ABSTRACT

of A.A. Kashevkin's thesis on the topic:
«Development of information and telecommunication networks for remote control and monitoring of oil and gas equipment», submitted to the competition for PhD degree in specialty 6D071900 – Radioengineering, Electronics and Telecommunications.

Timeliness of the work.

The integration of intellectual technologies, both in the technological processes themselves and in the operations of control, monitoring and diagnostics of industrial equipment, is a promising direction for the development of scientific and technological progress.

In the conditions of increasing competition in the world market of raw materials, work on the modernization of oil and gas engineering and improving the efficiency of oil production is a strategic direction for the stable economic development of Kazakhstan and ensuring energy security.

Modern computer and intellectual technologies can significantly improve the efficiency of control and monitoring of the technical condition of the equipment in order to adjust the life cycle and predict its residual life.

Although the integration of intellectual technologies is one of the topical innovative directions of scientific and technological progress, but at present, the range of tasks to be solved in this area is limited, and the developed intellectual technologies are not effective enough.

Most of the equipment involved in the oil and gas industry, as well as the process of oil and gas production itself requires control, diagnostics and monitoring, but these activities by service personnel are time-consuming and low-speed process, which is periodic and has a low accuracy of detecting defects at an early stage of their development.

Despite the obvious prospects for the use of expert systems, their work in the field of diagnostics of vibration signals can be considered insufficiently efficient, since at present only 50–60% of defects are identified with their help.

In most cases, existing diagnostic systems work locally and recognize a group of defects, rather than a separate defect.

The analyzed signals are often random; when converting them from the time domain to the frequency domain (in which diagnostic systems operate), the magnitudes of the errors increase, which leads to inaccuracy in determining possible defects.

Using the methods of diagnostics of vibration signals, expert systems (RPE ROS, Chevron, etc.) are being introduced into the processes of control and monitoring of industrial equipment.

Despite all the absolute advantages of expert systems, they have several significant drawbacks:

– there are no methods for universal processing of initial multi-scale information, therefore, a group of defects is recognized, and the defects themselves are not identified;

– there are no self-learning technologies;

– in most cases, existing expert systems operate locally and recognize a group of defects, rather than a separate defect.

In expert systems, the frequency characteristics of the signal are mainly analyzed, and there are no opportunities for remote group control and monitoring of oil and gas equipment.

The solution of the problems posed is associated with the use of artificial intelligence technologies and modern information and telecommunication networks.

In the recent past, wired information and telecommunication networks contributed to cost reduction, however, the latest developments in the field of wireless data transmission technologies lead to the rapid development of wireless networks based on small-sized sensors (motes) with low power consumption.

Aim of this thesis is to research and develop information and telecommunication networks and systems for remote control and monitoring of oil and gas equipment using intelligent algorithms and methods for collecting, processing and recognizing vibrosignals based on modern computer and wireless information and communication technologies to improve diagnostic efficiency.

Objectives of the study:

– to develop and investigate an efficient and universal method of analysis and processing of multi-scale and heterogeneous vibrosignals for monitoring and diagnostics of oil and gas equipment;

– to develop an algorithm and implement the software implementation of the method of analysis and processing of vibrosignals in the form of a computer device based on artificial intelligence;

– to create a database of defective states;

– to analyze the features of the organization and deployment of wireless information and telecommunication networks;

– to develop a wireless network structure for remote control and monitoring of oil and gas equipment.

Object of research – the set of equipment for the extraction and processing of oil and gas.

Subject of research – the processes of control, diagnostics and monitoring of oil and gas equipment; the processes of wireless collection, processing and display of information.

Methods of research. In the process of implementation of dissertation research, proven methods of processing and analyzing information, identification methods, methods for creating computer devices, software and hardware systems based on industrial controllers and information and telecommunication networks for wireless data transmission were used. In addition, experimental models were

designed and created, field tests were conducted during the operation of industrial equipment.

