USING OPTICAL SPECTROSCOPY FOR QUALITY CONTROL OF MINERAL TRANSFORMER OILS

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Currently, the main type of liquid dielectric for power oil-filled transformers is still mineral transformer oil. In practice, a regular oil quality control is performed, in which the most important electrophysical and chemical characteristics of the oil are determined. At the same time, the actual degree of change (degradation) of the hydrocarbon base of the transformer oil remains undefined.

The information on the hydrocarbon base of the transformer oil allows predicting a change in the operating properties of the oil, such as its oxidation rate and the solubility of water in the oil. In addition, information on the hydrocarbon composition of oils in some cases must be taken into account when interpreting the results of chromatographic analysis of dissolved gases in oil.

One of the effective methods for controlling the chemical composition of mineral transformer oils is optical spectroscopy. Depending on the purpose and the required accuracy and speed of research, various spectral ranges and research options (transmission, absorption, luminescence and color measurements) can be used for optical studies.

The most convenient and easy to implement for optical studies is the spectral range of 300 - 1000 nm. The main advantage of this spectral range is the possibility of using fiber-optic probes for express analysis in the field, as well as for on-line monitoring.

By analyzing the transmittance spectra of various types of transformer oils in the short-wavelength region, it is possible to determine the technology by which the transformer oil was produced: hydrocracking, selective purification, acid-base cleaning.

The transmittance curve in the 900 - 960 nm region contains information on the structural-group composition of oil-the concentration of naphthenic and paraffin hydrocarbons. For this purpose, the integral absorption bands were decomposed into separate components, as well as the calculation of the derivatives of the spectra. Based on the studies carried out, a method for determining the type of transformer oil was proposed, as well as a method for express determination of the content of an oxidation inhibitor in oil.

It was also found that thermo-oxidative and discharge processes in oil differently affect the shape of the curve of the transmission spectrum of oil $T(\lambda)$.

This allows in some cases, with the help of the transmission spectrum, separately to identify thermal-oxidation and discharge processes in the oil-filled electrical equipment.

Control of the intensity of thermo-oxidative processes in equipment can also be carried out from the spectrum of the luminescence of the oil. In studies, the excitation wavelength of the luminescence was 360 nm. It is shown that during the oxidation of the oil the luminescence intensity decreases. The interpretation of the detected effect is given.

It was also found that an increase in the optical density of transformer oils in the 300 - 500 nm region is due not only to the scattering of radiation by colloidal particles formed upon aging of oils, but also to the increase in molecular absorption of radiation by polyaromatic hydrocarbons. It is shown that the aging of mineral oils leads to the formation of complex polyaromatic compounds with several condensed benzene rings. The discovered mechanism of changing the hydrocarbon base leads to a change in the physico-chemical properties of the oils in operation.

Using the transmission spectra of oils, the color characteristics of the oils were determined. The possibility of quality control and chemical composition of transformer oil by means of color measurements is shown.

To study the depth of oxidation processes in transformer oils, IR absorption spectra of oils in the range 2000-1550 cm^{-1} were used. To obtain the results of IR analysis with the maximum amount of information, the optimal thickness of the oil layer was selected. On the IR spectra of oils, their acid numbers, as well as the content of various intermediate oxidation products of the oil, were determined with high accuracy.

An absorption band has been detected, with the help of which it is possible to determine the total amount of the consumed oxidation inhibitor of the phenolic type. IR analysis allows to control the total content of aromatic hydrocarbons, a method for controlling the content of mono-aromatic compounds is shown.

In the process of oil aging, there is accumulation of hydrocarbons, which have in their composition unsaturated bonds C=C. Such compounds have an increased reactivity. The content of unsaturated hydrocarbons can also be determined from the IR spectrum of the oil.