One of the most important aging indicators of transformers is the water content in the solid part of the insulation (paper, pressboard). Accurate diagnostic tools for determining the health of transformers is critical. The Omicron DIRANA is a unique and efficient device which determines the water content in the solid insulation.

Moisture entering in oil-paper insulations can cause three dangerous effects in transformers: it decreases the dielectric withstand strength, accelerates cellulose aging (de-polymerisation) and causes the emission of gas bubbles at high temperatures. Water in transformers comes from four sources: residual water after drying, water from cellulose and oil aging, water through leaky seals or repairs, and water due to breathing. Therefore, even in the case of a non-breathing transformer the moisture can reach a critical level.

The dielectric response analyser measures the dielectric response of solid insulation in equipment. Dielectric response is a unique characteristic of the particular insulation system. Increased moisture content of the insulation results in a changed dielectric model and, consequently, a changed dielectric response. By measuring the dielectric response of the equipment in a wide frequency range, the moisture content can be assessed and the insulation condition diagnosed.

For dielectric response tests, the test performed is a traditional ungrounded specimen test (UST) made from the high voltage winding to the low voltage winding (CHL) in a two winding transformer. See Fig.1. We are most concerned with the CHL test, as this is the measurement which contains the most cellulose insulation material.

The test connections and modes are the same as used in a traditional transformer insulation power factor test with the difference being that the test is performed at a low voltage, up to 200 vpp, and test at frequencies from 1 kHz to 10 μHz.

Fig. 2 shows the response curve for oil-impregnated paper. This curve shows a frequency vs. dissipation factor relationship. With increasing moisture content, temperature or aging the curve shifts towards the higher frequencies. Moisture influences the low and high frequency areas. The linear, middle section of the curve with the steep gradient reflects oil conductivity. Insulation geometry conditions determine the “hump” which is located to the left side of the steep gradient.

The analyser combines the polarisation current measurement (PDC) method in time domain with the frequency domain spectroscopy (FDS) and thus significantly reduces the testing time compared to existing techniques. Essentially, time domain measurements can be accomplished in a short time period but are limited to low frequencies. The extended measurement range of 5 kHz down to 50 μHz, allows the analyser to discriminate between the oil, insulation geometry and paper. The result is independent of moisture equilibrium.

A patented technique combines the advantages of both principles. It acquires data in the time domain from 10 μHz to 0,1 Hz and in the frequency domain from 0,1 Hz to 5 kHz. This reduces the measuring duration by up to 75% compared to exclusive frequency domain measurements.
Moisture determination is based on a comparison of the transformer’s dielectric response to a modeled dielectric response. A fitted algorithm compares the measured data to the modeled data and calculates the geometry data, the moisture content, as well as the oil conductivity. The moisture assessment is based on IEC 60422.

The software is very easy to use, and the user only needs to enter the oil temperature. Fig. 3 shows the measurement assessment results displayed by Omicron’s software. Aged transformer oils often have increased values of conductivity through acids and other aging by-products. This can lead to incorrect water content results. The insulation model in the analyser software compensates for this influence.

Other applications of the analyser

- Bushings
- Instrument transformers PtsCTs
- Monitoring of transformer drying
- Paper-mass insulated cables

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