ABSTRACT

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"Development of an intelligent system for diagnostics and monitoring of power equipment" thesis,
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The research topicality. The improvement of intelligent technologies and their further integration into various technological processes is a promising direction in the science and technology development. The progress of this development direction is also relevant in the field of diagnostics, control and monitoring of electric power equipment.

Work on the modernization of electric power facilities and improving the efficiency of generation, transmission and distribution is one of the most important areas of economic development of the Republic of Kazakhstan.

Significant increase in the efficiency of obtaining results during diagnostic work is possible with modern intelligent technologies and computerized systems. The result of a symbiosis of diagnostics and modern information processing technologies is an increase in the life of the equipment and more accurate prediction of its residual life.

At the same time, existing intelligent technologies used in monitoring and diagnostics are not effective enough. The range of tasks is limited by the technology for the technical implementation of diagnostic equipment and the methods of conducting diagnostic work.

Most of the equipment involved in the energy industry, as well as the process of generating and transmitting electricity, require timely monitoring of the condition. However, the conduct of such events by personnel of electric utilities is a labor-intensive and low-speed process. Moreover, the diagnostic work is periodic in nature and, therefore, is not always able to identify developing defects in order to correct them at an early stage of their development.

The use of expert systems, at first glance, is becoming a promising direction in the development of diagnostic processes. But their work is not effective enough. The fact is that expert diagnostic systems used in the diagnostics of electric power equipment determine not a specific defect, but a group of defects with similar characteristics. To clarify the results requires expert work and additional tests.

Measuring signals are usually random in nature. Diagnostic systems that work with the spectral characteristics of the signal work with harmonic components. When switching from a temporary analysis of a signal to a frequency, errors inevitably increase, which, in turn, can lead to an erroneous diagnostic result.

In response to the existing problem, new methods for receiving and processing diagnostic signals are being introduced into expert systems.

But, despite the advantages of modern expert systems, they are not without a number of disadvantages:

- due to the lack of universal data processing algorithms, a group of defects is immediately diagnosed;

- as a rule, there is no possibility of self-learning of the system;

- Existing expert systems, most often, can only work locally, and comparing data on diagnostics of a fleet of equipment (especially those located at a distance from each other) requires the use of additional technical means and time.

The solution to these problems can be implemented using modern computerized systems, as well as the use of artificial intelligence technologies.

The research aim is a control system development for electric power equipment using intelligent algorithms for processing and recognition of acoustic signals based on modern technologies in order to improve the efficiency of troubleshooting.

The research objectives:

- to assess the probable defective conditions of power equipment;

- to determine the type of the most informative diagnostic data and methods for their receipt;

- to develop an algorithm for processing diagnostic signals based on the theory of identification measurements and statistical signal processing for power equipment in the electric power industry;

- to offer the best option for the implementation of the control system and monitoring the status of power equipment;

- to develop an algorithm and to implement a software implementation of the method of analysis and processing of diagnostic data based on elements of artificial intelligence;

- to create a database of defective states of oil-filled transformer;

- to conduct tests of the developed system.

The research object - oil power transformers of electric power systems.

The research subject - control processes, diagnostics and monitoring of electric power equipment; processes of collecting, processing and displaying information.

The research methods.

approved methods for processing and analyzing measurement information, methods for identifying measurements, methods for creating computer devices, software and hardware systems based on industrial controllers were used in the process of the dissertation research,. In addition, field tests were conducted to diagnose power equipment during their operation.

The scientific novelty consists in the following provisions and results:

- an intelligent method is proposed for processing measuring signals of electric power equipment based on the provisions of the theory of identification measurements and statistical information processing, which made it possible to recognize individual defects, as well as to increase recognition accuracy;

- a methodology for digital processing of diagnostic signals has been proposed, characterized in that the processing of quasi-random signals occurs using artificial intelligence technology and identification measurements;

- a model is proposed for grouping the qualitative characteristics of the state of electric power equipment according to the values of identification and statistical parameters of diagnostic signals, as well as their systematization;

- a technical implementation of the monitoring and diagnostic system was proposed, which works on the basis of the developed methods and algorithms, which allows determining qualitative characteristics for electric power equipment, as well as being able to replenish the database of possible states in the "training" mode.

The practical significance.

The developed method and algorithm for analyzing diagnostic signals by identification and statistical parameters allows creating compact and universal tools for monitoring, diagnostics and monitoring of electric power equipment.

