

# Determination of Changes in the Parameters of Electrical Machines after Repairs to Prevent an Unacceptable Increase in Vibration of the Building Structure

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**Abstract.** This article discusses the improvement of control methods for electrical machines after repair. These methods allow during testing of an electric machine to determine deviations of parameters that can lead to an increase in the level of vibration and subsequent failure of both the machine itself and the elements of building structures.

## 1. Introduction

One of the safety factors for building structures is the permissible level of vibration. For industrial buildings, the level of vibration is affected by the operation of mechanical equipment driven by electric machines. When designing such buildings, measures are taken to minimize the vibration load on building structures. Over time, the parameters of the electric machine and the mechanical transmission of movement can change, especially if the equipment is out of order and has been repaired. Testing of equipment put into operation after repair allows you to identify unacceptable changes in the parameters of electrical machines and prevent their commissioning.

## 2. Materials and methods

Methods of controlling changes in the parameters of electric machines are: vibration diagnostics using special devices and analysis of voltages and currents to exclude false diagnoses of previous studies. Spectral analysis is the main procedure for diagnosing electrical machines. The purpose of the analysis is to identify vibration at frequencies characteristic of particular malfunctions. The operation of the machine is considered normal if the amplitude of all components does not exceed the specified limits. Typically, the quantity to be analyzed is the speed of vibration, but acceleration in the case of high speed machines or motion for low speed can also be used. To study the bearing assemblies, the spectral curve envelope method is often used. The bearing is a resonant system. It has three resonating parts. These are the outer, inner rings and rolling bodies. The outer ring, for example, has several intrinsic resonances: longitudinal, transverse, in thickness, and so on. Each of these resonances has another set of harmonics. That is, depending on the configuration, the ring has several orders of resonance [1].

Diagnostic signs of one or another deviation of the parameters of the mechanical and electrical parts of the electric machine are constantly being improved. Separately, we can single out the problem of improving test benches to control the parameters of electrical machines and mechanical equipment.

On the basis of the electrical repair workshop in the city of Magnitogorsk (Russia), studies were conducted to improve the diagnostic signs of changes in the parameters or defects of electrical

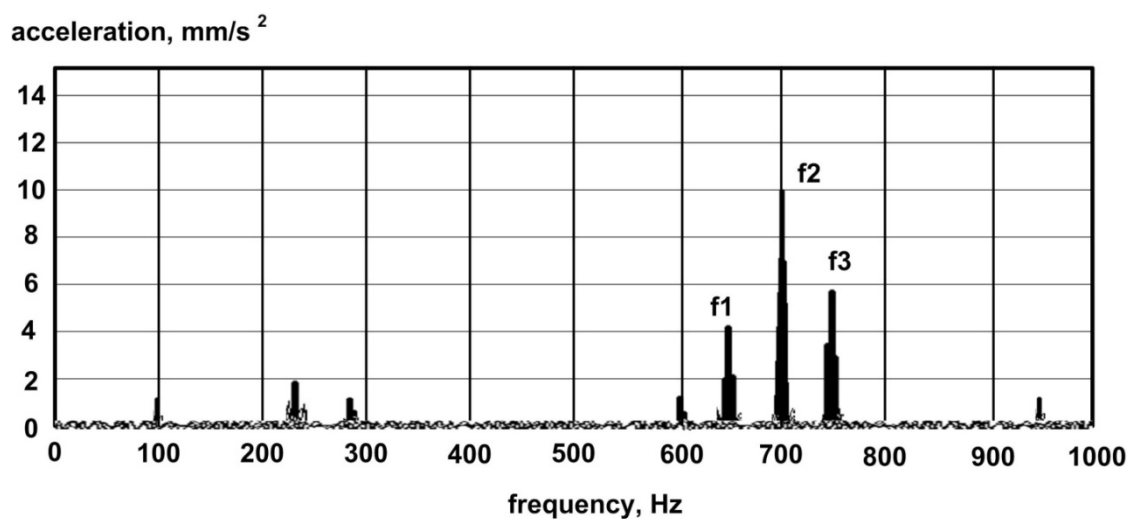


machines after repair. An example is the study of induction motors after repair from the point of view of changing parameters that can lead to an increase in the level of vibration. As a measuring tool, we used a vibration analysis instrument manufactured by VAST (Novosibirsk, Russia) with «DREAM» software. This program allows you to process vibration diagnostic signals by all known methods.

It is proposed at the initial stage of testing to identify electrical machines with uneven air gap between the rotor and stator. The unevenness of the gap indicates inaccuracies in the installation of the rotor or inaccuracies in the position of the electromagnetic system of the electric machine. It is known that the unevenness of the air gap can be detected by the spectrum of vibration acceleration.

