Dielectric Strenght Testing of Transformer Oil

Natasa Mojsoska [1] and Blagoja Stevanoski [1]

Abstract – **Main issue in this paper work is transformer oil. The function of liquid dielectric is to provide insulation and cooling. The various characteristics of transformer oil are describes such as physical, chemical and electrical. Dielectric strength, also called breakdown voltage BDV is one of electrical parameters that is very important, specially for transformer oil in use. Described is the process of purification of the oil sample, with the elements of the Purifying station for transformer oil. Measured is the dielectric strength of the transformer oil.**

Keywords – **Transformer, Transformer oil, Dielectric strength, Measurement.**

I. INTRODUCTION

The parameters of transformer oil are categorized as:

1. Electrical parameters: dielectric strength, specific resistance, dielectric dissipation factor.
2. Chemical parameters: water content, acidity, sediment content.
3. Physical parameters: interfacial tension, viscosity, flashpoint, firepoint.

The function of transformer oil is to provide insulation and cooling. Because of these oil properties associated with the composition, transformer oil should fulfill several requirements:

1. In the cold condition must be sufficiently rare to run across all active parts of the transformer.
2. It must not contain moisture because it reduces dielectric strength.
3. Does not contain any solid materials, because they reduce the insulating properties.
4. Do not contain acid and sulphur that eat away and destroy insulation.
5. Must have high thermal flammability.
6. Must be able to apply at low temperatures.
7. The new oil should have a dielectric strength of at least 80 kV / 2,5 cm, and the transformers in operation must have at least 30 kV / 2,5 cm.

II. CHARACTERISTICS OF THE OIL

A. Physical and chemical properties of oil

The purpose of testing is to determine the suitability of oil application and assessment of its quality. Based on the results of the measurements it is possible to determine the corrective measures in terms of bringing the oil condition which is allowed for use.

Color and clarity - is not a critical feature, but it is useful in comparative terms (quick change of color can be a sign of accelerated aging and pollution).

Water content - water in the oil derived from the production itself, from the humidity of the atmosphere or it occurs as a product of aging paper (cellulose).

Acidity - it is a measure of free organic and inorganic acid present in the oil.

Sediment - it occurs as a result of the aging of the oil and paper insulation in the working life.

Neutralization number - it is a measure of the acidic compounds or oil pollution.

Interfacial tension - measured at the oil-water, and indicates soluble polar impurities and degradation products, the value is changing quite rapidly in the initial stage of aging, therefore the results should be interpreted in conjunction with other features.

Oxidation stability - is determined by measuring the aging of the product oil in the laboratory, thus measuring the content of sediment, volatile or soluble acids.

Viscosity - n few wards, viscosity of transformer oil can be said that is the resistance of flow, at normal condition. A good oil should have low viscosity so that it offers less resistance to the convectional flow of oil thereby not affecting the cooling of transformer. Low viscosity of transformer oil is essential, but it is equally important that, the viscosity of oil should increase as less as possible with decrease in temperature.

Flash point and fire point - Flash point of a volatile liquid is the lowest temperature at which it can vaporize to form an ignitable mixture in air. The flash point is an empirical measurement rather than a fundamental physical parameter. The Fire point is defined as the temperature at which the vapor continues to burn after being ignited. It is the lowest temperature at which, on further heating beyond the flash point, the sample support and combustion for five seconds.

B. Electrical parameters of oil

Specific resistance - This is another important property of transformer oil. This is measure of DC resistance between two opposite sides of one cm3 block of oil. Its unit is taken as ohm-cm at specific temperature. With increase in temperature the resistivity of oil decreases rapidly. Just after charging a transformer after long shut down, the temperature of the oil will be at ambient temperature and during full load the temperature will be very high and may go up to 90°C at over load condition. So resistivity of the insulating oil must be high at room temperature and also it should have good value at high temperature as well.

[1]Natasa Mojsoska is with the Technical Faculty at University St Clement Ohridski of Bitola, Makedonska falanga 33, Bitola 7000, Macedonia, E-mail: natasa.mojsoska@tfb.uklo.edu.mk.

[1] Blagoja Stavanoski is with the Technical Faculty at University St Clement Ohridski of Bitola, Makedonska falanga 33, Bitola 7000, Macedonia, E-mail: blagoj.stevanovski@uklo.edu.mk.

