ANNOTATION

of P.A. Petrov's Dissertation work
"Development of high-precision automated control system for two-motor asynchronous electric drive of large-size units rotation mechanism",
submitted for the Ph.D. degree in the specialty
6D071900 Radio engineering, electronics and telecommunications

The general idea of the study is to build an adaptive to dynamic loads control system for the rotation mechanism of large objects.

To localize the issue of choosing the object of rotation, it is necessary to take as a basis a specific type of large-size unit. Therefore, in this study, railcars will be taken as a basis, as objects on which specific mechanical effects (rotation) are performed. If you approach the study as a whole, in the role of rotating objects can be any other large objects, by their weight, size, structure and internal mechanical connections comparable to railcars.

Actuality of work. The topicality is justified by the increased demand for railway products including grain carriers ("hoppers"). The existing systems are multi-ton structures exposed to increased dynamic actions during the rotation of the load.

Nowadays, the topical issue is the creation of a microprocessor control system for the rotation of railway cars with the possibility of adaptation to increased dynamic loads, which will significantly improve the technological process, reduce the cost of production, installation and repair of railcars. The developed system will differ from the existing analogues in the absence of the mechanism of the railcar-tilter. Such systems represent multi-ton objects where the railcar is placed by additional mechanisms of movement. Therefore, such complexes are quite large and energy-consuming. In this study, a technological solution is adopted in which the output shafts of each electric drive, entering the system, will be directly connected to the frame of the car mount, forming a frame rotator system. Therefore, such a system will be a priori characterized by low power consumption, due to the absence of additional dynamic loads in the system of the tilter.

The purpose of the dissertation work is to develop a microprocessor control system of a two-motor electric drive mechanism of rotation of specialized rail cars (or similar large-size units) adaptive to the dynamic moments of inertia and resistance. The developed system will consist of five main parts:

– computer model of control system of the two-motor electric drive of the mechanism of rotation of railway cars;

– control unit, implemented on electronic components, including a microcontroller or microprocessor, as well as digital data acquisition boards, performing the role of multiplexing devices;

– unit of measuring devices, including angular displacement sensors, fixing the number of circulations of the output shaft of each electric drive;

– the executive part including the system of the two-motor electric drive connected to the model imitating a frame fastening of the railway car;

– power part including various converters (power regulators, three-phase inverters, rectifiers, power regulators, etc.).

The object of the study is is the technology of rotation of specialized freight railcars (in particular, “hoppers”).

In the field of study of rotation technology of railcars can be divided into four parts:

– study and analysis of the mechanism of rotation of a railcar, including a two-motor electric drive and a frame of fastening of the car;

– study of the existing automated electric drive systems and the choice of the most suitable method of implementation;

– study and analysis of the methods of control of the two-motor electric drive (including regulation);

– study and analysis of the method of identification of changing in the process of rotation parameters of control objects (of two-motor electric drive).

The subject of the study is a matter of learning the way of building a microprocessor-based adaptive control system of two-motor drive mechanisms for rotation of large aggregates. The developed system should be characterized not only by the speed and accuracy of the control process, but also the ability to adapt to the changing parameters of the controlled object.

The scientific novelty of the work lies in the following:

1. The structure of the control system of two-motor electric drive of the mechanism of rotation of large-size units with vector control and adaptation to the moment of resistance and load, different from the already developed by the presence of the subsystem of synchronization of circulations and rotation speeds of the shafts of the two-motor electric drive connected with the frame of the rail car mount, has been developed.

2. The subsystem of speed control of the output shaft of the two-motor electric drive differs from the existing ones by the presence of the identifier of the parameters of the mathematical model of the control object (automated electric drive), thereby minimizing the dynamic loads in the construction of the mechanism of rotation of railcars, has been developed.

3. The algorithms of operation of the microprocessor control system of the automated two-motor electric drive using signals of precision photoelectric digital sensors for measuring the angular displacement of the output shaft of the two-motor electric drive connected to the frame rotator have been improved. As a result, there is a decrease in dynamic loads during the rotation of the railcar.

Methods of the study. The following research methods were used in the dissertation research:

– scientific apparatus for identification, adaptation and optimization of systems with automated control;

– theory of automated electric drive, including multi-motor;

– computer simulation of subsystems of the control system of rotation of railway cars and the whole system with the help of modern applied packages of semiconductor electric drive design systems;

– application of scheme-technical design methods of electronic modules;

– methods of data collection and processing using modern debugging platforms on a 32-bit microprocessor, as well as interface digital data acquisition boards;

– methods of visual (graphical) programming block diagrams using modern application packages and compile (load) the program code in the microprocessor, which is the main element of the control unit.

