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

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Introduction. The operation of induction motors (IM) requires constant monitoring of their technical condition, including checking for the presence of various defects, one of which is the rotor eccentricity. Its appearance in IM significantly impairs the performance of the machine. The reasons for the appearance of eccentricity in IM may be the imperfection of the technological process at the production or assembling of the machine, and unfavorable conditions of its operation.

There are several varieties of eccentricities: static, dynamic, angular, and a combination of these. At static eccentricity (SE), the rotor axis is offset parallel to the stator axis and does not change in time as the rotor rotates. At dynamic eccentricity (DE), the rotor axis is offset parallel to the stator axis and rotates around it as the rotor rotates. In the case of SE and DE, the stator and rotor axes remain mutually parallel. Due to the small air gap in the IM, even a slight eccentricity of the rotor violates the electromagnetic symmetry of the entire machine design and significantly impairs its operation.

Therefore, the problem of timely diagnosis of the presence of DE rotor is urgent, especially for powerful IM, which influence on the reliability of responsible technological processes. The most effective system for the DE diagnosis is vibrational diagnostics, in particular the monitoring and analysis of changes in electromagnetic vibrations of IM, depending from the type and degree of DE development. This article is a continuation of the article [1]. Eccentricity studies based on the analysis of vibroperturbing forces are also devoted in articles [2, 3].

The purpose of the work. The aim of this work is to study the methods of mathematical modeling of the rotor IM DE diagnostic features on the basis of spectral analysis of vibroperturbing forces signals.

Material and results of the study. To determine the diagnostic features of the IM rotor DE was investigated a powerful three-phase IM of ATD type by 5000 kW, which has the following parameters: rated voltage 6 kV, stator current 545 A, efficiency 94,8%, power factor 0,89, nominal speed 2985 rpm, number of poles pairs - 1; air gap - 6 mm; the diameter of the stator bore is 675 mm. According to the results of the analysis of the distributions and spectra of the signals of the vibration sensors, which are proportional to the vibroperturbing forces in the IM in the presence of DE, the following results are obtained.

In fig. 1 are shown the calculated signals of the vibration sensors and their spectra, calculated for different values of DE ε during one revolution of the rotor ATD-5000 at a point located on the inner surface of the stator bore in the area of minimum air gap.