That is why specific resistance or resistivity of transformer oil should be measured at 27°C as well as 90°C.

Minimum standard specific resistance of transformer oil at 90°C is 35×1012 ohm–cm and at 27°C it is 1500×1012 ohm–cm.

Dielectric dissipation factor DDF is also known **as loss factor** of transformer oil. When a insulating materials is placed between live part and grounded part of an electrical equipment, leakage current will flow. As insulating material is dielectric in nature the current through the insulation ideally leads the voltage by 90°. Here voltage means the instantaneous voltage between live part and ground of the equipment. But in reality no insulating materials are perfect dielectric in nature. Hence current through the insulator will lead the voltage with an angle little bit shorter than 90°. Tangent of the angle by which it is short of 90° is called dielectric dissipation factor or simply tan delta of transformer oil.

Dielectric strength of transformer oil is also known as **breakdown voltage** of transformer oil or **BDV** of transformer oil. It refers to the ability of the oil to withstand dielectric stress.

Breakdown voltage is measured by observing at what voltage, sparking strands between two electrodes immerged in the oil, separated by specific gap. Low value of BDV indicates presence of moisture content and conducting substances in the oil

The dielectric strength of transformer oil at transformers over 10 MVA must control twice a year and at transformers under 10 MVA once a year.

Dielectric strength of an insulation material depends on pressure, temperature, humidity, electrode configuration and nature of applied voltage. Breakdown strength analysis of transformer oil gives effective results through which suitable dielectric material for the related high voltage applications can be explored. The Breakdown Voltage (BDV) test kit consists of two electrodes mounted on horizontal axis with 2.5 mm gap and enclosed in a glass chamber as shown in Figure 2. Electrodes used in test apparatus is of sphere-sphere electrode configuration since the sphere-sphere configurations provides uniform field distribution. Diameter of sphere electrodes is of 19.8 mm.

C. Structural analysis of the oil

Is made by the method of infrared spectrometry and provides information on the chemical structure of the oil. In case of accelerated aging of the oil can detected the degree of chemical degradation.

Example for physical - chemical analysis of the oil or characteristics, appearance or her unit are measured with specified application for a declaration of the property is given in the Table 1.

The criteria for the purpose in the table are based on experiences gained good insulating oils in the transformer factory, and comply with the requirements of IEC 422/89.

TABLE I
PHYSICAL AND CHEMICAL CHARACTERISTICS OF TRANSFORMER OIL

	measure unit	request
looks	clean	clean
collor (acc. DIN 51578)	-	-
neutralization value total acidity	mg KOH/g	<0.2(<0.3)
Interfacial tension at 20°C	mN/m	>25(>20)
Presence of oxidation inhibitor	-	present
Sediment value n-heptanol	-	absent
Dielectric strength (BDV electr. 2.5mm)	kV	>50(>40)
Factor of dielectric losses at 90°C	-	<0.1(<0.2)
Specific resistance at 90°C	GΩm	>10 (>1)
Water content	mg/kg	<20(<30)

III. TECHNOLOGY PURIFICATION OIL

A. Vacuum purifying transformer oil

The device works on the principle of eliminating the drying gas and oil in the vacuum chamber, unlike the older generation where they used spin.

With its features, and depending on the size of the device and its flow and size (power) of the transformer is possible in the short term to achieve a very high dielectric strength of oil. Device works in a completely closed system, and each contact of humans and animals oil environment is minimized.

The process of purifying transformer oil down into several phases that subsequently occur. The oil is first filtered by filter coarse impurities and heated to 55 ° C. The inherent drying chamber is under vacuum -1 bar resulting in a lower boiling point of water at approx. 40 ° C.

In dryer water and undesirable gases evaporate and drain through a vacuum pump, and oil further filters filters and returns to the transformer.

Quality oil clean transformer in the circular process through the device. This is done until the oil has reached a high dielectric strength.

The advantage of the technology of purification of oil is beneficial oil additives that are not separated from the oil. Extraction of oil additives significantly accelerates aging of the oil itself.

Examples of devices that will describe the technology of purification with this method is WH-020 of the famous Swiss company Micafil.

B. Preparation for treatment

Before you begin the process of purifying transformer oil necessary to ensure the workplace in accordance with the "golden rules to protect electricity", which includes the following:

1. It appears to be separated from the transformer voltage,
2. Prevent reconnection of the transformer (put insulation board)
3. indicator to check no voltage condition (indicator previously examined).

