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Usage of characteristic function as informative diagnostic feature

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Abstract

The statistic analysis of instantaneous values of vibration and acoustic signals showed that in particular the form of probability density function of instantaneous vibroacoustic signal values changes depending on the condition of the device under vibration-based diagnostics. The shape of the probability density curve can be described by the characteristic function. With regard to the diagnostics of reciprocating compressors the hypothesis had been put forward that the characteristic function of the vibroacoustic signal of reciprocating compressor is an informative diagnostic parameter of the technical condition of the unit. The article presents the results of a study of the statistical moments of the characteristic function parameters obtained for the different conditions of the test device. The studies revealed that the module of the characteristic function is the informative diagnostic symptom of reciprocating compressors faults and allows to assess the state of their units and parts.

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1. Introduction

It is known that the success in diagnosis of any machinery largely depends on the rational choice of diagnostic parameters, which accordingly present characteristics of oscillatory processes sensitive to change in the machinery condition. The most useful diagnostic parameters are the ones that are invariant (insensitive) to change in interclass parameters and have a wide range of changes in their values in going from one state class to another [1].

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An essential vibration analysis section is statistical description of different vibration parameter measurements. Statistical methods of analyzing vibration taken at a specific point of the machine or equipment are used in cases where it is impossible to accurately set the vibration value x(t) at any time t, or the vibration is complex, i.e. vibration signal can be interpreted as a random process [2 – 4].

If the signal waveform does not continue for the time, though its condition and operation remain unchanged, the statistical moments of the signal are usually not affected under these conditions. Thus, one-to-one correspondence between the signal statistical moments and the device condition can be established, even in principle [5].

2. Selection of characteristics describing the device condition

The statistic analysis of instantaneous values of vibration and acoustic signals showed that in particular the form of probability density function of instantaneous vibroacoustic signal values changes depending on the condition of the device under vibration-based diagnostics (Figure 1) [6]. Consequently, the fact of change in the probability distribution curve for instantaneous signal values can be used as an informative diagnostic parameter of the machinery condition.

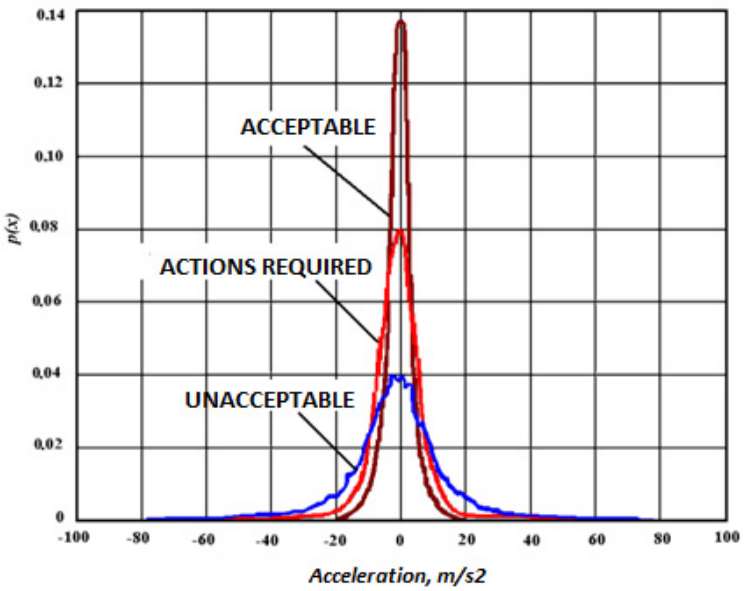

Fig. 1. Probability density function of instantaneous values of acceleration signals for different conditions of the unit under test.

It is known [3] that the probability density is a spectrum for the characteristic function. It is a probabilistic spectrum of instantaneous signal values, each component of which shows the probability of instantaneous set value in the signal. Therefore, the characteristic function is itself a characteristic that evaluates the shape of the probability curve. Mathematically, the characteristic function and the probability density are associated with Fourier transform (forms a Fourier transform pair).

One might assume that, for the purposes of reciprocating compressors diagnostics, the characteristic function of the vibration and acoustic signal of the reciprocating compressor is an informative diagnostic parameter of the device condition.

The purpose of this work is to study the statistical moments of the characteristic function parameters obtained for different conditions of the test device.