DRYING AND DEGASSING OF TRACTION TRANSFORMER OILS

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Annotation. The article discusses the multiplicity and duration of overload, the degree of current asymmetry, the temperature of the hottest point of the oil and windings, the degree of aging of the turn insulation, the composition of gases released during malfunctions using chromatographic analysis, the loss of electrical energy and analyzes.

Key words. Transformer, transformer oil, winding, dielectric, dielectric strength, liquid insulation, solid insulation, cellulose, vacuum.

At present, the maximum permissible values of the quality indicators of various transformer oils, such as test voltage, moisture content and gas content (РД 16363-87), are established. Oil with enhanced insulating properties can only be obtained if it is deeply dried and degassed using vacuum measurement and dosing technology.

Effective drying of transformer oils is consumed when they are treated with zeolites (molecular sieves). Zeolites show increased activity and capacity for water concentration and therefore reduce the removal of oil from a sample of a portion of the dissolved water, even a little at its content. It is advisable to dry the oil with zeolites at a breakdown voltage of the oil of 10 kV or more. The average pore size of synthetic zeolite of the NaA brand and the ПЦГ-2 brand, which are most widely used in power plants, is $4 \cdot 10^{-10}$ м ($1 \cdot 10^{-10}$ м = 1 А). Physical and chemical parameters of synthetic and natural zeolites are presented in table.1.

Data on zeolites exceed 7–10–10 m, so they cannot be used to determine oils.

During storage, zeolites absorb and partially consume gases from the environment, therefore, before using them, it is necessary (to ask) for their recovery from the following situation:

• drying in a thin amount (10 - 20 mm) at a temperature of 350 - 400 ° C for five to six hours, which is carried out in a drying cabinet, electric furnace;

• drying by blowing hot air or inert gas (nitrogen) through the zeolite layer for three hours at a temperature of 300 - 350 °C, air (gas) consumption is 0.5 - 0.6 m3/h per 1 kg of zeolite;

• vacuum drying of the zeolite at a temperature of 250 °C and a residual fluctuation not higher than 5332 Pa (40 mm Hg) for two to three hours.

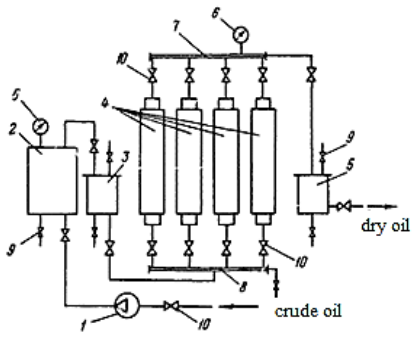
Table 1.

Index	Synthetic zeolite			Natural zeolite
	NaA-2МШ (ГОСТ 5.1290-72)	*NaA* without binders (ТУ 95-400-81)	*NaA with binding additives* (ТУ 38-10281-75)	Uzbek ПЦГ-2 ТУ 113-12-127-82
Chemical composition	-	0,9 Na_2O ´ Al_2	O_3 ´ 1,9 SiO_2	0.6 - 1,2 [Na_2O ´ (1 - 2)] Al_2O_3 ´ (6 - 10) SiO_2
Bulk weight, g/cm^3, not less than (non-dried zeolite)	0,97	0,97	0,97	0,94
Appearance	Spherical or oval granules	Hard pink grains		Zerno irregular shape
at least	99,5	90	80	-

The last two methods are most effective, which allow drying zeolites directly in working adsorbers (cartridges) and thereby prevent partial wetting of the zeolite when it is loaded into adsorbers (cartridges). Before loading into the adsorber (cartridge), the zeolite must be sifted from dust and fine fractions (less than 2.8 mm). The zeolite loaded into adsorbers (cartridges), when used for drying oil directly in electrical equipment, must be additionally washed with dry transformer oil from dust residues. The storage of the prepared zeolite is carried out in a sealed tank under a layer of dry transformer oil (U_{prac} more than 60 kV) without loss of activity for a sufficiently long time. In Fig.1. the technological scheme of the unit of the ПЦУ installation for drying oil with zeolites is shown. Stationary zeolite plants can be installed on the territory of the oil facilities using the standard equipment of the oil

facilities (adsorbers, filter presses, oil pumps), according to technological schemes similar to the ПЦУ scheme.

