COMPREHENSIVE ASSESSMENT OF THE QUALITY OF THE AC MACHINE STATOR BY ELECTROMAGNETIC AND VIBROACOUSTIC METHODS

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Introduction. Electric machines have found application in manufacturing, home appliances, training equipment, etc. Prolonged operation in various operating modes leads to machine aging and defects. Defects also occur with poor quality materials used in the assembly and manufacture of the machine. The state of the machine is also affected by the breach of manufacturing technology, which causes its performance to deteriorate [1, 2].

The occurrence of defects or the sudden failure of the machine can result in the shutdown of the entire enterprise and result in significant monetary losses. Therefore, there is a need for comprehensive diagnosis of all units of electric machines.

The urgency of the problem of assessing the quality of interlayer insulation in magnetic core is that most of the known methods are not convenient, since they require a lot of time to be used at repair shops, and the absence of special necessary equipment makes it necessary to abandon standard methods. Creating a new, much simpler and faster method will solve this.

The purpose of the research work is to develop the methods for a comprehensive assessment of the quality and the production of a prototype device for monitoring the state of the magnetic core of electric machines.

Main part. In this article some methods of investigating the defects of active steel of asynchronous general purpose motors have been analyzed, considered and used, and a new method for determination the quality of interlayer isolation is proposed, based on a combination of high frequency and vibroacoustic method for assessing the quality of the state of interlayer isolation [3].

Induction method of laminations analysis. The principle of the method is the reaction of the measuring coil to the magnitude and phase of the eddy currents that occur in a metal product (core) when it (or part of it) is placed in an alternating magnetic field. The exciting and measuring coil can be separated, or it can be the same coil [5]. With a harmonious or pulsed action on the controlled system, to obtain the results, each harmonic requires phase shift measurements, i.e., processing of voltage, current and power signals, which complicates the control operation. Due to the indicated difficulties in direct measurement of losses, an attempt to find a physical quantity that can be used as an information signal is promising. Since in the event of a breakdown of the inter sheet insulation [4, 6], eddy currents in the magnetic core first of all grow, the desired signal should characterize the intensity of the eddy currents along the defective contours. It was proposed to use the analysis of the transient process when the magnetic flux changes in the magnetic core. Scheme of the study of active steel by the wattmeter method show in Figure 1.

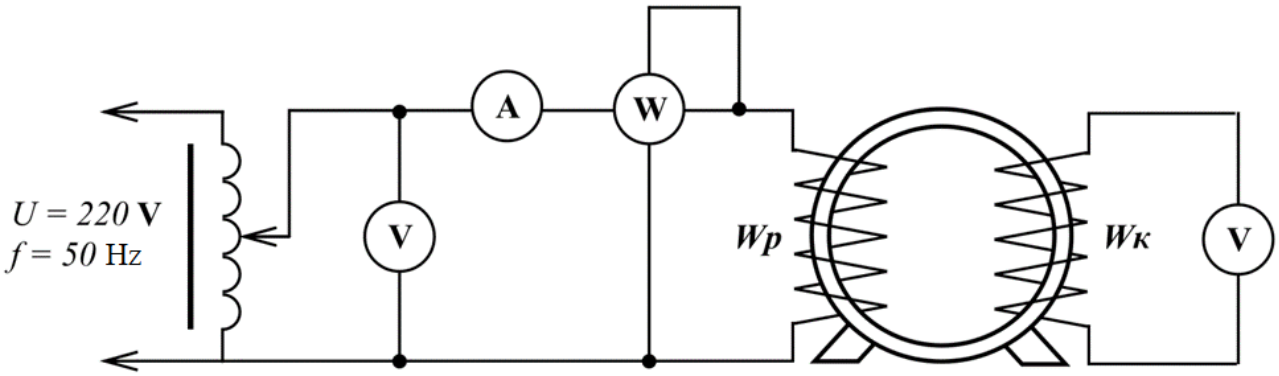

Figure 1 – Scheme of the study of active steel by the wattmeter method.

The closure of the core sheets among themselves as a result of various kinds of damage to the inter-sheet insulation creates a “partial effect of a massive magnetic core.” This effect is manifested in the fact that in the core, assembled from separate sheets without sufficient isolation, additional eddy currents appear between them, which are closed along defective contours.

So, an indicator of the quality of the dialed core can be an assessment of the influence of stray eddy current circuits on the degree of approach of a charged magnetic core to a massive core in the entire volume of the test core or in its individual parts. This goal is achieved by the fact that in the magnetic circuit or in its part with the help of the exciting winding through which direct or alternating current of low frequency flows an initial magnetic flux is created.When the steady-state flux reaches a value, the current in the field winding is cut off.

