VIBRATIONAL DIAGNOSIS OF INDUCTION MOTOR ATD-5000 ROTOR INJURY ON THE BASIS OF DIAGNOSTIC FEATURES ANALYSIS

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Introduction. Vibrational diagnostic devices are a modern tool for control, monitoring and diagnostics of the technical condition of induction motors (IM) with a short-circuited rotor and allow to determine damages in the process of their operation, which reduces the cost of their further repair. In order to build the ideology and algorithms of such control over the vibration sensor signal readings, it is necessary to analyze the physical processes occurring in the IM in the case of damage and to develop methods for detecting the damage in the IM.

The diagnostic system must not only detect the rotor damage, but also identify these types of damage, which requires the construction and justification of an appropriate system of diagnostic features. It is advisable to perform justification of the system of diagnostic features by methods of mathematical modeling. This requires the development and analysis of modern field mathematical models of IM with corresponding defects. This article is a continuation of the article [1]. The dedication of the vibroperturbing forces studying in IM is also devoted in articles [2-5].

The purpose of the work. The purpose of the article is to substantiate the methodology of vibrational diagnostics of short-circuited IM rotors defects on the basis of the system of diagnostic features.

Material and results of the study. The article investigates three-phase IM of ATD type by 5000 kW with short-circuited rotor (fig. 1), operating in nominal regime and the parameters of which are as follows: rated voltage 6 kV, stator current 545 A, efficiency 94,8%, power factor 0,89, rated speed 2985 rpm, number of pairs of poles - 1; air gap - 6 mm; the diameter of the stator bore is 675 mm.

An important component of this mathematical model is the model of vibroperturbing electromagnetic forces [3], which are determined by the Maxwell magnetic tensor, which characterizes the density of the electromagnetic force applied to the unit surface of the stator bore. Taking into account the periodic nature of the change of vibrating excitation forces, it is advisable to perform a spectral analysis of the normal component of the magnetic tensor and to study the individual components of the spectrum. This allows to identify diagnostic features that are appropriate for different types of damage.

Rules of diagnostic of defects of a rotor of IM on the basis of system of diagnostic signs. The conducted researches have allowed to reveal characteristic changes arising both in time distributions of signals of vibration sensors, and in their spectra at occurrence of different types of IM rotor damages. This allows to formulate diagnostic features and appropriate diagnostic rules that allow to identify specific types of damages with sufficient accuracy.

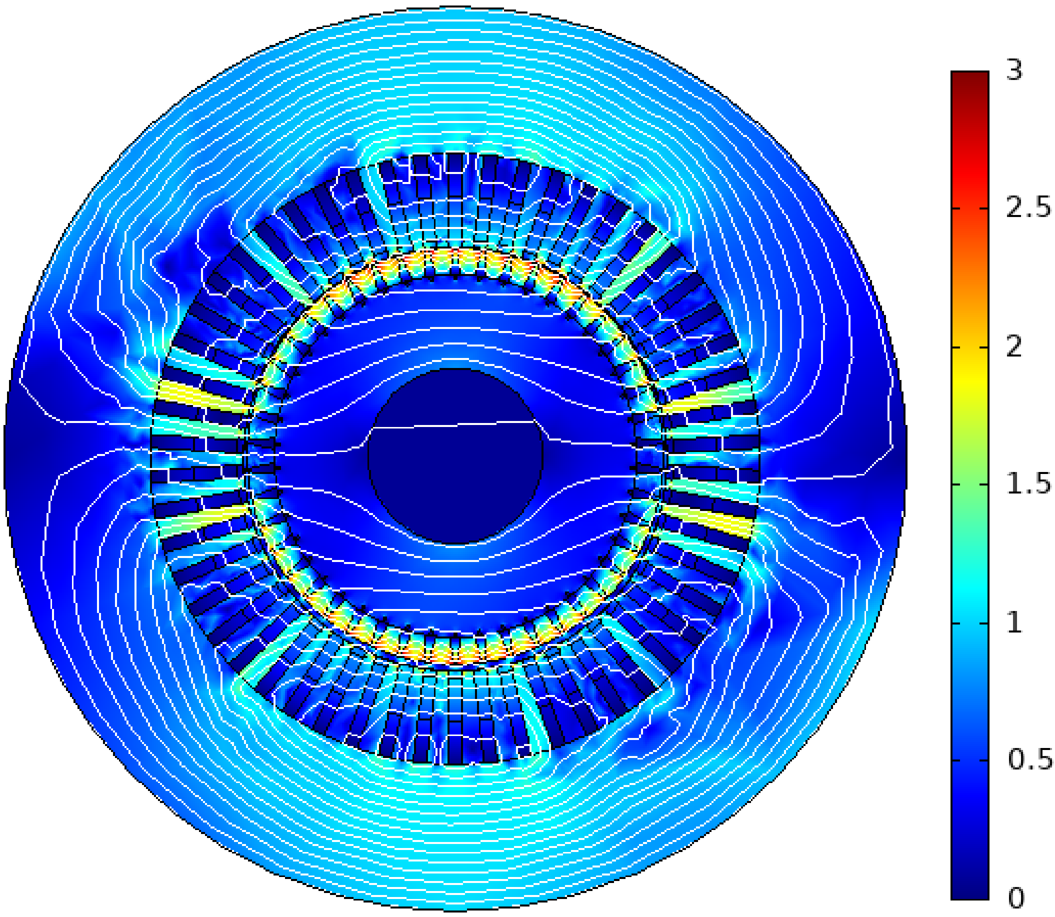


Figure 1 – Distribution of magnetic flux density and lines of vector magnetic potential in ATD-5000, T.

