VIBRATIONAL DIAGNOSTICS OF ROTOR STATIC ECCENTRICITY OF INDUCTION MOTOR ATD-5000 ON THE BASIS OF VIBROPERTURBING FORCES ANALYSIS

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Introduction. In the long-term operation of inductions motors (IM), it's often exhibits the eccentricity of the rotor, resulting in significantly deteriorating performance of the machine, in particular, the unevenness of the machine's air gap appears, and electromagnetic vibrations increase [1, 2]. The causes of eccentricity in IM are as the errors in the production and assembly of the machine, as well as unfavorable conditions for its operation. With a static eccentricity (SE), the rotor axis is displaced parallel to the stator axis and does not change in the moment of the rotor rotating. In this case, the stator and rotor axes remain mutually stationary. Due to the small air gap in the IM, even the small eccentricity of the rotor, which breaking the symmetry of the design of the machine, greatly impairs its operation.

Therefore, the problem of timely diagnosis of the SE rotor is relevant. The most effective diagnostic system of the SE is electromagnetic vibration diagnostics - monitoring and analysis of changes in the vibrations of IM electromagnetic origin, depending on the type and degree of development of the SE.

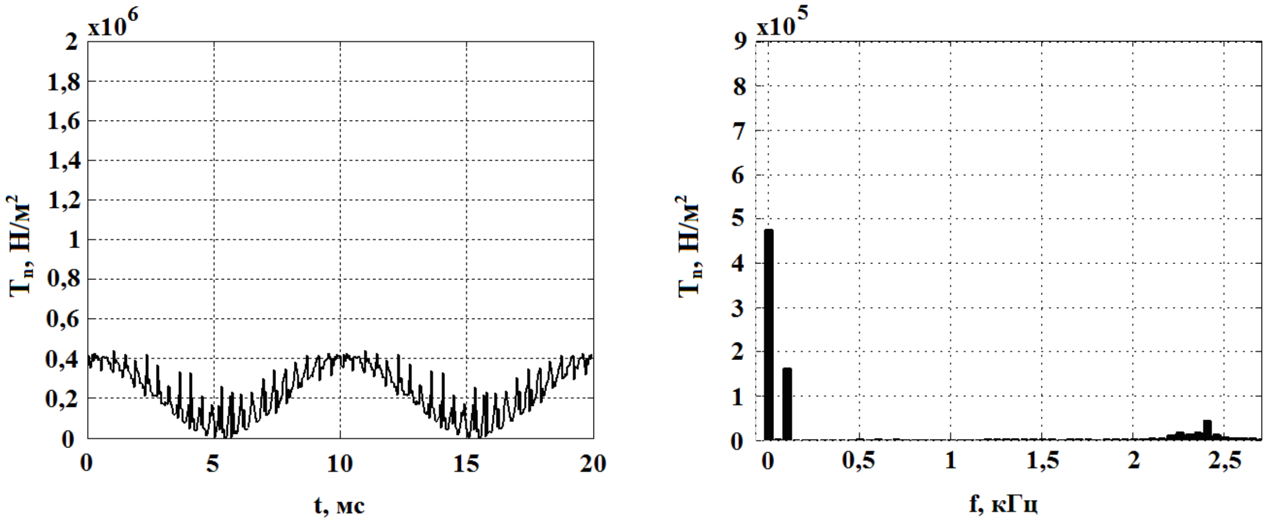
The goal of the work. The goal of the work is to substantiate with the methods of mathematical modeling of diagnostic features of the SE IM rotor on the basis of spectral analysis of signals of vibroperturbing forces.

Material and results of the research. To determine the diagnostic features of the SE IM rotor, a powerful three-phase IM ATD type of 5000 kW power was selected, which has the following parameters: nominal voltage - 6 kV, stator current 545 A, efficiency 94.8%, power coefficient 0.89, nominal frequency rotation 2985 rpm, air gap - 6 mm; inner diameter of the stator - 675 mm.

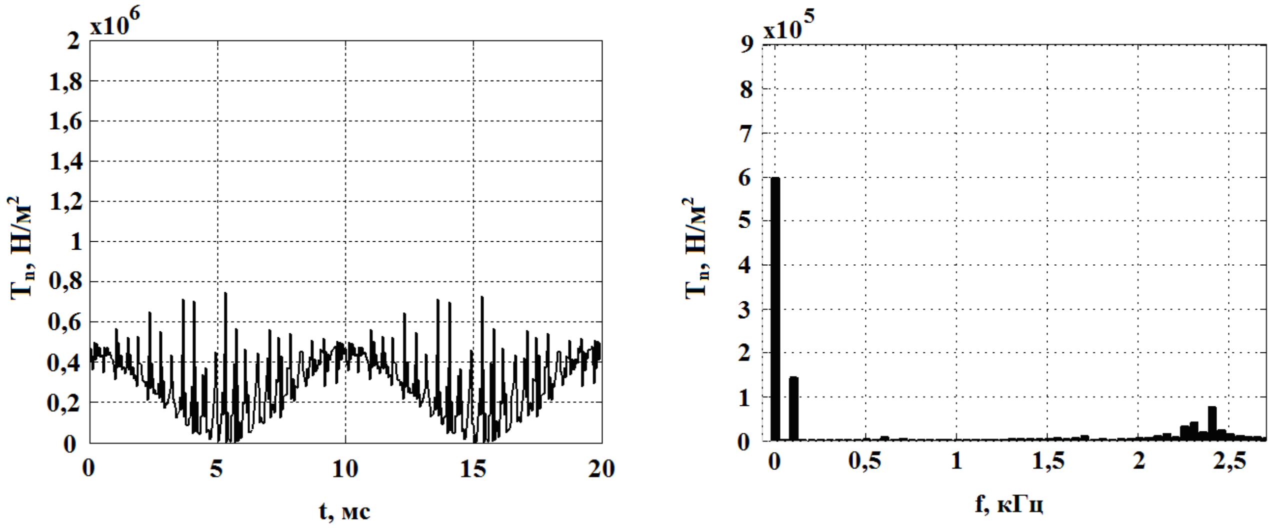
According to the results of the signals analysis of vibroperturbing forces in the IM in the presence of SE, the following results are obtained.

