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## **TRADITIONAL AND MODERN METHODS OF TRANSFORMER OIL DIAGNOSTICS IN THE DOMESTIC POWER INDUSTRY**

It is well known that transformer oil is an important component of transformers and other electrical equipment used in various sectors of our country's fuel and energy sector. It plays a key role in providing insulation, cooling and protection of electrical installations from corrosion. The condition of the oil directly affects the reliability and safety of transformers. However, it is important to note that the latter is capable of losing its properties over time, which often leads to failures in the operation of the designated equipment. Therefore, in the field of electric power engineering, it is important to regularly carry out diagnostics of transformer oil in order to timely identify and eliminate possible problems. The realization of this activity does not do without the use by responsible personnel of traditional as well as modern methods of transformer oil diagnostics, the detailed consideration of which is devoted to the present work.

The analysis of scientific publications has shown that nowadays a number of classical and modern methods of oil diagnostics, as well as their joint use in accordance with the rules of guiding documents, allow very successfully control its condition during the operation of transformers and timely identify potential problems that can cause damage to power systems and disrupt the continuity of power supply to consumers [1].

The classical methods of transformer oil diagnostics include simple, cheap and time-tested methods: visual inspection; dielectric constant measurement and the use of specialized devices. Let's consider their general principles.

### **1. Visual method**

Visual method of transformer oil diagnostics is one of the simplest and most accessible ways to assess the condition of oil in electrical transformers and other electrical equipment. It is based on inspection of oil through special sight glasses or through openings in the equipment casing. During visual inspection of the oil it is possible to determine its color, transparency, presence of visible contaminants (dust, dirt, water) and other defects (air bubbles, emulsions). It is also possible to assess the oil level in the tank, which is important to ensure proper operation of the equipment. However, the visual method has a number of limitations. First, it cannot determine the chemical and physical properties of the oil, such as dielectric

constant, acidity, water and gas content. Secondly, the visual method does not provide an opportunity to identify hidden defects that can lead to accidents. Third, the visual method requires it to be performed regularly to ensure that problems are detected in time and prevented from developing.

Thus, the visual method of transformer oil diagnosis is an important tool for the maintenance of electrical equipment, but the researchers emphasize that it should not be the only method of oil condition assessment. Additional diagnostic methods, such as dielectric constant analysis, should be used to obtain more information about the quality of transformer oil [2].

### 2. Dielectric constant measurement

This measure is often mandatory in the diagnosis of transformer oil. This method, as opposed to visual inspection, allows a more accurate determination of the condition of the oil and identification of possible problems in the operation of electrical equipment.

In general terms, dielectric constant is a value that characterizes the ability of a material to conduct an electric current. It is measured in units of relative permittivity and indicates how many times the capacitance of a capacitor with a given dielectric is greater than the capacitance of the same capacitor with vacuum.

Measurement of the dielectric constant of oil can be performed using a special instrument – dielectric spectrometer. This instrument consists of an alternating voltage generator, a measuring capacitor and a recording system. The generator creates an alternating voltage, which is applied to the capacitor. Inside the capacitor is the oil sample under study. The capacitance of the capacitor changes depending on the properties of the sample and this change is recorded by the recording system.

For transformer oil diagnostics, it is important to know how the dielectric constant of the oil changes depending on its condition. For example, if the oil is contaminated, its dielectric constant will be higher than that of clean oil. This is because the contaminants increase the capacitance of the capacitor. In addition, measuring the dielectric constant can help determine how old the oil is. Over time, oil oxidizes and loses its properties, causing its dielectric constant to increase.

Thus, measuring dielectric permittivity allows you to assess the degree of oil aging and decide whether to change or regenerate the oil. This method is easy to use, does not require sophisticated equipment and can be performed directly at the transformer site [3].

### 3 Use of specialized instruments

Samplers, gas analyzers, moisture analyzers and other instruments are often used for oil analysis. They allow you to quickly determine the quality of the oil and identify possible problems.

A sampler is a device used to take oil samples from a transformer. Samplers can be manual or automatic. Manual samplers are typically used for small volumes of oil, while automatic samplers allow for larger volumes to be sampled.

Gas analyzers are used to determine the content of gases in transformer oil. They can be used to detect gases such as oxygen, hydrogen, nitrogen and carbon dioxide that may indicate problems with transformer insulation.

Moisture analyzers are used to measure the water content of transformer oil. Water can lead to corrosion of metal parts of equipment and deterioration of equipment performance. Moisture analyzers can quickly and accurately determine the moisture content of the oil, which allows timely action to remove it.

