APPLICATION OF VIBRATION DIAGNOSTIC METHODS FOR CHECKING THE TECHNICAL CONDITION OF THE MOTOR

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Introduction. The reliability of any power plant to a certain extent depends on the reliability of its constituent elements - both main and auxiliary, which, in particular, include electric drives and other auxiliary equipment. An example of such auxiliary equipment is an induction motor (IM) with a short-circuited rotor (Fig. 1).

Figure 1 – Three-phase induction motor with a short-circuited rotor

Timely detection of IM malfunctions contributes to increasing the reliability of their operation and service life, as well as shortens the time for repairs and reduces the costs of unexpected emergency failures.

Certain vibrodiagnostic methods are used to assess the condition of electromechanical equipment and identify problems of a vibrational nature, in particular in the frontal parts of IM.

Currently, vibration diagnostics methods are the most promising and widespread for assessing the technical condition of an electric motor with probable mechanical damage. The advantages of such methods are:

- economy,
- convenience,
- the method allows you to find hidden defects,
- the possibility of detecting malfunctions at the stage of their origin,
- reduction of the expected risk of an emergency situation during the operation of the equipment.

Vibrodiagnostic devices for diagnosis have a relatively low cost, and the diagnosis itself does not require decommissioning the machine, which is their advantage.

Figure 2 – The process of vibration diagnostics

The goal of the work. To analyze modern vibrodiagnostic methods and causes of vibration in IM.

Materials and research results. The essence of vibrodiagnostic methods is to measure and analyze the vibration parameters of IM at various points using vibration sensors that are installed on the external non-rotating parts of the motor or bearing shields. To improve the accuracy of the search for the causes of increased vibration in various parts of the electric machine, diagnostics are carried out at maximum motor load using high-resolution vibration spectrum analyzers [2] (Fig. 3).

Figure 3 – High resolution vibration spectrum analyzers

Contact vibrometers are used to measure the root mean square value (RMS) of vibration (Fig. 4).

Figure 4 – RMS contact vibrometer (RMS)

The reasons for the appearance of vibration in the main parts of the electric motor are [2]:

1) Rotor damage:
- break and damage of contact in the rings of the "squirrel cage" or in the rods;
- imbalance of the rotor;
- weakening of pressing in the area of teeth;
- the eccentricity of the outer surface of the rotor relative to the axis of its rotation;

2) Stator damage:
- break or shorting of turns and sections in the stator winding;
- incorrect axial mounting of active stator and rotor packages;
- weakening of steel package pressing;

3) Damage of the condition of the bearing units
- wear of the seating surfaces of the bearing shields;
- mechanical destruction of bearings.

Methods of vibration diagnostics. The simplest method of vibration diagnosis of the condition of an electric machine is the method of measuring vibration with the simplest contact vibrometer of the root mean square value (RMS) and comparing this value with the permissible norm. These norms are determined by standards or written in the documentation of the electric machine.

Of course, machines of different types and capacities have their own values of the permissible levels of vibration [4]. Permissible standards of vibration of electric motors are given in the Rules for the operation of electrical plants and networks (PTE) and in DSTU ISO 10816.

The main methods are:

I. <u>The Peak factor method</u>

This method of vibration control is easy to implement and consists in the periodic control of two vibration parameters: root mean square value (RMS) of vibration acceleration and peak amplitude of vibration acceleration (positive, negative or scope). In the presence of a bearing defect, the amplitude peak curve constantly increases, just like the RMS curve, but with a delay in time. Separately, these curves are uninformative, which cannot be said about the Peak factor - the ratio of the peak value of the vibration acceleration to its RMS. It was experimentally established that the moment of passage of the Peak factor function through the maximum (Fig. 5) corresponds to the residual life of the bearing of the order of 2-3 weeks [5].

II. Method of kurtosis

Kurtosis is a statistical value that characterizes the deviation of the probability density of the instantaneous values of the vibration signal from the normal distribution (Gaussian distribution). It is customary to characterize kurtosis by the coefficient of kurtosis. When micro- and macro-shocks appear in the bearing, the probability density curve takes on a sharper character (Fig. 6) and the degree of development of the defect can be judged by the value of the kurtosis coefficient:

Es<3 corresponds to the serviceable state of the bearing;

Es>3 – permissible operation of the bearing till of its nearest replacement;

Es<5 – unacceptable operation of the bearing [5].

