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Thermal Control of Power Transformers

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Abstract *— In this article, the control of the heat system of Transformers is analyzed by the example of autotransformers. Concepts are also given about the types of heat dissipation and their control.*

Keywords — power transformer; oil pumps; filters; fans; internal heating**;**

Introduction

The thermal control in relation to the power transformer is a complementary diagnostic method that provides along with traditional methods (measurement of insulation characteristics, no-load current, gas chromatographic analysis of the composition in oil, etc.) [2]. Experience with IR-diagnostics of power transformers has shown that it can help to reveal the following error:

1. The emergence of magnetic stray fields in the transformer due to insulation failure of individual elements of the magnetic circuit (console, studs, etc.);
2. Violation of the cooling systems (oil pumps, filters, fans, etc.) and an assessment of their effectiveness;
3. Change the internal circulation of oil in the transformer tank (formation of dead zones) due to dead zones, structural failures, swelling or bias winding insulation (especially transformers with a long service life);
4. The internal heating coils NO contact connections with transformer leads;
5. The circuit of coil windings embedded in CT;
6. Deterioration of the contact system Load adjustment some performances, etc.

Infrared Capabilities diagnostics applied to transformers insufficiently studied. The difficulty lies in the fact that, firstly, the heat in the event of local defects in the transformer "muted" natural heat flow from the coils and the magnetic core, and, secondly, the work of cooling devices, rapid oil circulation as it smooths out the temperature, appearing in place of the defect [1].

In the analysis of infrared diagnostic results must take into account the construction of transformers, the method of cooling coils and magnetic circuit, the conditions and duration of the operation, production and other factors technology.

Since the assessment of the internal condition of the transformer thermal imager is performed by measuring the values of the temperatures on the surface of the tank it is necessary to reckon with the heat and the nature of the magnetic coils. Additionally, heat sources are:

1. Massive metal parts of the transformer, including the tank, the press rings, shields, pins, etc., in which heat is generated due to the additional losses from eddy currents induced scattering fields;
2. Live parts bushings, where heat is generated by current-carrying part of the losses in the transition resistance connector tap winding; load adjustment contact switches [3].

Heat transfer conditions, the nature of the temperature distribution in the transformers of various design in detail in the technical literature. As applied to transformers, the most common designs with natural circulation of the oil (refrigeration system M and D) temperature change on the nature of the transformer height and in the horizontal section is shown in Figure 1.

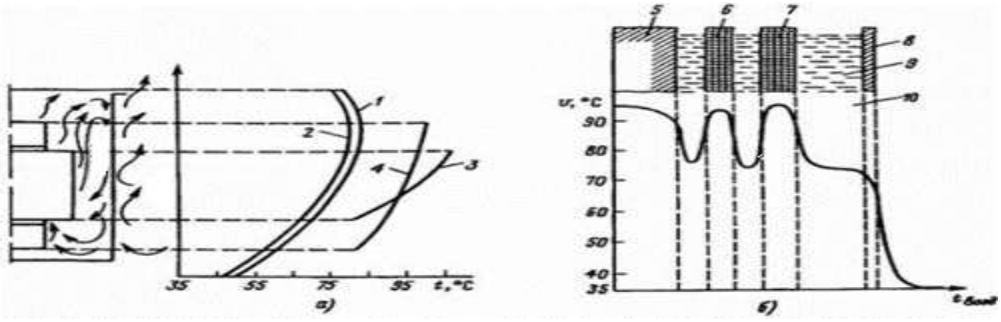

Figure 1. The character of the temperature change in the power transformer:
and - changes in temperature adjustment; b - the temperature distribution in a horizontal section; 1 - oil temperature; 2 - the temperature of the tank walls; 3 - winding temperature; 4 - magnetic temperature; 5 - magnetic wire; 6 - LV windings; 7 HV winding; 8 - the tank wall; 9- oil; 10 – air

Retraction of heat loss from the core and windings, and the oil from the latter to the cooling system is accomplished by convection. heavy oil movement zones are present only in the transformer tank surface where heat transfer occurs. The rest of the oil in the transformer tank is in relative rest and in motion or when the load changes the temperature of the cooling air [4].

In accordance with paragraph 5.3.13 PTE temperature of the upper layers of oil at rated load should not exceed:

• 75 ° C in transformers and reactors with cooling DC;

• 95 ° C in transformer oil cooled with natural cooling and D; At 70 ° C with cooling transformers C (at the inlet of the oil cooler).

