the efficiency of use will be high. At the same time, due to the lack of a simple and perfect method of identifying transformer malfunctions in the energy system and industrial enterprises, the accidental failure of transformers leads to the stoppage of technological processes and the failure of transformer resources. It is economically and technically difficult to replace transformers that have expired in a short period of time. There are several methods of evaluating operational oil power transformer failures, and it is economically feasible to choose the optimal method for rapid analysis of failures.

Diagnostics of oil power transformers is divided into two parts; work (exploitation) and is carried out in the state of being disconnected from the network [3].

Vibrodiagnostics of oil power transformers allows timely detection of the development of dangerous defects in transformers and prevention of emergency situations. At present, vibration diagnostics at the place of installation of transformers is carried out by measuring the general level of vibration in the transformer tank or by analyzing frequency spectra. The basis of this method is the quantitative and qualitative dependence of vibrational parameters and spectra on the state of the core and ferromagnetic core. During the operation of the transformer, the level of compression of the windings decreases, which leads to an increase in the general level of vibration and a change in the frequency spectrum. Therefore, control can be carried out in the following ways.

Method 1 - measuring the general level of vibration on the wall of the transformer tank.

The transformer is carried out using any vibrometer capable of measuring the total vibration speed, vibration acceleration or vibration displacement on the wall of the tank. Despite the simplicity of implementation, this method is very laborious, since it involves successive measurements at measurement points along the surface of the tank and graphical drawings. Before starting measurements, the entire wall of the transformer tank is marked in several levels and sectors - along the perimeter. each isolated part of the tank is numbered and a number of measurements of the selected vibration parameter are made sequentially in the isolated part along the perimeter. The results of measuring the general level of vibration are summarized in a table, where the value of the measured parameter exceeds the maximum permissible value is marked with a color, and the graph of the measured parameter is drawn in parallel [1, 2 b].

Figure 1. Points for measuring the level of vibration of the wall of the transformer tank.

Despite the lack of standardization for power transformers, it is customary to consider the pressing of coils and magnetic circuits as acceptable if the vibration parameters do not exceed the following values:

He proposed a method of determining the density of coils by the value of vibration on the outer wall of the transformer. Failure assessment of the transformer assembly allows to determine whether or not it can continue to operate.

$(0,68 \div 0,73)\sqrt[4]{(F/\alpha)}$ (1)

Here F- is the compressive force of the coil in the initial state (in newtons), a is constant for the value of a certain type of transformer (in N / Hz4).

Using the above formula (1), the state of the circuit is estimated by monitoring the vibration frequency of the transformer

It is clear that the residual compressive force in the coil is not sufficient to ensure the electrodynamic stability of the design. the value of the short circuit current. The selected interval (0.5 ÷ 0.6) allows to set such threshold value with sufficient accuracy for practice [2].

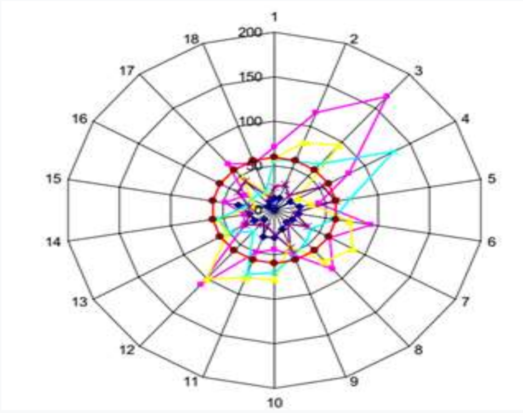

Figure 2. RMS diagram of vibration displacements on the surface of the transformer tank.

According to the experience of the "ZTZ-Service" scientific research center, a normally operating transformer is characterized by the following values of vibration parameters:

• vibration acceleration - 10 m/s2;

• vibration speed - 10 mm/s;

• vibration displacement - 100 microns.

Method 2. Spectral vibration diagnosis of transformers.

Useful diagnostic information in the transformer spectrum is from 100 to 700 HZ. In the lower frequency part of the spectrum, vibration components arising from oil pumps and cooling fans, as well as self-resonance peaks of tank elements are concentrated, vibration components with a frequency higher than 700 Hz quickly fade in oil and are useful does not contain data. If we look at the spectrum of an ideal transformer, then only three peaks are found - at frequencies of 100, 300 and 500 Hz. The first peak with a frequency of 100 Hz, equal to twice the frequency of the voltage in the network, depends on the magnetostriction of the magnetic circuit and the electrodynamic processes in the coil [1,5 b].

