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MONITORING OF DISTRIBUTION OIL TRANSFORMERS USING THE SENSOR TECHNIQUE

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Introduction

Power transformers are key equipment for transfer and distribution of the electric power. Considering the significance of the power transformers in the electric system, their price and possible damages occurred by accidents, it is necessary to pay attention to their higher prevention.

Power transformers must be designed so, that the effect of short-circuits currents, which can emerge in the place, will not start up on them the destruction or the deformation of the electric, mechanical or thermal character. Except for permanently deformation results of the effects of short-circuit current come to also by correct dimensioning of electric equipment to progressive ageing, which can make worse his mechanical properties.

Experimental measurement

As an example of analysis and monitoring of thermal processes in transformer by using the thermovision and method of monitoring refrigerating curves we will introduce experimental measurement with distributional oil transformer with natural cooling system 22/0.4 kV, 30 kVA, which is located in the Laboratory of electrical machine diagnostics of the University of Zilina. [2]

To measure the windings temperature we used two optical detectors with measuring unit Neoptix, which were installed on the top and the middle part of the middle primary phases (Fig.1 – white stripes).

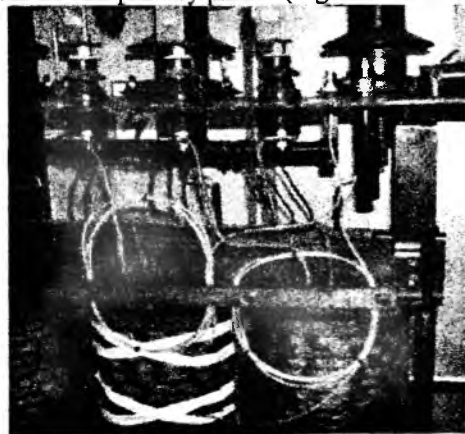


Fig. 1. View of the optical detectors positioning (covered by white stripes)

Optical detectors were led out by special duct to the top part of the transformer's tank and from there they were led by two optical fibers further to the measuring system NEOPTIX T, which was subsequently evaluating measured winding temperatures.

Transformer bushings and tank is monitored thermovision camera. In Fig.2 is vertical decrease of temperature for monitoring transformer tank. Thermal strain is the greatest in the top area of the transformer.

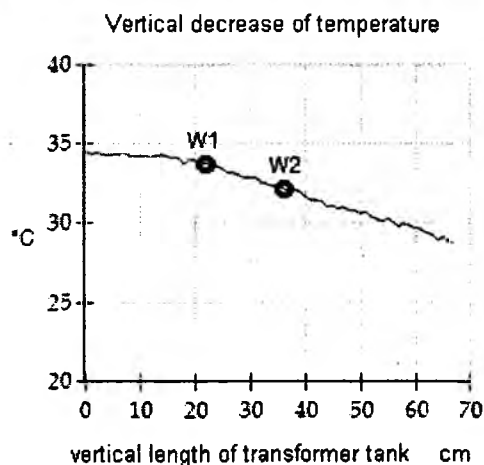
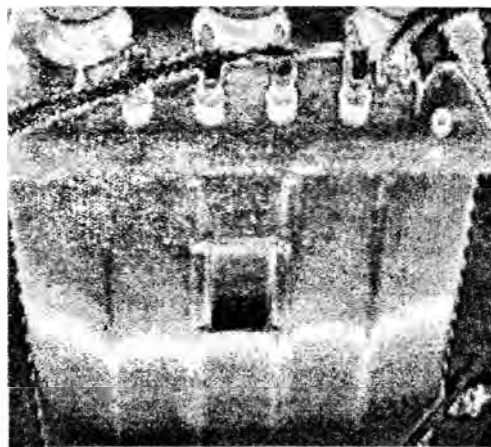


Fig.2. Decomposition temperature of monitored transformer 22/0,4 kV – 30% load

After several months lasting operation of the transformer at approximately 30% load the analysis of measured temperature values in dependence on time at its sudden cut off was performed on measured winding phase.

It is necessary to mention that in oil tank the top and the middle part of the winding reacts differently on sudden changes. Thereby we observed possible behavior differences at two winding parts during refrigeration process after cutting the device off. Levels of refrigeration decrease may include level of winding mechanical strength, insulation quality and viscosity of oil in the transformer tank.

Fig.3 shows the comparison of measured windings temperature values in dependency on the time after cutting the device off. The temperature decrease to 48 °C in the top part of the windings (W1) took 75 seconds and in the middle part (W2) only 50 seconds. That corresponds to the expected oil's temperature distribution after cutting the transformer off.

The temperature of oil in the transformer tank increases from certain minimum value at the bottom of the tank to the maximum value - approximately to the height of the windings top edge. This maximum temperature is more or less maintained in the whole mass of oil under the top transformer cover.

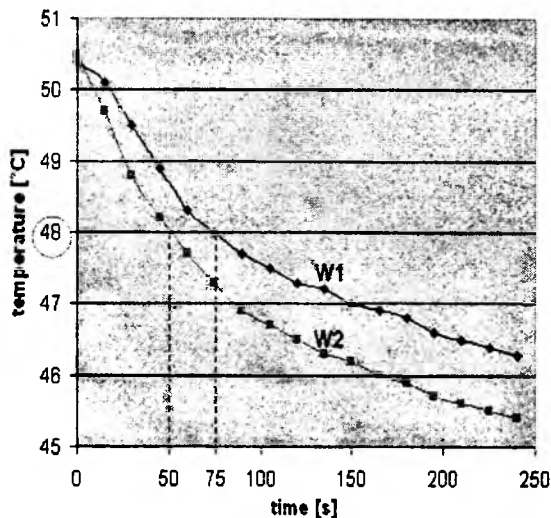


Fig.3. Measured windings temperature values in dependency on the time

Discussion to the measured data

By comparing the measured refrigerating curves on the top part (W1) and on the middle part (W2) of the same winding's phase, we came to some conclusions.

Both parts show different refrigerating curves. It is mainly caused by the level of distribution of the oil temperature rise and the winding's surface with respect to the ambient along the height of the transformer. According to Fig.2 it is temperature difference 2 °C between optical sensors W1 and W2, which was measured on surface of tank by thermovision camera.

When decreasing the selected temperature $\vartheta = 48$ °C (which represents approximately 60% of the amount of exponential curve), we determined the cooling time for the W1 $t_1 = 75$ s and for the W2 $t_2 = 50$ s from the graph.

By comparing these two values using the equations (2) and (12) we found out on the top part of the windings (W1) 1,5 times higher stress of the mechanical strength caused by temperature shocks (short-circuit currents) than on the middle part of the windings (W2). That is also proved in the following equation:

$$a = \frac{A_1}{A_2} \div \frac{t_2}{t_1} = \frac{75}{50} = 1,5 \quad (1)$$

where a – multiple of short-circuit strength,

A_1, A_2 – damping coefficients at cooling process,
 t_1, t_2 – cooling time.

It is obvious that the top part of the windings will be the most heavily stressed by the effects of temperature degradation by operation or short-circuit currents.

Conclusion

By the experimental measurements and following analysis we showed the practical thermovision for diagnostics of power oil transformers in field mechanical strength of winding. It is obvious that the total temperature shock degradation is given by several factors – the grade of the windings mechanical strength, the insulation quality, but also the oil viscosity in the transformer tank.

Acknowledgments

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