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Selection of coherent frequency components of vibroacoustic signals from assemblies of rotor machinery

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Abstract

The purpose of this article is to determine optimal conditions for rotor machinery operation in order to evaluate its condition using coherent function. The coherent function is an analogue of the correlation factor in frequency domain. The function reflects the linear relationship levels of harmonic components of parallel signals covered in the article. The conditions are considered optimal when the coherence function is expressed the most evidently. In other words, the coherent components are close to one.

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1. Introduction

Machinery condition is determined by condition of its assemblies and mechanisms. Each of them has its own diagnostic features of failures and defects. In order to assess the machinery condition, one requires a comprehensive approach to analysis of vibroacoustic signals for the purpose of diagnostic feature detection [1].

One of the areas of the approach application is analysis of vibration signals during parallel measurements using coherent function.

The coherent function is an analogue of correlation factor in frequency domain. The coherent function also shows linear relationship ratio between harmonic components of the parallel signals under consideration. One of the major techniques in obtaining the coherent function is a cross spectrum analysis [2].

The coherent function is calculated by the formula:

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$$\gamma^2(f) = \frac{|S_{AB}(f)|^2}{S_{AA}(f) \cdot S_{BB}(f)}, \quad (1)$$

Where $S_{AB}(f)$ is cross spectrum of A and B signals;
$S_{AA}(f)$ is auto spectrum of A signal;
$S_{BB}(f)$ is auto spectrum of B signal;

The value of the coherent function changes within the 0 to 1 range. If the coherent function equals 1 on a certain frequency component, it means that harmonic components of spectra have the same phase relations and the same source of origin.

If coherent function equals 0, it means that the harmonic components have different sources of origin.

To divide spectra into coherent and non-coherent types, the discrete coherent function $\gamma_d^2(f)$ is used. In order to obtain the latest one, it is needed to use threshold function [3] that equals 0 if the values of coherent function is less than threshold values and equals 1 if the coherent function value is more than threshold value.

During the analysis of parallel signals using coherent function it is essential to determine condition or working procedure of the machinery unit where the coherent function is expressed the most evidently. In other words, the coherent components of the spectrum are close to 1.

2. Methods and study subject

The major change for the rotor machinery working procedure is the change of rotary rotation frequency. Consequently, the purpose of this work is the research of correlation between the coherent function values and rotary rotation frequency.

In order to achieve the purpose the following objects have to be accomplished:

- To measure the vibration signals on different rotation frequencies from two coupled assemblies of rotor machinery;
- To calculate and construct the coherent function per each frequency of rotor rotations;
- To calculate and construct the discrete coherent function for which purpose to determine the threshold value 0,5;
- To make a conclusion on the basis of the data obtained about relationships between coherent function and rotor machinery working procedure.

The research was carried out on the wheel-motor unit of electric train ЭТ2М-048 №048601. A traction electric motor bearing (1 on the Figure 1) and a bearing of casing of reduction gear (2 on the Figure 1) connected via elastic couplings (3 on the Figure 1) were selected as assemblies under research. The measurements were executed on three frequency rotations: 10, 15, 20 Hz.

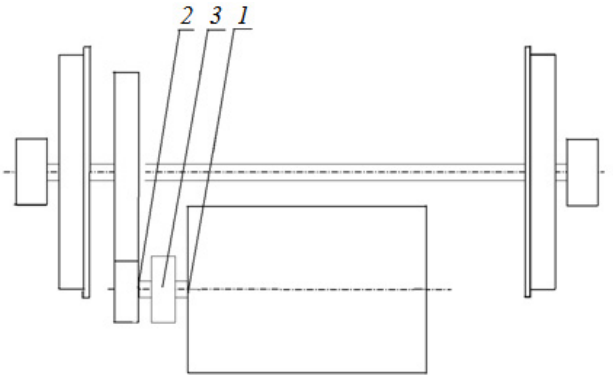

Fig. 1. Flow-chart of a wheel-motor unit of an electrical train.