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SPECIFIC OPERATION CONDITIONS OF POWER TRANSFORMERS AND REASONS FOR THEIR FAILURE

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Abstract: the work is devoted to specific operating conditions analysis of power transformers are placed on rural substations and main reasons their structural elements are damaged, as well as to identify the operational impacts that affect the structural reliability of the main elements of power transformers.

Keywords: power transformer, windings, magnetic circuit, defect, operational impact, diagnostic feature.

Power supply reliability is a determining factor for normal operation of electric motors are set in technological equipment. An accident-free supply of electricity to consumers depends to a greater extent on the reliability of the power supply system generally and power transformers 10/0,4 kV particularly. The power transformers failure in agricultural industry is 8-10% annually. The reasons are specific operating conditions of power transformers – asymmetrical phase loading, load schedule depending on season, fluctuations of environmental temperature, long transmission lines and economic situation [1, p.19]. Almost 70% of power equipment has ran out of their resource. Although the power transformers shutdowns in agricultural industry remains small but only one power supply failure can cause significant economic losses due to under-production and services of dozens of energy objects.

The main reasons the power transformer's breakdowns are short circuits in power grids, overloads, atmospheric overvoltage, poor quality of transformer oil, deterioration of cooling conditions, load asymmetry. A great distance from service centers and dispersion over a large area plays a significant role in reliability of rural power transformers. They are practically not serviced on a regular basis, there is no information on the current modes of their operation, the reconstruction of substations and grids is not timely and in insufficient volumes. A considerable part of rural power transformers has worked out its 25 years' resource but renovation due to economic conditions is going slow. For example, only 1.2% of transformers are upgraded yearly in Melitopol district (Ukraine).

Damage analysis of power transformers 63-250 kVA over the last 3 years shows as a percentage the following indicators: high-voltage bus damage – 21%; windings and insulation damage – 57%; damage or transformer oil flow – 9%, magnetic circuit damage – 4-5%. The most significant consequences are observed in such defects as: reduction of high-voltage bus terminal electrical strength; wetting, pollution and deterioration of the winding insulation.

It should be noted the proportion of power transformers damages, accompanied by internal short circuits with transformer's winding damage is about 50% of the total number of accidents after 10 years of operation, 60% – after 20 years and 61% – after 25 years [2, p.26]. The number of power transformers in Ukraine with a lifetime of more than 30 years is increasing – the share of such equipment is now 50% and in the next five years it will increase by another 20%.

The reliability problems of power electrical equipment can be divided into structural and operational [1, p.20].

The structural defects of individual components of power transformers include insulation defects, the manufacturing imperfection of windings and magnetic circuits. Consumers cannot to influence the structural reliability and the only way to improve equipment reliability is increasing an operational component.

The power transformer reliability is largely depending on its windings' reliability, which depends on the state of conductive material insulation. Under the influence of

operating modes, the initial manufacture defects of power transformers are further developed. The natural aging processes of insulation under the influence of operational factors play a decisive role. Thermal insulation wearing is crucial and causes both local winding insulation defects and complete transformer short circuits and failures at last.

Ambient temperature and solar radiation are the most common factors affecting power transformers. The air temperature fluctuates both during the day and during the season. Increasing the ambient temperature directly causes the insulation to overheat, intensive wearing and its destruction, phase short circuit, failure of the power transformer (Fig. 1).