Vibroacoustic method of laminations analisys. The essence of shock vibrodiagnostics consists in the excitation of vibrations in the studied node using an external shock pulse and in the further measurement and analysis of the received response. In this case, the response spectrum is determined mainly by the resonance properties of the object of study, while the spectrum of vibrations measured during functional vibration diagnostics depends on the operating mode of the equipment under study at a given time and may contain strong additional frequency components that are not related to the technical characteristics of the object of research. Thus, the main advantage of impact diagnostics is that it makes it possible to determine the main resonant characteristics of the studied node [7]. Currently, there are shock vibration diagnostics systems designed to diagnose various components of industrial equipment, and the vast majority of such systems are based on a deterministic approach. Scheme of the study of active steel by the vibroacoustic method show in Figure 2.

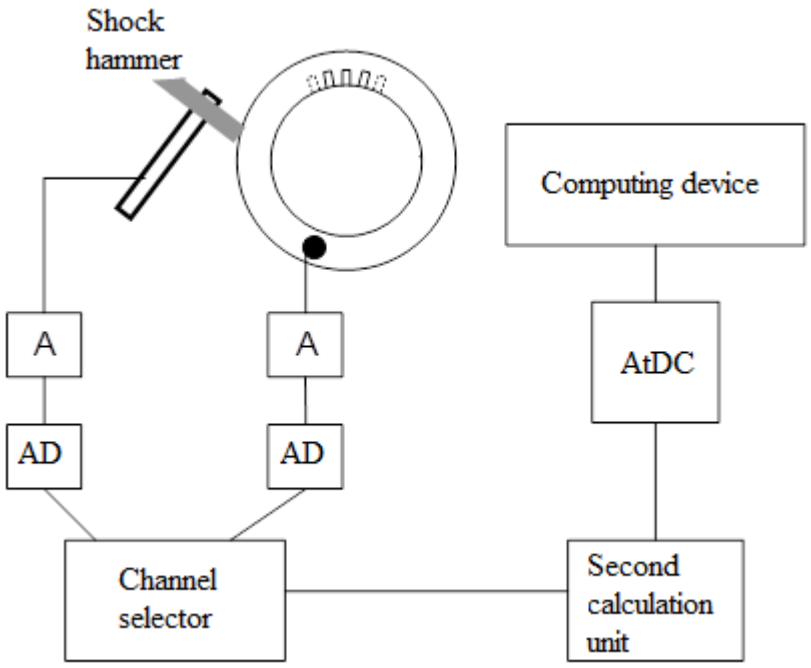

Figure 2 – Scheme of the study of active steel by the vibroacoustic method

The method for assessing the quality of an AC machine stator in actual condition. In order to combine the two methods, an installation was developed that allows simultaneously checking the quality of pressing and the quality of the inter-sheet insulation. The given spectrum of mechanical vibrations shows that the most informative zones are in the range of 500-700 Hz [8]. It is necessary that the initiated electromagnetic process of switching current in the field of excitation be synchronized with the onset of mechanical action. Scheme of combined method show in Figure 3.

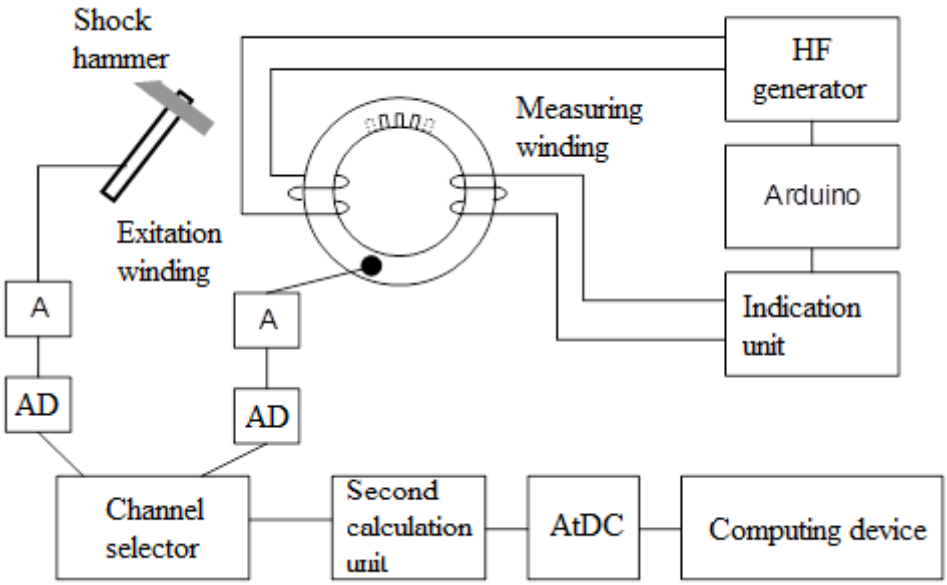

Figure 3 – Functional scheme of a system of compatible diagnostics quality interlayer insulation and the degree of compression of the magnetic circuit.

