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Short Communication

Entropy processing of diagnostic parameters

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Abstract

Modern means of energy transportation are subject to the highest conditions in terms of operational reliability. This is achieved not only by the use of advanced technologies but also by constant monitoring of the technical condition. One method is vibration control, which involves processing the desired signal in various ways, one of which is the entropy method. The purpose of the work is to increase the reliability of the assessment of the technical condition of pipelines.

Introduction

At present, methods of technical diagnostics based on vibration control are gaining popularity for the analysis of complex systems. At the same time, the vibration diagnostic signal of the tested sample is measured and then processed [1].

A diagnostic signal is a characteristic of an object used to determine diagnostic features that can describe the state of the object of study. This is due to the fact that the steady-state vibration diagnostic signal of the object under study has extensive information that fully describes its technical condition. The vibration signal is transmitted from a piezoelectric sensor installed at the diagnostic object [2].

Each signal under study must be processed, namely time-sampled or quantized by level, in other words, digitally displayed.

Signal conversion methods may vary. Methods such as analog, digital, and combined processing are known [3].

A variety of methods are used to convert vibration diagnostic signals, such as wavelet transforms or Fourier transforms, which are the most common methods for spectral analysis of the diagnostic signals under study. After processing, it is important to choose methods for analyzing and comparing the received signals in order to probabilistic assess changes in their parameters and obtain the most complete picture of the technical condition of the diagnostic object [4]. For this purpose, a variety of methods of statistical analysis are used, but the most expedient is to use entropy indicators, such as the entropy of Shannon, Kolmogorov, Kolmogorov-Sinai and others.

The formula for calculating Shannon's entropy is as follows:

$$H_{sh} = -\sum_{i=1}^{n} p_i \log_b p_i$$

Where n is the number of possible events; b is the unit of measurement of information (2 - bits, 3 - treats, etc.); pi is the probability of the event.

Shannon's entropy indicates the degree of variability of the ongoing process, in other words, it can clearly show a quantitative assessment of the deviation of the distribution of time series values by levels from an equally probable one [5].

Kolmogorov entropy or epsilon-entropy (ε-entropy) is a concept defined by A. N. Kolmogorov to classify such functions. It makes it possible to determine the complexity of the function

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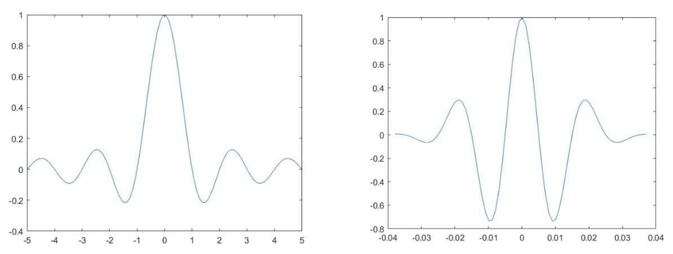
under study, that is, to determine the value of the minimum number of characters used, which is necessary to determine the function with the necessary accuracy ε. However, there is Kolmogorov complexity, which is also a measure of the amount of information, conceptually very different. In Shannon's theory, the concept of information derives from the concept of probability. At the same time, Kolmogorov's theory uses the opposite way - the concept of probability is derived from the concept of information, which is introduced on the basis of the universal Turing machine. This leads to very deep methodological differences, for example, in machine learning. In other words, the application of Kolmogorov entropy is impossible, since in practice time series are mostly finite in length.

In information theory, Renyi's entropy is a more generalized version of Shannon's entropy and is part of a family of functionals used to quantitatively diversify the uncertainty or randomness of the system under study [6].

The results of studies of useful vibration signals of defective and defect-free products (defective and defect-free pipelines were used in the work, on which vibration vibrations of the outer walls were recorded at the same points) unequivocally showed the acceptability of Shannon entropy for determining a defective product (Figure 1).

Figure 1 shows the sinusoidal signals generated on defect-free and defect-free products.

The Shannon entropy value for a faulty (defect-free) pipeline ranged from minus 0.4 to plus 1, and for a faulty (defective) pipeline, the Shannon entropy interval ranged from minus 0.8 to plus 1. The defect was a through-hole with a diameter of 2 mm [7]. The Shannon's entropy parameterization has the main advantage in that the noises that partially carry information about the state of the object are not cut off [8].



a) b)

Figure 1: Rice. 1. Signals characterizing the (a) absence of and (b) the presence of a defect.

Conclusion

Known methods of processing and comparison of the useful signal ensure the reliability of the diagnosis of the technical condition of the diagnostic object, but it is necessary to look for methods to improve it. One such method is Shannon's entropy parameterization, the main advantage of which is that noises that partially carry information about the state of the object are not cut off.

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