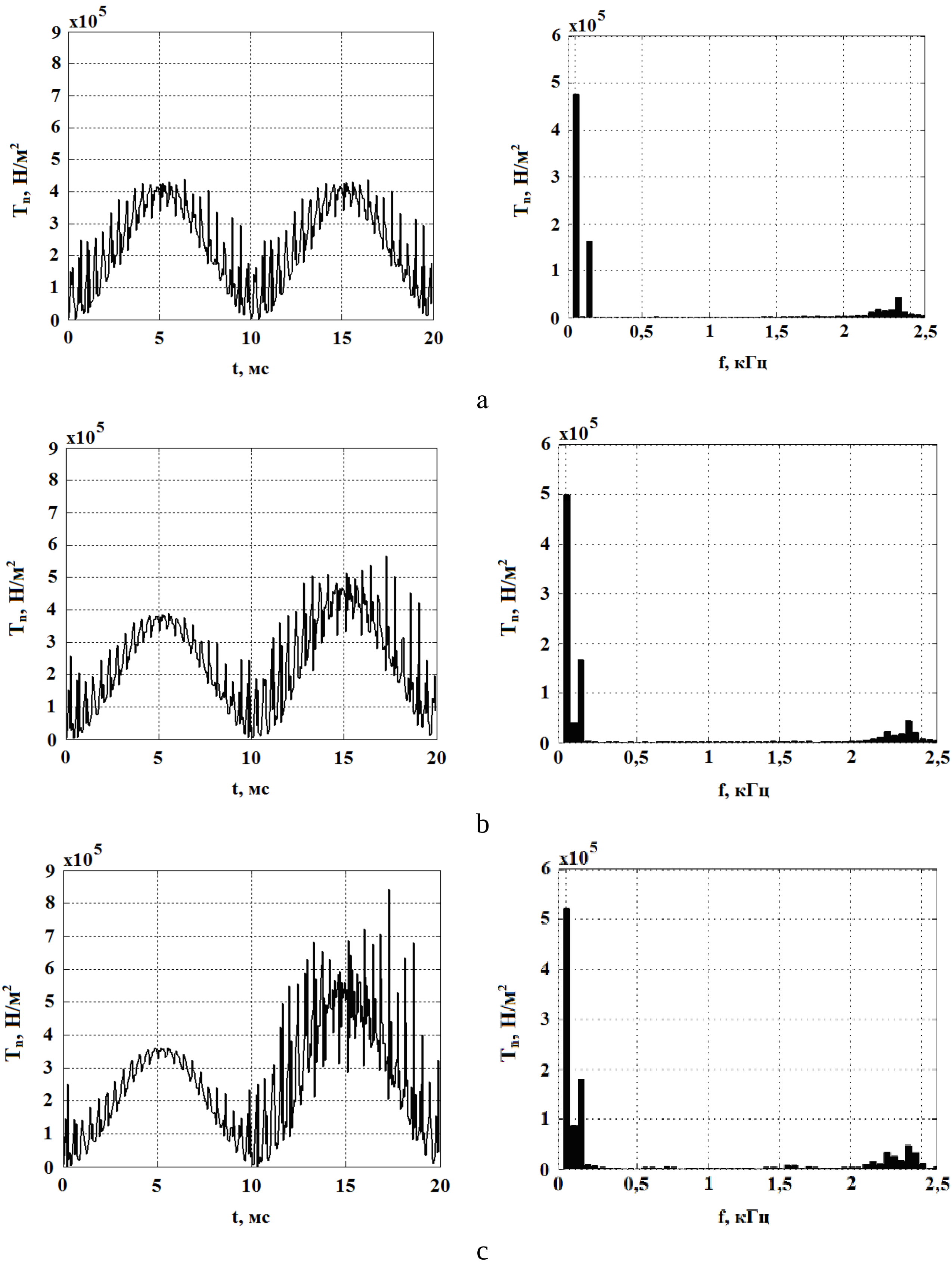

Figure 1 – Signals of vibration sensors and their spectra, calculated at the point with a minimum air gap during one revolution of the rotor ATD-5000:
a) undamaged ATD, ε = 0; b) DE ε = 0,36; c) DE ε = 0,59.

From the analysis of fig. 1, it can be concluded that, when passing the region with the smallest air gap above the sensor located at a specific point on the stator, significant distortions in the vibration signal occur, and the amplitudes of the tooth harmonics (2,3 kHz) significantly increase. Moreover, with increasing of DE coefficient ε, the amplitude of the tooth harmonics increases on one half of the signal and decreases on the other. Therefore, in the process of rotation of the rotor in the signals of the vibration sensors will be observed a change in the amplitude of the tooth harmonics.

However, unlike SE [1], the main diagnostic feature of DE is the appearance in the spectrum of the vibration sensor signal of the rotating frequency harmonic (49,75 Hz).

With DE increasing, in addition to an increase in the overall vibration level, there is also an increasing in the constant component of the spectrum, which depends on the overall amplitude level of the tooth harmonics. At ε = 0,59, the constant component increases by 9,3%, and there is a unilateral attraction of the rotor to the stator in the direction of a small air gap.

In contrast to SE, there is no effect of the location of the vibration sensor on its signal because the minimum air gap rotates relative to the stator together with the rotor. This simplifies the system of vibrational diagnostics and uses only one vibration sensor to detect DE.

Conclusions. With the help of mathematical modeling, the following diagnostic features that appear in the signals of the vibration sensors and their spectra at the appearance of DE are identified and analyzed:

a) in addition to increasing the overall vibration level, there is an increasing in the amplitudes of the tooth harmonics;

b) the constant component of the spectrum increases, which leads to unilateral asymmetrical attraction of the rotor to the stator;

c) unlike SE, in the temporal distribution of the vibration sensor signal, the tooth harmonics have different amplitudes at different half-periods of the signal;

d) appearance in the spectrum of the rotational frequency harmonic signal without its lateral harmonics.

The investigated diagnostic features can be used in the design and improvement of vibrational diagnostics systems in order to detect DE in IM at an early stage of their development.

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