In pic. 1 showed the calculated signals of vibration sensors and their spectra calculated for different eccentricity values ε during one rotor rotation ATD-5000 at the point, located on the inner surface of the stator hole in the minimum region of the air gap.

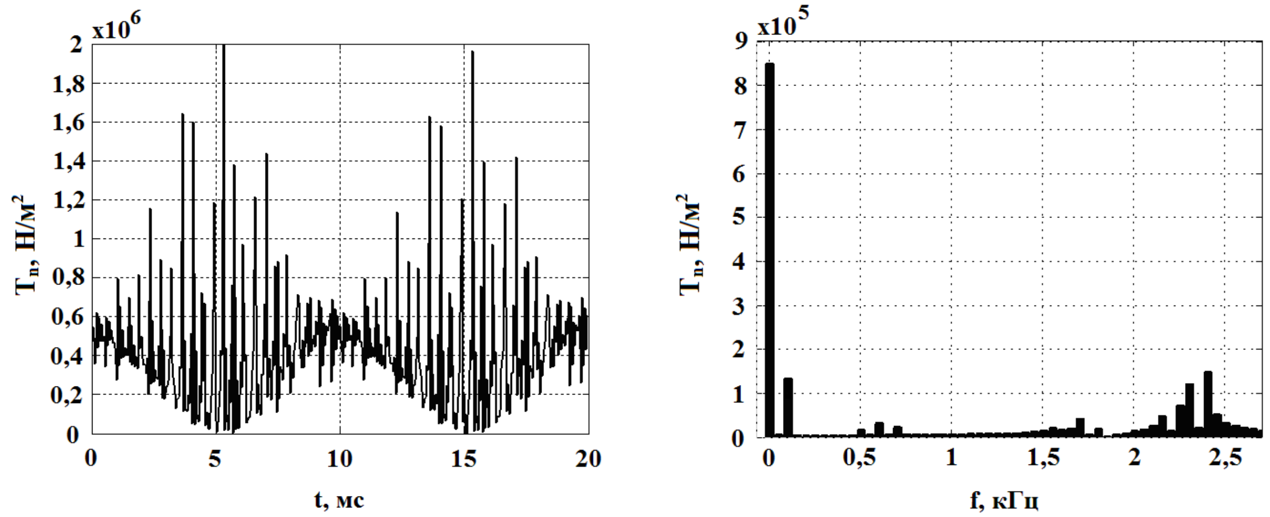
In pic. 1 it is seen that with increasing SE, the amplitudes of the toothed harmonics of the magnetic tensor increase substantially. The magnetic induction increases significantly, which is accompanied by an increase in the toothed harmonics in the spectra, with the appearing of the SE in the minimal gap region Amplitudes of the toothed harmonics (for ATD the frequency of the first harmonic is equal to $f_{Z1} = 2{,}3$ kHz) depend reversely on the size of the air gap at the location of the sensor.



a



b



c

Picture 1 – Signals of vibration sensors and their spectra, calculated at a point with a minimum air gap for ATD-5000:
a - intact ATD, ε = 0; b - SE ε = 0,36; c - SE ε = 0,59.

When the vibration sensor is displaced from the point of the minimum air gap to the point of maximum gap, the amplitude of the toothed harmonics is reduced. Thus, the results of the diagnosis of SE depend on the location of the sensor on the stator and for reliable diagnostics of the SE it is necessary to have at least two sensors, which located in two orthogonal planes.

To analyze the change in the overall vibration level, the coefficient of the change in RMS value of the vibration acceleration spectrum $k_{СКЗ\_a}$ is used, which characterizes the ratio of RMS vibration acceleration spectra of damaged and intact IM:

$$k_{СКЗ\_a} = \frac{\sqrt{\sum_{i=1}^{N} \left| T_{ni\_У} \right|^2}}{\sqrt{\sum_{i=1}^{N} \left| T_{ni\_НУ} \right|^2}},$$

where N - the number of harmonics taken into account in the spectrum; i - number of harmonic; $T_{ni\_У}$, $T_{ni\_НУ}$ - i - th harmonic amplitudes of the magnetic tensor in the vibration spectra, respectively, damaged and intact IM. For example, if ε = 0,59 coefficient of the change RMS of the vibration acceleration spectrum increases to the value $k_{СКЗ\_a}$ = 1,66, that is, the total level of vibration of the engine increases in 1,66 times, which is easily fixed by the system of vibration diagnostics.

With an increase of the SE, in addition to an increase of the total level of vibrations, an increase of the constant component of the spectrum, which depends on the general level of the amplitudes of the toothed harmonics, is also observed. If ε = 0,59 the constant component increases in 1.75 times, with one-sided attraction of the rotor to the stator in the direction of a small air gap. The diagnostic feature of SE is also the absence in the spectrum of the vibration sensor signal of the harmonic of the rotating frequency (49,75 Hz).

Conclusions. With the help of methods of mathematical modeling, was found and analyzed diagnostic signs, that arise in the vibroperturbing forces of IM and its spectra with the appearance of SE. Investigated diagnostic signs can be used in vibration diagnostic systems for detecting SE in IM at an early stage of their development. At the same time for the diagnostics of the SE it is necessary to have at least two sensors installed on the stator in orthogonal planes.

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