### 3. Results

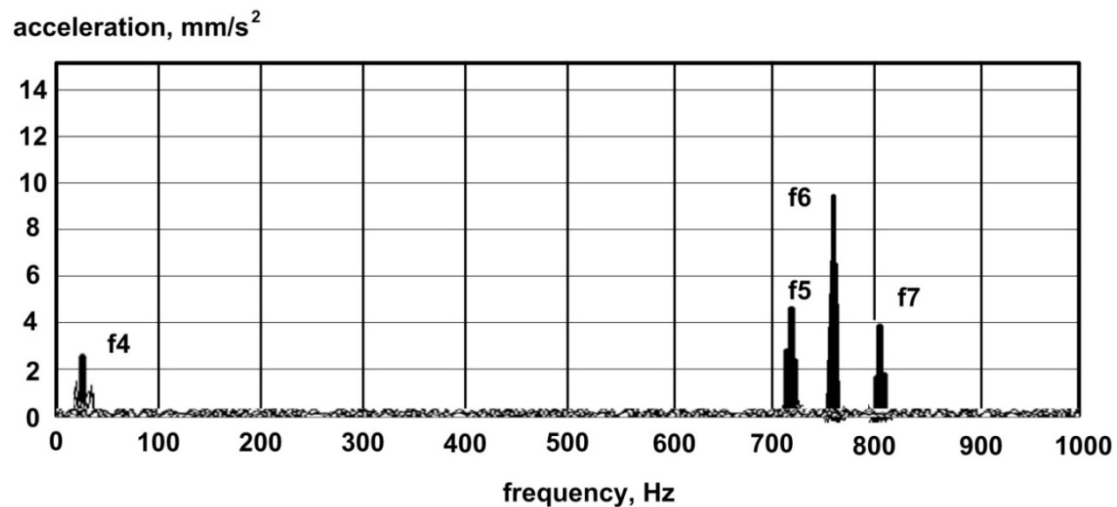
As an example in figure 1 shows the processing of the spectrum of vibration accelerations for an induction motor 1 after repair. Frequencies whose level exceeds the noise level are highlighted. The highest signal levels have frequencies  $f_1$ ,  $f_2$  and  $f_3$ .



**Figure 1.** Spectrum of vibration accelerations with a predominance of frequencies of static rotor eccentricity.

The frequency  $f_2$  corresponds to the tooth frequency equal to the product of the rotor speed and the number of teeth of the rotor. The frequencies  $f_1$  and  $f_3$  differ from the frequency  $f_2$  by the level of the double frequency of the mains voltage. The predominance of such frequencies in the spectrum indicates a static eccentricity of the rotor. The frequencies  $f_1$  and  $f_3$  differ from the frequency  $f_2$  by the level of the double frequency of the mains voltage. The predominance of such frequencies in the spectrum indicates a static eccentricity of the rotor [1].

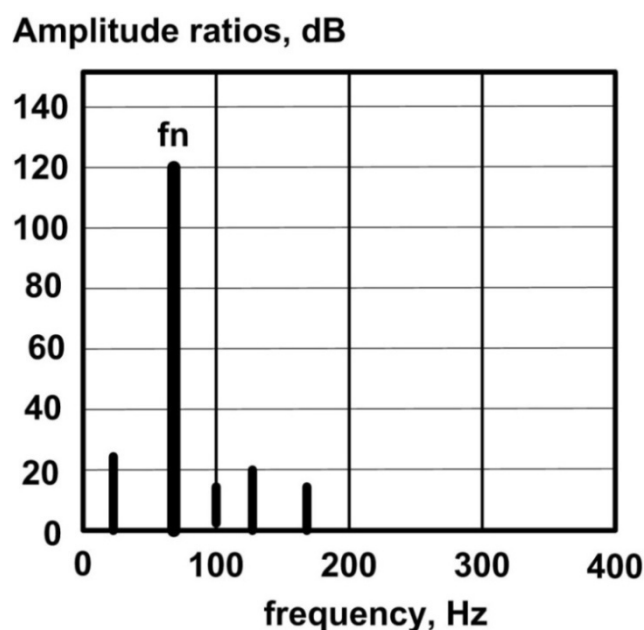
In figure 2 shows the processing of the vibration acceleration spectrum signal for an asynchronous electric motor 2. In figure 2, the prevailing frequencies  $f_4$ ,  $f_5$ ,  $f_6$ ,  $f_7$  are highlighted. The frequency  $f_6$  is the tooth frequency. The frequencies  $f_5$  and  $f_7$  differ from the frequency  $f_6$  by the value of the rotor speed. Separately, the frequency  $f_4$ , equal to the rotor speed, is distinguished. The predominance of such frequencies in the spectrum indicates the dynamic eccentricity of the rotor [1].