The use of specialized devices is currently no less relevant than modern diagnostic methods, and allows to obtain complete information about the state of transformer oil and with a low error to determine the need for its replacement or repair [4].

At the intersection of traditional and modern methods of analyzing the condition of oil-filled electrical equipment is a widespread method – transformer oil acidity test.

As already mentioned, over time, oil can lose its properties due to various factors, including oxidation and acid formation, so it is important to conduct timely research on their analysis. Here, the acidity of fractions is determined by measuring the hydrogen ion content (pH) of an oil sample. The acidity test is carried out using specialized equipment – a pH meter. The result of the test shows the acidity level of the oil, which can indicate the degree of oxidation and the presence of corrosion processes in the transformer.

The researchers note that high levels of oil acidity can lead to a variety of problems, including corrosion of transformer metal parts, deterioration of the transformer's insulation properties, and reduced cooling efficiency. In some cases, increased acidity can lead to complete loss of transformer performance. Oil acidity test is carried out as part of regular maintenance of transformers in operation in our country's power systems. This allows us to monitor the condition of the oil and take timely measures for its replacement or additional cleaning. In addition, the test results can be used to predict oil life and plan oil replacement [5].

As for modern methods of transformer oil diagnostics, they can be grouped into two key categories: chromatographic analysis and Fourier spectroscopy.

#### 1. Chromatographic method

Chromatography is a method of separating and analyzing mixtures of substances based on differences in the distribution of components between two phases, the mobile phase and the stationary phase. In transformer oil chromatography, the mobile phase is the oil itself and the stationary phase is the transformer tank walls. Chromatographic methods are used to analyze the composition of

transformer oil for impurities and gases, to determine the degree of aging of the oil, to assess the condition of transformer insulation, etc.

Chromatographic analysis of transformer oil determines the following parameters: the content of various impurities (e.g. water, acids, mechanical particles, etc.); the presence of gases (e.g. oxygen, hydrogen, nitrogen, carbon dioxide, etc.), which may indicate leaks or other problems in the insulation of transformers; the degree of oil aging (by change in dielectric constant). Based on the results of the analysis, it is possible to determine the need for oil replacement, assess the condition of transformer insulation, identify problems in the operation of the equipment and take measures to eliminate them.

Specialized instruments – chromatographs – are used for chromatographic analysis. They consist of the following main elements: sample input system (sampler); chromatographic column, where the components of the mixture are separated; detector, which registers the components of the mixture coming out of the column; recording device (recorder, computer); control unit, which ensures the operation of all elements of the chromatograph.

Currently, the chromatographic method is one of the most effective ways to diagnose transformer oil. It allows obtaining reliable information about the condition of the oil, necessary for making decisions on its replacement or repair of the transformer [6].

## 2. Fourier spectroscopy

Fourier spectroscopy is a technique based on the Fourier transform, which is used to measure the absorption or transmission spectra of oil samples under study. The method is based on measuring the interferogram of the fraction under study, which is then converted into a spectrum using a Fourier operation.

The main advantages of Fourier spectroscopy: high accuracy of measurements; possibility of obtaining high-resolution spectra; universality of the method, the possibility of studying various properties of transformer oils; ease of use and automation of the measurement process.

Methods of Fourier spectroscopy include: 1) IR spectroscopy – measurement of absorption spectra in the infrared region; 2) UV spectroscopy – measurement of transmission spectra in the ultraviolet region; 3) NMR spectroscopy (nuclear magnetic resonance) – measurement of nuclear magnetic resonance spectra.

The use of Fourier spectroscopy in the analysis of transformer oils is currently relevant for the following tasks: determining the presence of impurities and contaminants in the oil; monitoring the condition of insulating materials and their aging; assessing the degree of oxidation of oils and their corrosiveness; determining the content of water and gases in oils; analyzing the composition of oils to determine their compliance with the requirements of standards and specifications.

Fourier spectroscopy allows obtaining highly accurate data on the condition of oils, which is important for ensuring reliable and safe operation of operating transformers [7].

Thus, in the article various traditional and modern methods of transformer oil diagnostics, used today in the sphere of domestic power engineering, were considered. All of them, to varying degrees, allow to determine the current state of the oil and its suitability for further operation. However, in order to obtain the most complete information about the quality of the studied sample fractions, it is recommended to use a set of the above methods in accordance with the rules of regulatory documents.

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