Scientific novelty lies in the following propositions and results:

– the proposed an intelligent method for processing different-scale and heterogeneous vibrosignals of oil and gas equipment based on identification measurements and artificial intelligence, which allows to recognize defects and increase the probability of a forecast to P = 0.75;

– the proposed method of digital processing of vibration signals for control, monitoring and diagnostics, characterized in that the processing of heterogeneous and different-scale random vibration signals occurs using artificial intelligence technology and identification measurements using the waveform and virtual frequency parameters;

– the model was proposed for systematization of the qualitative characteristics of the state of oil and gas equipment based on the values of the identification parameters of the waveform and the virtual frequency of the vibration signals;

– the intelligent computer device has been developed, embedded in the control, monitoring and diagnostics systems, which allows determining the quantitative parameters and qualitative characteristics for a wide range of oil and gas equipment and capable of replenishing the state database in the “training” mode;

– the distributed noise-resistant information and telecommunication network for remote control and monitoring of oil and gas equipment, including artificial intelligence technologies and identification measurements of signals, was developed.

Work’s practical relevance.

The developed method and algorithm for analyzing diagnostic vibrosignals by virtual frequency and waveform parameter (distribution of instantaneous values) allows you to create compact and versatile tools for control, diagnosing and monitoring oil and gas equipment.

The proposed algorithm of an intelligent computer device allows you to integrate it into existing systems of control, monitoring and diagnostics with an expanded range of equipment.

The developed information and telecommunication network of remote control and monitoring improves the efficiency of data collection and processing and can be used to improve complexes of remote control, monitoring and diagnostics of the state of technological equipment.

Communication with government programs.

The research presented in the dissertation was conducted within the framework of grant financing of the MES RK (state registration 0115PK01225) on the topic: “Development of intelligent computerized instruments and systems for diagnostics and monitoring of oil and gas equipment”, where the author was a performer.

The results of the thesis were introduced into the educational process of the specialty 5B071600 - Instrument Engineering, into the curriculum, developed

under the project “Capacity Building in Higher Education” according to the ERASMUS + Program - Development program.

Scientific propositions of the thesis submitted for defense (scientific results):

– the method of digital processing of diagnostic random signals based on the theory of identification measurements of signals;

– the model of systematization of the qualitative characteristics of the state of oil and gas equipment according to the values of the identification parameters of the waveform and the virtual frequency of the vibrosignals;

– the algorithm of operation of an intelligent computer device for processing vibrosignals based on the theory of identification measurements of signals;

– the structure of the intelligent wireless info-telecommunication network of remote control and monitoring of oil and gas equipment;

– the set of recommendations to improve noise immunity in the development of wireless networks for remote control and monitoring.

Practical approval. The main results of the dissertation research were presented and discussed at: XIII International Scientific Congress "MACHINES. TECHNOLOGIES. MATERIALS" (Bulgaria, 2016); International Conference on Applied Mathematics, Modeling and Simulation (AMMS, China, 2017); International Scientific and Practical Conference "Kozybayev readings – 2015: prospects for the development of science and education" (Kazakhstan, 2015).

Publications. The main results of the dissertation research are reflected in 17 scientific papers, including 3 articles published in publications recommended by the Committee on the Control of Education and Science MES RK, 3 articles in an international scientific journal with a non-zero impact factor (indexed in Web of Science database), in 4 papers reflected in the works of international scientific conferences, including 3 foreign (one conference in the Web of Science database, the other in the Scopus database), 4 in international scientific journals, one work in the republic magazine, as well as monographs and patent.

Specific personal participation of the author.

The main results of theoretical and experimental studies were obtained by the author independently. In printed works, which are co-authored, the applicant has a leading role in the generalization and analysis of the results obtained.

Thesis structure and scope. The thesis has a classical structure: the introduction, the main part (four chapters), the conclusion, the list of references and the applications. The work is presented on 116 pages of computer text, includes 65 figures, 16 tables and 117 bibliographic sources.

Works published on the topic of the thesis.

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