With the combined action of vibrational and pulsed electromagnetic effects, the following results were obtained:

1) In the case of high-quality inter-sheet insulation and high-quality pressing, the decay time constant of eddy currents remains unchanged at about 50 μs, which corresponds to normal specific losses of 2.8-3.2 W / kg. The magnetic core is suitable for operation.

2) In the case of high-quality insulation and with weakened pressing, the decay time constant of eddy currents remains relatively constant at 50-60 μs, which corresponds to the specific loss of 2.8-4 W / kg. The number of resonant peaks increases to three or more. The magnetic core requires technological operations to eliminate excessive fluffing.

3) In the case of a significantly broken insulation and simultaneous fluffing of the magnetic circuit, the decay time constant of eddy currents is 130 μs, which corresponds to the specific loss of 8-10 W / kg. In the absence of mechanical shock, the eddy current decay time constant is 80 μs. The magnetic core is not suitable for operation

The new method for assessing the quality of an AC machine stator in actual condition. The idea of the method is as follows: each eddy current, when flows, creates its own magnetic flux, flows from eddy currents to interact with the main magnetic flux, and since these flows are directed towards each other, then there is a weakening of the resulting magnetic flux. Thus, since the loss of eddy currents in the damaged magnetic core is increased, then the stronger weakening of the magnetic flux [7, 8] can be observed.

In order to obtain more illustrative and expressive results, the researchers suggested conducting measurements at frequencies above 50 Hz, from 1 Mhz to 250Mhz. Because superficial effect shows on frequency higher than 50Hz (network frequency) and losses will increase in quadratic law. In this case, it is useful and the benefit of it is that, with the surface effect, eddy currents will be concentrated near the edges of the sheet and the flows from these currents will be stronger. As a result, the resultant flow will be further weakened. With increasing frequency there are two opposing tendencies. The first one – with increasing frequency, linearly increasing loss of hysteresis, and losses on eddy currents grow quadratically, and the second trend – the surface effect appears, which leads to a decrease in the active section of the sheet of the magnetic core. As a result, the flow and losses also decrease. Therefore, it is not enough simply to ask a high frequency value, but it is necessary to determine the most suitable values of the frequency at which the demagnetizing effect from eddy currents is the most obvious.

It is proposed by researchers to use a technique based on the effects of eddy current and surface effect at frequencies higher than industrial. We need to carry out the measurements on two values of the frequency with maintaining the constant value of voltage at the working winding. Then it is necessary to find the relation between the voltage values on the measuring winding at these two points. According to our theory, if f1 and f2 are the frequencies for which the experimental points were removed, where f1 is the frequency corresponding to the larger value of the EMF - E1, and f2 is the frequency corresponding to the lower value of EMF - E2, the value

of the ratio E2 / E1 will be greater for the qualitative magnetic core and, accordingly, smaller for a magnetic core with defects.

It is necessary to find the best frequency values for better measurements. We need to find such values at which the difference between the values of the EMF for a defective and nondefective magnetic core will be significant. To do this, you need to conduct experiments and calculations and identify the following points.

With the use of this technique, the received EMF ratio of the any magnetic core will be compared with the statistical data obtained earlier from magnetic cores with different quality states, and to conclude on the condition of the magnetic core. Thus, the need for reference data disappears, which makes this method rather simple in execution and suitable in use. In addition, in repair shops there are special brackets that can be installed on the back of the magnetic core, and the demand in coil winding on the magnetic core disappears.

Conclusion. The interlayer insulation is damaged during the operation, production of electric machines and repair work.

Therefore, the specific losses in the magnetic core increase more than the nominal estimated losses, so it is necessary to create methods for assessing the actual state of the active steel of electric machines.

The damaging of interlayer insulation primarily leads to the appearance of stray circuits of eddy currents, which at highly increases the specific losses in the magnetic core.

Therefore, an actual assessment of the state of the active steel of electric machines is required to improve its operational quality.

A combination of two assessment methods and sound recommendations for the continued use of electric machines is proposed.

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