The proposed algorithm for processing diagnostic signals allows you to integrate it into existing systems for diagnosing, monitoring and monitoring the status of various technological equipment.

Thesis provisions to be defended:

- the method of digital processing of measuring random signals based on the provisions of the theory of identification measurements and statistical data processing;

- qualitative characteristics of the state of power equipment according to the values of the diagnostic parameters of the measuring signals;

- the algorithm of the intelligent instrument for processing measuring signals based on the provisions of the theory of identification measurements and statistical data processing;

- the structure of the intelligent control unit and monitoring of power equipment.-

The approbation of results. The main results of the dissertation research were reported and discussed at: III International Scientific and Technical Conference (Omsk, 2019); International scientific-practical conference "Problems of the development of technical potential and directions for its increase" (Ufa, 2019); International scientific and practical conference "Kozybaev readings-2018: Eurasian potential and new development opportunities in the face of global challenges" (Petropavlovsk, 2018); International scientific conference "International Conference on Applied Mathematics, Modeling and Simulation" (AMMS, China, 2017); International scientific-practical conference "Youth and Science - 2018" (Petropavlovsk, 2018).

Publications. The main results of the research are reflected in a number of scientific papers, including 4 articles published in publications recommended by the Committee for Control in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan, in 2 articles - in international scientific journals with non-zero impact factor (indexed in database of Web of Science and Scopus), in 4 articles reflected in the proceedings of international scientific conferences, including 2- in foreign and 2- in republican, as well as in 2 patents.

The personal contribution of the author.

The main results of theoretical and experimental studies were independently obtained by the author. In printed works that are written in collaboration, the doctoral student has a leading role in the synthesis and analysis of the results.

The structure of the thesis.

The thesis has a classical structure: introduction, the main part (six parts), conclusion, bibliography of literature cited. The thesis is presented on 102 pages of computer text, includes 54 figures, 8 tables and 102 titles of Bibliography of Literature Cited.

The research results.

The research object is an electric motor and oil-filled transformer. Based on the research results, it was decided to choose vibro-acoustic signals as measuring information. A method and algorithm for processing diagnostic signals based on the provisions of the theory of identification measurements, processing of statistical data and elements of artificial intelligence are developed.

Based on the accumulated data, the most informative characteristic indicators are selected. For vibration diagnostics of electric motors such indicators became: identification parameter of form and virtual frequency. When diagnosing oil-filled transformers, the most informative parameters were: shape parameter, virtual frequency, signal energy, root mean square value and dispersion.

Due to artificial intelligence technologies, we managed to move from determining the state of an object to recognizing individual defects. Such a transition was made possible due to individual indicators of the signal characteristics for each defect.

The implementation of the algorithm is possible both on a computer basis and by industrial controllers. The second option makes it possible to create compact systems that can remotely monitor the condition of equipment from an expert. Due to the communication modules, the controllers, if necessary, perform actions to turn off the power, and also signal the occurrence of a defective state on the central server.

Embedding the developed algorithm in existing diagnostic systems can significantly improve the quality of recognition of defects already at an early stage of their development. For example, when embedding the algorithm in the “Kamerton” diagnostic system, made it possible to switch from recognition of the states of the electric drive to accurate and clear identification of defects. The accuracy of diagnosing the engine condition increased by 10%.

Summing up the research, the following points can be distinguished:

- an intelligent diagnostic method and an algorithm for processing measurement signals of power electric equipment based on the provisions of the theory of identification measurements and processing of statistical data using artificial intelligence technologies have been developed, which allows to increase the accuracy of obtaining a diagnosis;

- a model for the collection and systematization of characteristic indicators of the condition of the diagnosed equipment according to the values of identification parameters and statistical data is proposed;

- approbation of the proposed method showed that the vibration diagnostics of electric drives can identify defects with a probability of 0.75, and acoustic diagnostics for partial discharges, with a probability of 0.9;

- a proposed intelligent algorithm for the operation of the diagnostic system operates in the "training" and "measurement" modes, which, in turn, allows you to programmatically integrate it into existing systems for monitoring, control and diagnostics of various technological equipment;

- possibility of bi-directional communication with the diagnostic device allows you to maintain technological equipment located at large distances from the expert (server), which is especially important when using extended electric power systems with a branching structure.

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