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Analysis of overvoltages in transformer windings with considering of distributed parameters

Abstract. *The procedure of mathematical model forming intended for electromagnetic processes analysis in Transformers when distributed parameters are taken into account is presented. Problems of calculation of the equivalent circuit parameters and solving of partial differential equations are discussed.*

Keywords: transformer winding, distributed parameters, mathematical model

Overvoltages appearing during fault and switching processes are different and higher from those which are used for analysis of transformer insulation properties. Therefore the problem of electromagnetic processes analysis in power transformers when distributed parameters should be taken into account must be solved.

In order to define the necessary of electromagnetic processes analysis when distributed parameters should be considered the following criterion was selected: it is the relation between travelling time of the electromagnetic wave along with the whole length of transformer winding and time interval when current and voltage deviates considerably. In the transformer windings if pulse voltages and currents are applied the time of voltage and current deviation is equal to the travelling time of the wave along winding.

Insulation of high voltage transformers must ensure their non-fault operation both during long-lasting voltage applying and short lasting external and internal overvoltages [1].

To make a proper choice of insulation gaps it is necessary on the stage of their design to compare root-mean square and allowed voltages at different insulation gaps.

The voltage distribution when pulse voltages are applied depends on transformer geometry and parameters of windings. It is caused by oscillations of the voltage in windings. The voltage amplitude and frequency depend on inductive and capacitive coupling both in windings and between them. Therefore the impulse voltage distribution is special for different constructions of transformers, so it is necessary to analyze the voltage distribution in windings for each transformer on the stage of its design.

Calculation of capacitive parameters for the equivalent circuit is carried out if coils are elements of the windings. Later according to the accepted splitting of the winding on separate elements obtained capacity of the coil is coupled with corresponding element which contains this coil.

A lot of attention is paid to the correct calculation of magnetic coupling considering the mutual induction between all elements of the winding under research.

When inductive parameters of the equivalent circuit, self and mutual inductances are calculated for all elements which are analysed usually the skin effect and the transformer core influence on the pulse process in the winding are neglected.

Equations containing just one variable, for example, u(x, t) and describing the wave processes in the transformer windings were obtained using the equivalent circuit of the transformer winding with considering of all inductive and capacitive couplings in windings and between them [2].

In order to solve such equations the method of separation of variables was used [3].

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