**Figure 2.** Vibration acceleration spectrum with a predominance of rotor dynamic eccentricity frequencies.

It is further proposed to clarify the effect of defects in the electromagnetic system of an electric machine. If, when the electric machine is disconnected from the mains, the diagnostic indicators change very fast, then the electromagnetic system affects the diagnostic results. This requires additional research. If the diagnostic indicator does not change, the mechanical part should be tested. In the study of electric motors 1 and 2, the influence of the electromagnetic system on the results of the study was excluded. After this, it is proposed to use the diagnostic technique for bearing assemblies using the method of spectrum analysis of the envelope curve. The following results were obtained for the engines under study.

Figure 3 shows the processing of the envelope spectrum signal on a logarithmic scale for motor 1 (values above 5 dB are indicated). In figure 3, the frequency prevails, which corresponds to the frequency of the rolling elements of the bearing of the rotor of the electric motor [1, 2].

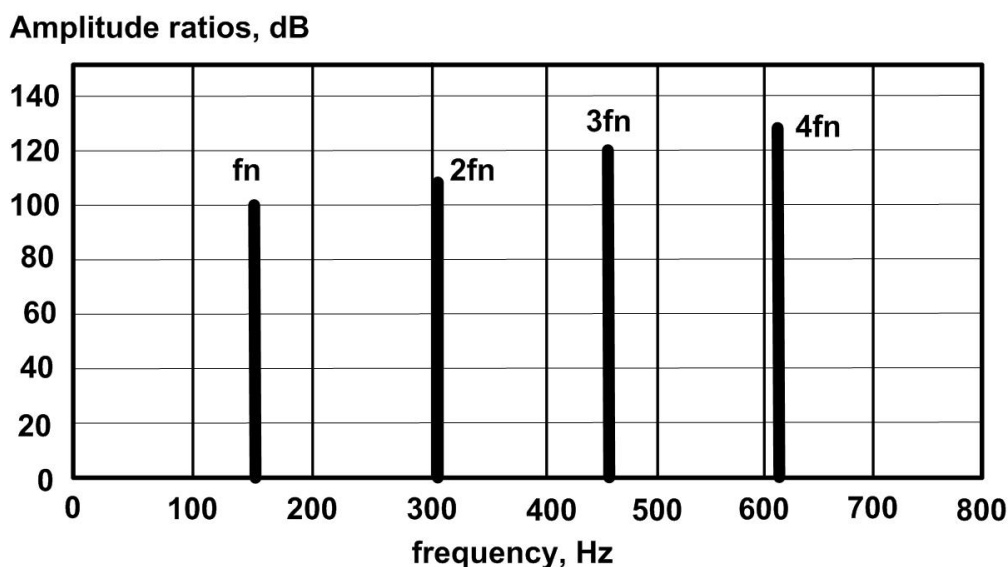


**Figure 3.** The envelope spectrum of the vibration acceleration curve with a predominance of rolling frequency.

Standard software diagnoses this situation as deterioration on the outer ring of the bearing. In the case of motor 1, new bearings were installed during the repair that could not be subject to wear. When disassembling the motor, it was found that the bearing was installed with a weak landing, and the completion of this unit is necessary.

Figure 4 shows the processing of the envelope spectrum signal on a logarithmic scale for motor 2. In this figure, a predominance of several frequencies multiple of the rolling frequency of the rolling elements of the bearing is observed. Standard software diagnoses this situation as well as deterioration on the outer race of the bearing. In the case of a new bearing, this range turned out to be for a bearing with a slight misalignment [1-3].

Based on the research results, the diagnostic signs of deviation of the parameters of the electric machine from the nominal ones were expanded. This allowed us to more quickly identify and eliminate defects in electrical machines after repairs. These types of defects can lead to unacceptable levels of vibration, which lead to failure of mechanical and electrical equipment [4,5].



**Figure 4.** The envelope spectrum of the vibration acceleration curve with a predominance of frequencies that are multiples of the rolling frequency.

#### 4. Conclusion

The paper provides examples of clarifying diagnostic signs of changes in the mechanical parameters of electrical machines after repair. According to the method of diagnosing changes in the parameters of electrical machines, further studies are carried out. The result of these studies is the quick elimination of defects in electrical machines. If these defects are not detected in a timely manner, they can lead to failure of mechanical and electrical equipment, as well as to an increase in the effect of mechanical vibrations on structural elements of industrial buildings.

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