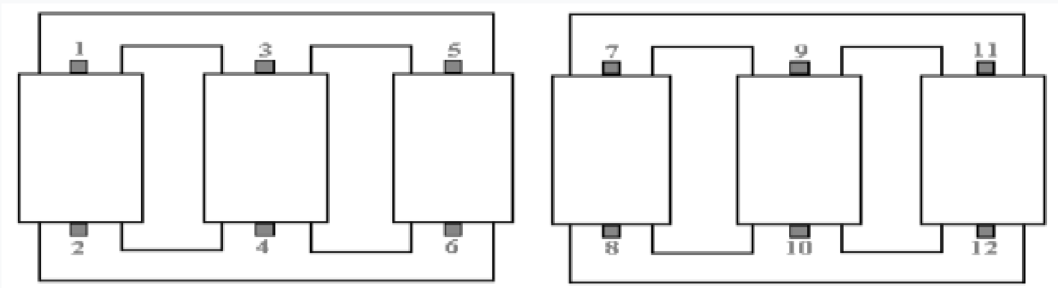

Figure 3. Sketch of the active part of the transformer.

In order to obtain a signal from the magnetic core, it is necessary to measure simultaneously at all points located on the upper and lower edges of the coil, but for obvious reasons, this is practically impossible, and in practice, by going around each point a series of successive measurements are made. The measurement results are analyzed. By a special expert program that calculates compression factors of transformer elements, a larger value of the coefficient corresponds to a higher quality of the circuit, and the following coefficient gradations are accepted:

• from 0.9 to 1.0 - a good condition of the size corresponding to the normal operation of the transformer;

• from 0.8 to 0.9 - the "worried" state of the transformer;

• Less than 0.8 - unsatisfactory condition of the transformer, requiring routine or repair work.

Method 3. Frequency control method.

Pressing force is determined by changing the frequency(s) of vibration of the mechanical system to press the pads. With a decrease in pressure, the frequency of the maximum spectral density is shifted to a low-frequency zone, and with an increase in pressure, it is shifted to a high-frequency zone.

The vibrations of the pressure system of the intestine are evaluated based on the measurement of the transient implementation of stress processes induced in the intestines under pulsed mechanical action. The appearance of voltage at the transformer inputs is the result of a change in the gradient of the magnetic field strength of the residual magnetization of the active part during the propagation of mechanical stress waves caused by the mechanical impact of the pulse. Often this physical phenomenon is called piezomagnetism. The spectral composition of the voltage induced in the coils describes the spectral composition of the vibrations of the active part of the transformer. All work on determining the compressive strength of coils by the method of frequency control is carried out in an isolated and damaged transformer [1, 10 b].

During the measurements of the voltage induced in the windings of each phase of the transformer and suitable standards according to the formula, the frequency of its maximum spectral density is compared with the voltage:

$$\overline{P_i} = \overline{P_0} \cdot \left(\frac{f_i}{f_0}\right)^n \quad (2)$$

Maximum spectral density frequency for the transformer under study, in the absence of suitable reference data, the maximum spectral density obtained for a "matched reference" transformer of another size similar in weight and design to the transformer measured. it is allowed to use density frequency. For this, it is necessary to enter the mass characteristics of transformers into formula (2).

$$\overline{P_i} = \overline{P_0} \cdot \left(\frac{f_i}{f_0}\right)^n \cdot \left(\frac{m_i}{m_0}\right)^{n-2} (3)$$

$\overline{P_i} = \frac{P_i}{P_{max}}$ - the relative compressive strength of the windings of the i-transformer under investigation;

P_i-checked - the power to press the pins of the i-transformer;

P_{max}- permissible (nominal) pressing force - i-th transformer;

$\overline{P_0} = \frac{P_0}{P_{max}}$- is the relative pressing force of the windings of the corresponding standard transformer;

P_0 - is the power to press the terminals of the corresponding standard transformer;

P_{max} - is the permissible (nominal) power of pressing the terminals of the corresponding standard transformer;

m_i- the mass of the active part of the transformer under investigation

m_0- is the mass of the active part of the corresponding reference transformer.

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