Diagnostic features are divided into basic and additional (tables 1 and 2). The main diagnostic features characterize the changes that occur in the spectra of the vibration sensor signal when there is damage in the IM. In particular, new components of the spectra, which are not present in the spectra of undamaged IM, are recorded and analyzed.

Additional diagnostic features are based on the analysis of the time dependence of the vibration sensor signals and are used in cases where the basic diagnostic features do not accurately characterize the damage and may indicate several different types of damage (for example, a damaged rod or segment of the short-circuit ring of the IM rotor).

Both basic and additional diagnostic features were obtained as a result of mathematical modeling of IM damage using the presented field mathematical model [3].

The formulated set of basic and additional diagnostic features is an orderly consistent system of diagnostic rules, which allows to identify a specific type of the IM rotor damage, is easily algorithmized and embedded in a computerized knowledge base of the vibrational diagnostics system.

Table 1 – The main diagnostic features identified in the spectrum analysis

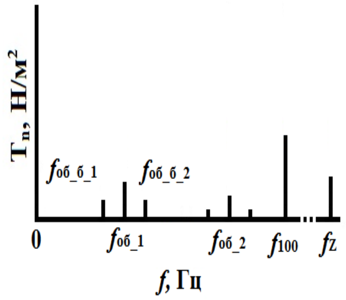
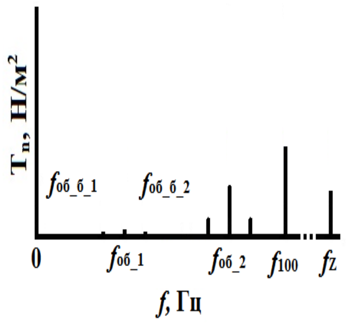
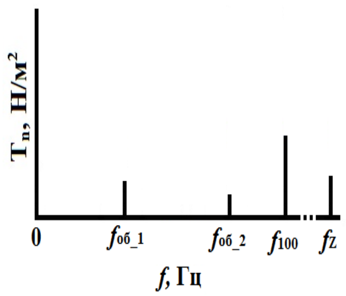
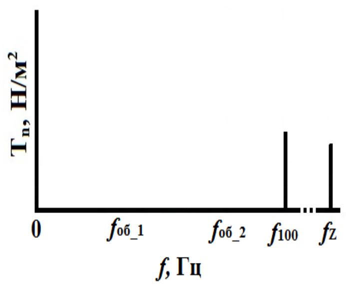
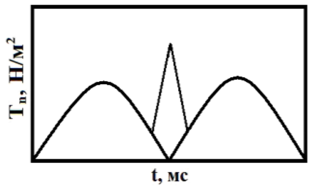
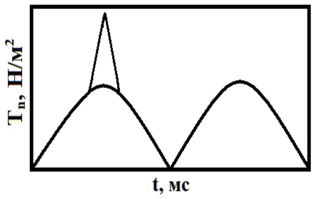
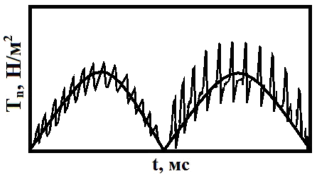
1.		The presence of the first and higher harmonics of the rotational frequency with their lateral harmonics in the spectrum of the sensor signal of the damaged ATD indicates damage to either the rods or segments of the short circuits of the IM rotor winding.
2.		The presence in the spectrum of the significant second harmonic of the rotational frequency at low first harmonic indicates the spatial shift between the damaged rods. At a shift angle α = 180º, the first harmonic of the rotating frequency is absent, and the second harmonic is clearly expressed. The deviation of the change coefficient magnitude of the rotating frequency amplitude from its maximum value, determined for a compact group of damaged rods, indicates a spatial shift between the damaged rods.
3.		The presence in the signal spectrum of the damaged IM vibration sensor the first and higher harmonics of the rotational frequency without their lateral harmonics with increasing the total level of vibration (the value of the change coefficient k_{rms} of the acceleration increases) indicates the existence of dynamic eccentricity. The presence of dynamic eccentricity is also indicated by the increasing the tooth harmonics amplitudes.
4.		The absence in the spectrum of the damaged IM vibration sensor signal harmonics of the rotating frequency and their lateral harmonics on the background of increase of the general level of vibration indicates the presence of static eccentricity. The presence of static eccentricity is also indicated by the change in the amplitudes of the tooth harmonics as the sensor moves along the surface of the stator.

Table 2 – Additional diagnostic features that are determined when analyzing the time dependencies of the vibration sensor signal

1.		The presence in the temporal signal of the vibration sensor of the "signal of damage" peak, located between two adjacent peaks, indicates the damage of the rods of the IM rotor winding.
2.		The presence in the temporal signal of the vibration sensor "signal of damage" peak located on top of one of the maximums of the signal indicates the damage of segments of the short circuited IM rotor winding.
3.		The change in the amplitudes of the tooth harmonics during one rotation of the IM rotor indicates the presence of dynamic eccentricity.

Conclusions. Rules of IM rotor damages diagnostics were formulated on the basis of the system of diagnostic signs which allow to establish correspondence between the type of damage and change of the temporal and spectral characteristics of the vibration sensors signals. Diagnostic features allow to determine the presence of damage and to identify its appearance based on the analysis of the vibration sensor signal temporal distribution or its components.

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