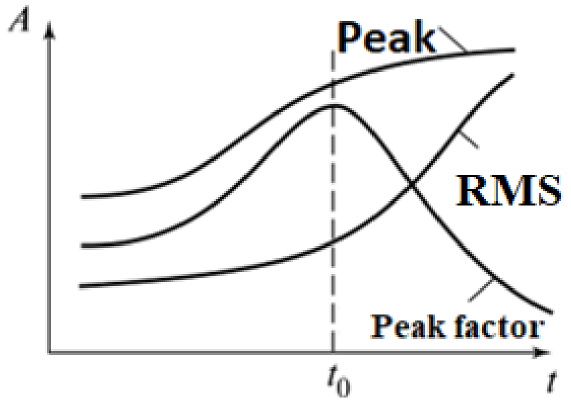

Figure 5 – Peak factor method

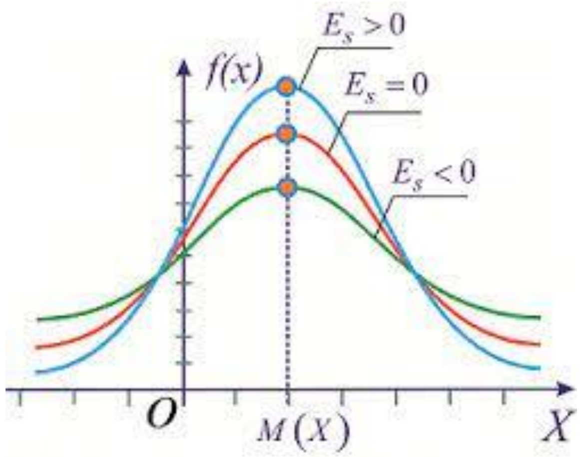

Figure 6 – The coefficient of kurtosis

III. Method of shock pulses

Shock pulses are low-energy pulses generated at frequencies of 28-32 kHz, caused by the collision of bearing parts and pressure changes in the rolling zone of the bearings. In the case of the operation of a healthy bearing, there is a certain "carpet" background of shock pulses, which is generated by frictional forces. In case of bearing defects, certain peak values appear in shock pulses. The amplitude of these peaks directly depends on the rate of collisions and the development of the defect. That is, the larger these values are, the larger the amplitude. Thus, the presence and depth of defects can be reliably diagnosed based on the peak amplitudes of shock pulses [5]. The shock pulse method is characterized by high sensitivity and is implemented with the help of an inexpensive, compact portable device - a shock pulse tester.

IV. Direct spectrum method (autospectrum)

This method consists in the analysis of frequency spectra, which are obtained with the help of vibroanalyzers (Fig. 3). Amplitude spikes observed on autospectra carry useful diagnostic information, as they are caused by defects in the equipment being tested

(Fig. 7). In addition, each type of defect corresponds to its own harmonics, which are clearly calculated depending on the kinematics and speed of rotation of the equipment. If certain harmonics are present in the spectrum, the occurrence of the corresponding defect is determined, and the degree of development of the defect is determined by the amplitude of the harmonics. This method is highly informative and is currently one of the most widely used. A relative disadvantage of the method is the impossibility of detecting defects at an early stage of development. Because emerging defects generate vibrations of small amplitude, which are still difficult to notice against the noisy background of the spectrum [5].

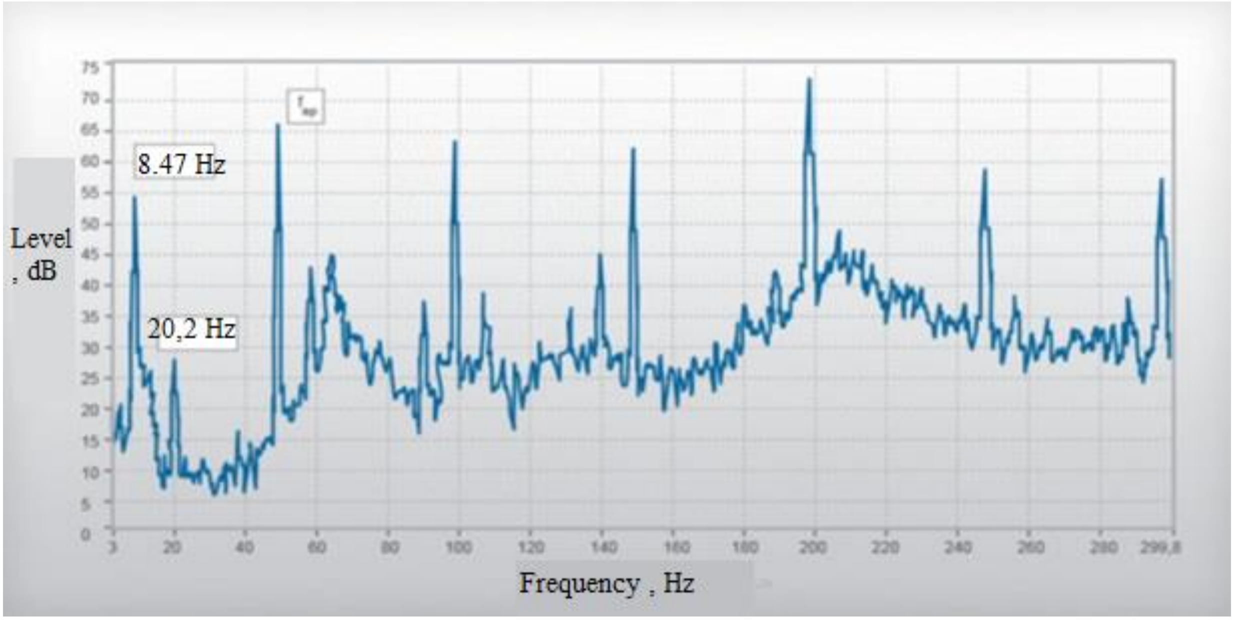

Figure 7 – An example of a direct spectrum

Conclusion. Vibration diagnostics is a common and effective method of analyzing the condition of an electric motor. It allows you to show a significant number of different types of damage to the main components of the motor, at the same time, it does not require decommissioning the electric machine. This type of diagnostics helps to detect malfunctions in the motor in advance, which allows to increase the service life and reduce the probability of unexpected failures of the electric motor. The main causes of abnormal vibration in a three-phase induction motor with a short-circuited rotor are damage to the stator, rotor and bearing assemblies.

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