EVALUATION OF QUALITY OF INTERLAYER INSULATION OF LAMINATED MAGNETIC CORES BY HIGH-FREQUENCY EFFECTS

Chumack V.V., Ph.D., Associate Professor, Kotliarova V.V., Assistant, Ihnatiuk Y.S., Postgraduate Student
Igor Sikorsky Kyiv Polytechnic Institute, Department of Electromechanics

Method of quality control of laminated magnetic cores. Due to the fact that to control the state of the sheet insulation in most cases it is impossible to use electrical methods, the most promising is the induction method [1].

When a harmonic or pulse effect is applied to the system under study, voltage, current, and power measurements are required to obtain results for each harmonic, making this operation difficult. Therefore, when directly measuring losses, it is promising to try to find a physical quantity that could be used as an information signal. Since when the interlayer insulation is violated, first of all the eddy currents in the magnetic circuit increase, the signal must characterize the intensity of the eddy currents along the defective circuits.

The task of control is the general estimation of interlayer isolation which, in the presence of defects causes increase in losses on eddy currents. It is also necessary to assess the presence of local defects of the toothed zone: superficial short circuits of the core sheets, local violations of the interlayer insulation, which cause an increase in local strata and local overheating.

The closure of the sheets due to various types of damage to the sheet insulation creates the effect of a massive magnetic core, which is manifested in the fact that in the core assembled from individual sheets without sufficient insulation between them there are additional eddy currents, which are closed by defective circuits. As a result, to determine the quality of the laminated core, we use the evaluation of the influence of the parasitic circuits of eddy currents on the degree of approximation of the laminated magnetic core to the massive core of the studied core or in its local area [2].

The analysis of the transient process when changing the magnetic flux in the magnetic core or in areas of local defects is used. Both the process of switching on and the process of switching off the excitation winding can be used for research.

The use of transient analysis to evaluate the core of an electric machine is achieved by the fact that in the magnetic core or in its area by means of an excitation winding through which a direct current flows, an initial magnetic flux is created, which at the time of the test is limited by switching should be less attenuation time of eddy currents in the magnetic circuit. It is this initial magnetic flux that determines the parameters of the transient process. Its magnitude is responsible for the excitation current, the switching time of the excitation current, the damping actions of the eddy currents that are closed inside each sheet, and the parasitic contours of the eddy currents [2].

High-frequency processes in the magnetic core of an electric machine. In General, the method of eddy currents is based on recording the change in the interaction of the intrinsic electromagnetic field of the winding with the electromagnetic field of the eddy currents induced by this winding in the investigated core [3].

The essence of the high-frequency method is based on the fact that a small winding is applied to the investigated core, which is fed by a high-frequency current. Under the action of the primary electromagnetic field of the winding in the steel there are eddy currents that flow in the surface layers of the material in annular concentric circles (Fig. 1). The average diameter of the trajectory of eddy currents depends on the diameter of the winding (1 - 1.6 diameter of the winding). The magnitude of the excitation current depends on the magnitude and frequency of alternating current, material properties, electrical conductivity, magnetic permeability, the relative position of the winding and the core, as well as the presence of inhomogeneities in the magnetic circuit. The higher the excitation current frequency, electrical conductivity and magnetic permeability of the material, the smaller the depth at which eddy currents can occur in electrical steel. These eddy currents create a secondary electromagnetic field in a certain volume of material, the direction of which is opposite to the primary field. As a result, eddy currents affect the impedance of the excitation winding, which is in close proximity to the investigated magnetic core. When using the measuring winding, you can also get information about the nature of eddy currents by the magnitude of the EMF, which is induced by the electromagnetic field of eddy currents and is proportional to them.

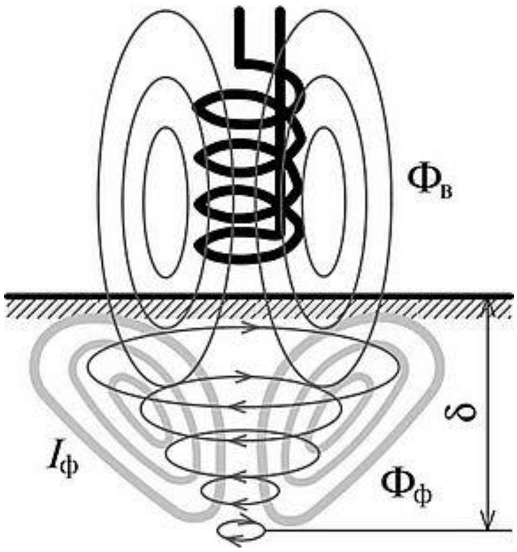

Figure 1 – The principle of operation of the high-frequency control method:
$\Phi_в$ – exciting magnetic field, $\Phi_ф$ – induced electromagnetic field, $I_ф$ – eddy currents, δ – depth of penetration [4].

Thus, the current flowing in the winding carries information about the test core and the presence or absence of defects. The characteristics of the secondary magnetic field are determined on a sample without defects of a similar material [5, 6]. If the excitation winding is placed above the defect, the nature of the eddy currents will change: instead of one vortex field in the presence of a defect, two fields appear (Fig. 2). The proper field created by the separate eddy currents will not have the same characteristics as when the winding passes over the undamaged area.

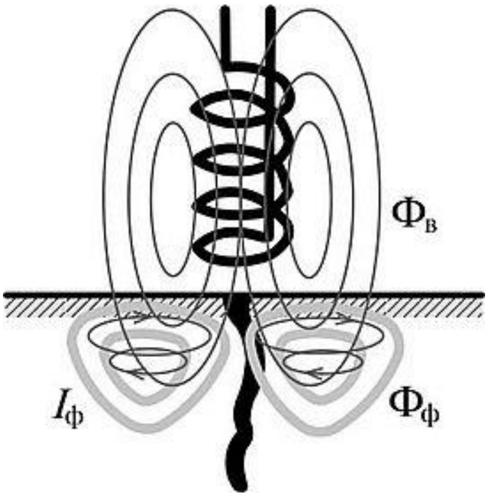

Figure 2 – The principle of operation of the high-frequency method of control in the presence of a defect: $\Phi_в$ – exciting magnetic field, $\Phi_ф$ – induced electromagnetic field, $I_ф$ – eddy currents, δ – depth of penetration [4].

The control of eddy currents is determined by the following factors:

- properties of the studied core (size, electrical conductivity, magnetic permeability, the presence of defects;
- characteristics of devices for research (frequency of alternating current, its arrangement concerning the investigated core [6].

Conclusions. The proposed method of high-frequency analysis of processes in the laminated magnetic core allows to detect interlayer short circuits with a sufficient degree of reliability associated with the measurement of specific losses in steel.

High-frequency methods allow to detect the deterioration of the sheet insulation by measuring the parasitic contours of eddy currents.

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