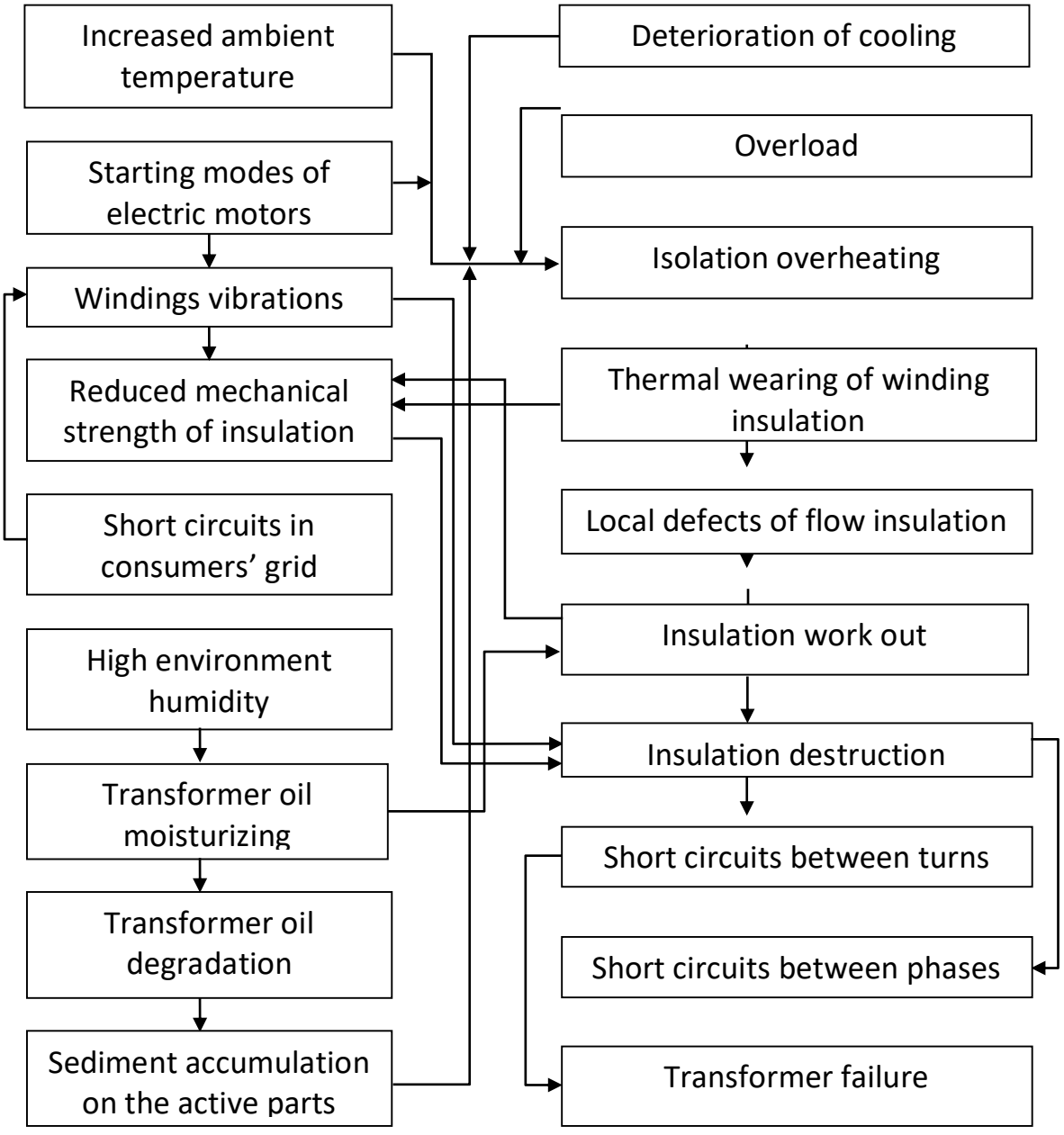

Fig. 1. Scheme of power transformer elements damage

Environmental humidity affects the transformer oil insulating properties, the moisture content of the oil, the accumulation of oxygen in it, the aging of transformer oil, the accumulation of sediment on the active parts of the transformer construction, the reduction of insulation mechanical strength and, most importantly, the wearing of insulation [3, p.64].

During the transformers operation, gases accumulate in the oil – they characterize certain types of defects in the transformer. Hydrogen H_2 is characterized by electrical defects (spark and arc discharges in oil); acetylene C_2H_2 – overheating the active elements; ethane C_2H_6 – thermal heating of oil and solid insulation of windings in the temperature range up to 300 °C; ethylene C_2H_4 – high-temperature oil heating and solid insulation of windings above 300 °C; carbon monoxide CO and carbon dioxide CO_2 – overheating and discharges in solid insulation of windings.

The next operational impact is transformers overloading. The load schedule of power transformers depends on many factors – seasonality of work, number and type of consumers, etc. Power transformer overloads may also be related to the poor design of power grids, the lack of automation and load control for most powerful consumers of electricity.

Dangerous operational influences on power transformer isolation are starting currents of powerful electric motors in terms of their measurable power output, short circuits and switching overvoltage in power grids.

Systematic overloads of transformers, dynamic stress due to short circuits and insulation degradation lead to short circuit and failure of the transformer.

Deterioration of cooling conditions is also one of the most common causes of transformer failures. It occurs due to the transformer oil leakage, insufficient ventilation.

The factors mentioned above can affect both individually and collectively in different combinations. It affects the insulating structure reliability of power transformer windings. Power transformers damage can also be caused by: damage to the protection system, fuzzy adjustment of the switching device, terminals pollution, poor quality of transformer oil, poor condition of terminals at the point of connection.

Further analysis should consider the cause and effect relationships of the reasons why the power transformer fails. The structural reliability of the transformer is not decisive in insulation damage processes development. Natural processes of its degradation under the influence of operational factors play an important role. Most of the factors lead to gain an insulation heating, which causes an increase the rate of thermal wearing.

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