Fig. 1. Connecting the transformer with device by hoses

4. earthling and short merged transformer,
5. fence parts under voltage

After that the procedure can start.

The transformer is covered with a cover to keep the heat from the transformer oil circulating through the transformer machine and back, and also reduces the duration of the procedure. The cover is made only in terms of low temperatures.

Input and output hose device to circulate the oil in the process of purification is related to the power transformer, as shown in Fig. 1.

C. Power plug the device

Preparatory work includes planning of connecting power connector installed power of device connectivity and planning due to its remoteness Fig. 2.

Fig. 2. Connect the device to a power source and connectors with extensions

D. Preparation of the vehicle treatment

The transmission device for purifying transformer oil, which is located in the vehicle has a great advantage, because the test is done on-site.

E. Cleaning equipment for transformer oil

Purifying station for transformer oil type Micafil is given on Fig. 3.

The image is labeled with the following elements:

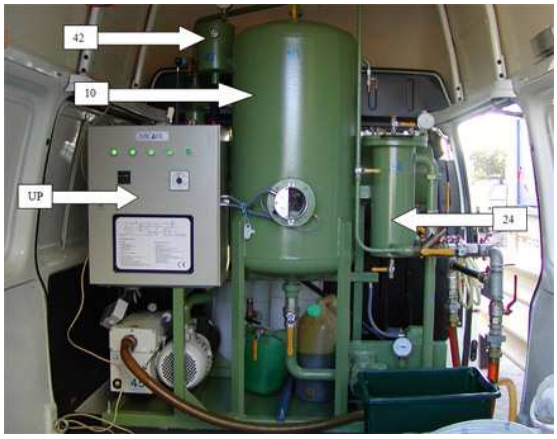

Fig. 3. View of purifying station inside

- 10 - drying chamber and degassing,
- 24 - 5 micron filters
- 42 - gas oil indicator suction vacuum pump oil,
- UP - Control Panel device.

Oil is brought through inlet hoses in the device, and then heated. It is expelled vacuum drying and removal of gases, which through a series of sieves is purified oil, water and gas and side drain through a vacuum pump. Warm oil with high quality returns to the transformer and wash it in a circular process 3-5 times. With help the pilot light lit inside the chamber and control the oil in the chamber, shown on the Fig. 4.a.

During treatment, it is possible to control the temperature of

Fig. 4.a Control the flow of oil from the window of the chamber

Fig. 4.b Contact thermometer in power transformer

the oil which circulates through a power transformer with a contact thermometer (given on Fig. 4.b)

F. The taking of samples and measuring the dielectric strength of transformer oil

Before testing the transformer oil and measurement of dielectric strength with container were adjusted distance between the electrodes of 2.5 mm shown on Fig. 5.

Fig. 5. Calibration of distance between electrodes of 2.5 mm

G. Releasing oil from the device

The oil is discharged from the device to remove impurities from drainage pipes and to take a clean copy. A copy of the oil control is taken in dry weather, and if necessary the wet weather then take special measures for protection from spraying (e.g. protection from rain, deleted and dried floodgates, waterproof covers transport of the sample).

The frequency and method of sampling of transformer oil in order to verify its dielectric strength (penetration) must be carried out in accordance with existing standards and regulations.

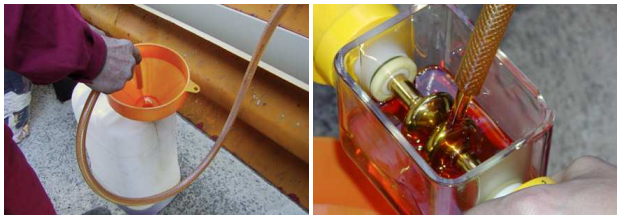

Fig. 6. Realizing oil from device, Filling the container with the sample to measure the oil

IV. RESULTS OF MEASURING

Portable Tester for testing dielectric strength of transformer oil in photos is BAUR Dieltest DPO60.

Fig. 7 shows that the measured dielectric strength of the oil is **46,9 kV / 2.5 mm**, which is the result of **187,6 kV / 1cm.**

Fig. 7. Measuring of breakdown voltage BDV of the oil

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