• According to the transformers cooling systems M and D the difference between maximum and minimum temperatures for the transformer height is 20 - 35 ° C.

The temperature difference along the height of the oil tank in a transformer cooling system and DC C is in the range 4-8 ° C. However, despite such alignment oil temperature at the height of the tank, the heat transfer from the coil is still done by natural convection oil. This means that the temperature of the coil windings in the upper part is considerably higher than at the bottom.

Thus, if a transformer with natural circulation of the oil temperature of the upper layers of oil and the temperature is approximately equal to the upper winding channels, the transformer with forced circulation of oil in the tank would be a significant difference between the oil temperature in the upper channels of the windings and the temperature of upper layers of oil in tank. Therefore, in transformers with natural and forced circulation of heated oil is the most top of the coil windings, which is aging faster insulation than the lower coils.

It is noted that in the evaluation of heating oil in transformers should consider the possibility of stagnation of the upper layers of oil and increased heating if the distance between the tank lid and nozzles radiators or coolers large (more than 200 - 300 mm). Thus, in the discharge cover "coffin" the oil temperature is below the top of the cover may be greater than the oil temperature at the upper cooling nozzle about 10 ° C [1].

The results of chromatographic analysis of the oil tank of the AODTSTN-267000/500

Table 1

Date of measurement	Gas content,%		
	CH_4	C_2H_6	C_2H_4
February (2019)	0,15	0,035	0,039
September(2019)	0,4 0,54 0,67	0,05 0,09 0,01	0,13 0,12 0,08

Note: The measurements were carried out for phases A, B, C.

The above temperature settings for individual transformers structures characteristic steady state operation. When conducting diagnostic PC- transformers must be considered that the time constant relative winding transformer oils of different performances is within 7.4 min and the time constants of the entire transformer - in the range of 1.5 - 4.5 hours Steady heat mode transformer windings on occurs within 20 - 30 minutes and smoothly through 10-20hrs. In view of the above temperature conditions of transformers below is an attempt to define the conditions to assess their condition during PC diagnosis.

The following are the some of the data that were obtained by the IR control of two autotransformers type AODTSTN-267000/500 and ATDTSTN-135000/220 . In the first case, all three phase autotransformer gases were detected: methane, ethane, ethylene, progressing with time (Table 1.).

Thermographic inspection phase autotransformers revealed temperature anomalies at phase autotransformer tanks, heat a large number of bolts in the bottom of the tank bell port. Opening tanks autotransformers phase revealed the following defects:

1. Darkening plates from overheating at the junction of sill to the lower magnetic consoles;
2. Earthing stud guide the lower tank bottom HH console adjustment rod near the autotransformer (AT);
3. Darkening from overheating and partial melting of washers, plates and bolts in place of touching the bottom console HH.

The type autotransformer ATDTSTN-135000/220 for a long time in the oil gassing occurred. I showed them to read as follows (Table 2) Chromatographic analysis of gases in the oil.

The rate of growth of hydrocarbon gas was methane - 7% for 2 months, for ethylene -. 13% for 1 month. As a result of thermographic examination revealed: the heating of the lower connector bolts AT bells in the middle part, abnormal heating of the walls of the tank AT Phase C, from both the 110 kV and 330 kV side. Thermographic examination is carried out before an internal examination AT revealed about ten magnetic pins with damaged insulation, some of which have not been restored at the time of thermal recording.

The results of chromatographic analysis of the oil from the tank ATDTSTN-135000/220

Table 2

Date of measurement	The content of gas						
	H_2	CO;	CO	CH_4	CA	CA	CA
25.04.2019	0,004	0,24	—	0,0066	0,0056	—	0,002
17.06.2019	0,0035	0,33	-	0,0076	0,0071	—	0,0026

Experiments on models have shown that with the infrared control in some cases can be detected in local heating transformer tank associated with the local overheating of individual coil windings; overheating of contact connections taps of windings; formation of stagnant zones of oil caused by the swelling of the paper insulation of coils, sliming or structural failures.

Overheating of coils (usually extreme), due to the presence of stray fields in transformers, depending on the rated power of the transformer, by which the loss of up to 30 - 50% core loss.

Conclusion

Significant influence on the temperature distribution on the surface of the transformer tank have a constructive measures used by the manufacturer to equalize the losses in the transformer windings. The uneven distribution of these losses on the winding can be one of the causes of local overheating, causing accelerated aging of insulation of separate coils or winding turns, as well as the emergence of local heating on the transformer tank wall.

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