Currently, the domestic industry produces zeolite plants ПЦУ 77-1100 and M0.02-A.



Rice. 1. Technological scheme of the ПЦУ unit for drying transformer oil with zeolite: 1 - oil pump; 2 - oil heater; 3.5 - fine oil filters; 4 - adsorbers (cartridges); 6 - pressure gauge; 7.8 - collectors; 9 - cranes; 10 – valves.

As zeolite adsorbers (cartridges), it is more expedient to use adsorbers in which the ratio of the height of the zeolite layer to the inner diameter of the adsorber is at least 4:1. The consumption of NaA zeolite during the drying of transformer oil is approximately 0.2% of the mass of the dried oil (the consumption of natural zeolite PCG-2 is approximately twice as high). The optimal performance of a zeolite plant with four adsorbers (50 kg of zeolite each) operating in parallel is 1.6 - 2.5 m3/h. Drying of oil is quite effective at a temperature of 15 - 25 ° C, that is, additional heating of the oil is not required. In one drying cycle, the breakdown voltage of the oil rises from 10 - 20 to 60 kV, and the water content can decrease by 10 times.

At present, along with the scarce and expensive synthetic zeolite of the NaA brand, it is possible to use the natural Georgian zeolite of the PCG-2 brand, which is much cheaper and more accessible than the synthetic one and its use does not require any change in the existing technological schemes and equipment. The combined use of zeolite and silica gel in the regeneration of transformer oils is rational. Preliminary drying of the oil with zeolites before regenerating the oil with silica gel (or other large-pore adsorbent) makes it possible to increase the adsorption capacity of silica gel with respect to the products of oil aging. Efficient drying and

degassing of transformer oil is ensured by vacuum treatment of the oil. Vacuum treatment of oil allows the separation of dissolved water and gas (air) from the oil.

The most effective ways of vacuum processing of transformer oils are vacuuming:

• oil spraying in large volume vacuum chambers;

• in a thin layer with a slow flow of oil over the surface of special packings (Raship rings, chord packings, spiral rings, etc.) in vacuum columns.

Considering that at atmospheric pressure transformer oil can contain up to 10% of the volume of air, oil degassing is necessary to prepare the oil for filling into sealed equipment (transformers with nitrogen or film protection, sealed bushings).

The optimum vacuum parameters for oil drying and degassing should be a temperature of 80 °C and a residual pressure of about 133 Pa (1 mm Hg). Currently, drying and degassing of oil can be carried out on mobile units URTM-200 M, UVM-1, UVM-2. UVM-1 and UVM-2 units are designed for drying, degassing, purification from mechanical impurities, nitriding and heating of transformer oil poured into power transformers and other electrical equipment. The units can be used in the repair, manufacture, installation of oil-filled high-voltage equipment. UVM units are equipped with electric heaters, oil and vacuum pumps, fine filters. They can be used to prepare oils for pouring into equipment after their regeneration with large-pore adsorbents using adsorbers directly on operating equipment.

The combined use of adsorbers and UVM vacuum units can provide all the necessary set of measures to restore and maintain the quality of operational transformer oils. The technical characteristics of UVM mobile units for vacuum treatment of transformer oils are given. It is desirable for each central oil farm to have UVM-type units. If it is necessary to degas the oil during operation (for example, to top up hermetic transformers with film or nitrogen protection) and there are no UVM-type vacuum units at the enterprise or power system, oil can be degassed by spraying it under vacuum in a sealed container that can withstand a residual pressure of up to 13.3 Pa (0.1 mm Hg). Modern requirements for the operation of transformer oils necessitate the widespread use of vacuum and

adsorption technology, so power plants need to have vacuum pumps of the VN, NVZ, AVR, AVM, 2DVN, AVZ, etc. series. (in the absence of vacuum units such as UVM).

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