ІНФОРМАЦІЙНЕ ЗАБЕЗПЕЧЕННЯ СИСТЕМ ДІАГНОСТУВАННЯ ОБ'ЄКТІВ ЕНЕРГЕТИКИ

За редакцією
чл.-кор. НАН України
В.П. Бабака

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INFORMATION PROVISION OF DIAGNOSTIC SYSTEMS FOR ENERGY FACILITIES

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V. Babak

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The monograph examines the issues of ensuring the operational reliability of energy facilities through the use of modern information provision. Mathematical models of diagnostic signals that arise during the operation of power equipment are analyzed, main results of their characteristics research of are outlined, methods and means of diagnostics of certain types of electric power and heat engineering equipment are considered.

For researchers, engineers, as well as lecturers and postgraduates of higher education institutions dealing with diagnostics of technical facilities.

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INTRODUCTION

To date, from 70 to 90 %, according to various estimates, of main and auxiliary equipment of the energy complex of Ukraine has developed its own resource. In these conditions, further operation of energy-intensive, and in some cases extremely dangerous (for example, nuclear power plants) equipment requires the creation of special, scientific-based methods and means that allow such operation, ensuring the necessary level of reliability and safety. Recently, due to new information technologies and Internet, a sufficient number of such methods and tools appeared. Among them, the most effective methods are non-destructive control, monitoring and diagnostics of energy equipment (EE) units. In all these methods, the carrier of information about technical condition of studied object is a diagnostic signal. Through comprehensive study of diagnostic signal (taking into account its measurement, conversion, processing and analysis), the researcher obtains necessary information about studied object.

For a confident solution of these problems, the researcher firstly needs a mathematical model of diagnostic signal that, based on the physical features of its formation in diagnosed object, allows to obtain objective diagnostic information about this object. Secondly, he should use methods and corresponding algorithms for diagnostic signals processing that could be implemented on a basis of modern electronic devices and information technologies. Herewith, chronologically, the model is primary and the choice of methods and technical means for diagnostic signals measuring and processing is secondary.

The construction of diagnostic signal mathematical model is specified by particular physical process selected by researcher as diagnostic information carrier, and also by EE unit as an object of diagnosis. In addition, the nature of diagnostic signal model depends on chosen type of diagnosis — test or functional.

It is known that each unit of diagnosed EE has its own peculiarities in diagnostic signals formation. That is why the monograph pays considerable attention to the development and analysis of mathematical models of these signals that are based on corresponding physical processes occurring at EE units.

While constructing these models, two basic approaches could be used: deterministic and statistical. With the first approach, deterministic function of time is chosen as initial mathematical model of signal coming from primary sensors. In this case, as the most informative, amplitude-frequency and phase-frequency parameters of diagnostic signal that characterize the operation of studied EE unit are commonly used. Diagnosis by deterministic methods is basically reduced to a theoretical definition of possible diagnostic attributes and their comparison with the results of experimental data analysis. If the latter substantially differ from theoretically obtained results, then a conclusion is made about the presence of defect in studied unit. In its essence, these methods are applicable in a case when the results of all observations with the same initial conditions are identical, and also if the same parameter (characteristic) is measured under the same conditions. This situation is either highly idealized or is observed with very low accuracy of measuring instruments used, when random effects on measurements are not perceived by these instruments. Consequently, with a deterministic approach, there is no need for multiple measurements, since they are all the same and conclusion about unit technical state could be made basing on one measurement. However, there is always a possibility, by increasing the accuracy of each individual measurement, to detect the unrepeatability of measurement results in the situation described above. Then the question arises, which of the resulting series of numbers should be considered as a measurement result. Therefore, the use of deterministic methods could not be considered as satisfactory and reasoned, since many physical processes (diagnostic signals) arising in different EE units are random by their nature, ie, their realizations varies from observation to observation. Thus, it is impossible to obtain from one observation a practically reliable answer about the technical state of diagnosed units.

Statistical approach allows us to recommend an algorithm based on a series of results of certain measurement experiment, by which the best approximation of the measured parameter to its true value is calculated in a probabilistic sense. Besides, when using statistical diagnostic methods, the measure of possible incorrect decisions about technical condition of diagnosed EE units is taken into account, and it is also possible to estimate the average number of possible incorrect conclusions, their dispersion, etc.

In most works, appropriate attention is not paid to the construction of mathematical and physical models of reference diagnostic signals, and without this, in our opinion, comparative analysis of various statistical methods of control and diagnostics is impossible. In a discussion of possibilities of statistical approach for monitoring and diagnosis, the very initial moment of diagnosis is often absent - measurements at diagnostic objects. These questions are also reflected in this monograph.

Summing up the results of a brief comparison of deterministic and statistical approaches to the construction of models, methods and diagnostic systems, the authors use the statistical approach in this study, because the vast majority of physical processes occurring in studied EE units are random by nature. Application of statistical methods for EE units diagnostic is also required by number of reasons associated with the presence of strong electromagnetic, thermal, acoustic and other fields in operating EE that act as a noise in measurement, converting, processing and analyzing information diagnostic signal.

An important point in constructing of diagnostic signal mathematical model, and then a diagnostic Information-Measurement System (IMS), based on this model, is diagnostic signal type used studying various objects. In this work, when diagnosing EE units, various types of diagnostic signals were used: vibration (vibration acceleration), acoustic emission, etc.

Working on development of IMS for EE units' diagnostics, authors of this monograph comprehensively considered problems of constructing mathematical probabilistic models of diagnostic signals, development of statistical methods for their analysis with the purpose of making a diagnostic decision and, finally, technical implementation of proposed diagnostic methods. Following the concept of primary nature of diagnostic signal mathematical model, authors found it expedient foremost to consider questions connected with the theory of random processes with infinitely divisible distribution laws, linear and linear periodic random processes. Considerable attention is paid to the problems of imitation modeling of diagnostic signals and their statistical estimation. The modern element base and new information technologies allowed authors to develop, build and practically test a number of experimental samples of information-measuring systems for statistical diagnostics of energy facilities.

A large volume of conducted experimental studies showed the operability and efficiency of constructed IMS samples.

The authors do not pretend to comprehensively consider issues on EE diagnostics using statistical methods and IMS, implemented on their basis. At the same time, the results of the studies described in this monograph are a natural continuation of the subject of statistical methods application in the field of control, monitoring and diagnostics for electric power facilities.

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Kiev, autumn 2017 *AUTHORS TEAM*

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CONTENT

CHAPTER 3.

SIMULATION AND SOFTWARE FOR DIAGNOSTIC SYSTEMS

CHAPTER 4.

TECHNICAL PROVISION OF DIAGNOSTIC SYSTEMS

В монографії розглянуті питання забезпечення експлуатаційної надійності об'єктів енергетики шляхом застосування сучасного інформаційного забезпечення. Проаналізовано математичні моделі діагностичних сигналів, які виникають при роботі енергетичного обладнання, викладено основні результати дослідження їх характеристик, розглянуто методи та засоби діагностування окремих видів електроенергетичного та теплотехнічного обладнання.

Для наукових співробітників, інженерів, а також викладачів і аспірантів вищих навчальних закладів, що займаються проблемами діагностики технічних об'єктів.

Наукове видання

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ІНФОРМАЦІЙНЕ ЗАБЕЗПЕЧЕННЯ СИСТЕМ ДІАГНОСТУВАННЯ ОБ'ЄКТІВ ЕНЕРГЕТИКИ

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