Practical significance of the work:

– control unit based on Arduino Due debugging Board based on SAM3X8E ARM Cortex-M3 microprocessor using the latest technologies of visual programming of microprocessors in the environment of MatLab 2013 Simulink software has been developed;

– a computer model of the adaptive control system of rotation of railway cars and its individual subsystems in the application package Simulink MatLab 2013 software has been developed;

– a prototype of the railcar rotation control system (experimental setup), which includes a computer model of the system, the control unit on the SAM3X8E ARM Cortex-M3 microprocessor, angular displacement sensors, power converters, actuators and the layout of the rail car mounting frame has been developed.

As a result of theoretical and experimental researches computer Simulink-models in the environment of MatLab 2013 of separate subsystems of the developed SUVV and all control system as a whole have been received..

The main provisions submitted for defence:

– the general concept of design of control system of two-motor electric drive of the mechanism of rotation of railway cars adaptive to the variable moment of loading and the moment of resistance;

– mathematical models: the entire mechanical system as a whole (including a railway car, a fastening frame, as well as a two-motor electric drive), the control object (an automated electric drive with vector control);

– functional diagram of the adaptive control system of the two-motor electric drive;

– the structure of the subsystem of the speed controller of the two-motor electric drive, which differs from those already developed by the presence of a subsystem of identification parameters of the mathematical model of the control object (automated two-motor electric drive), thereby minimizing the dynamic loads in the design of the mechanism;

– the structure of the adaptation subsystem, the input signals of which are the identified parameters of the control object (automated electric drive);

– the design concept of the experimental installation of the control system of the two-motor electric drive of the mechanism of rotation of railway cars on the basis of the microprocessor control unit and precision sensors of angular movement.

Reliability of the obtained results is confirmed by the coincidence of mathematical modeling and experiments, both with the computer model of the control system of the two-motor electric drive of the mechanism of rotation of railway cars, and with its experimental installation.

In addition, the accuracy of the results is based on the use of precision photoelectric angular displacement sensors, high-performance control unit on a 32-bit microprocessor with a 12-bit digital-analog converter, as well as selected inexpensive, convenient and energy-efficient electric drives.

The developed experimental stand, which includes a computer Simulink-model, microprocessor control unit and a real mechanical system with power converters and a two-motor electric drive, fully reproduces the work of industrial complexes on the rotation of railway cars.

Approbation of the work. The main results of the dissertation research were reported and discussed at the International scientific-practical conference "Kozybayev's readings-2016: Modern trends in cultural and civilizational processes of Eurasia" (Petropavlovsk, 18.11.16); LXV and LXVII International scientific and practical conferences "Technical Sciences - from theory to practice" (Russia, Novosibirsk, 28.12.16 and 27.02.17).); International scientific-practical conference "Youth and science-2017" (Petropavlovsk, 12.04.17). Also, part of the results of the dissertation research were heard and discussed at scientific seminars of the Department of Energy and radio electronics of NKSU named after M. Kozybaev, departments of "Electrical engineering" and "Radio engineering devices and diagnostic systems" of Omsk State Technical University.

Publications. According to the results of the dissertation research, 14 publications were published, including 4-in scientific journals recommended by the Committee for control in the field of education and science of MES RK; 1 – in the journal of Engineering and Applied Sciences (Islamabad, Pakistan), included in the Scopus database; 7 – in the materials of conferences, including 2 – foreign (Novosibirsk, Russia); 2 – in the regional periodic Bulletin of NKSU named After M. Kozybayev. Partial results of the dissertation research are reflected in the innovation patent for the invention № 27956 (from 25.12.13).

The volume and structure of the dissertation work. The thesis consists of an introduction, four chapters, conclusion, list of references. The total volume of the thesis is 121 pages. The paper presents 96 figures, 4 tables. The list of used sources consists of 118 names.

The list of works published by the author on the topic of the thesis.

In editions approved by CCFES MES RK:

1. Ivel V. P., Petrov P. A. Development of the Simulink-model of the control system for complex rotation of multi-ton objects on the basis of the Arduino Uno platform. // Bulletin of PSU named after S. Toraighyrov. Energy series. – Pavlodar. - 2016. - №4-P. 108-116.

2. Ivel V. P., Petrov P.A., Gerasimova Yu. V. design of an adaptive speed control system for an induction motor using the auxiliary operator method // Bulletin of PSU named after S. Toraighyrov. Energy series. – Pavlodar. – №2 (2017). – C. 66-72.

3. Petrov P. A. Using Matlab/Simulink package and Arduino MEGA 2560 debugging Board to control two-motor asynchronous electric drive / / Bulletin of the Shakarim state University of Semey. – Semey. - 2017. - №2 (78), volume 1. - P. 68-72.

4. Petrov P.A., Ivel V. P., Gerasimova Yu. V., Moldakhmetov S. S. System of rotation-lifting of railway cars / / Bulletin of the national Academy of the Republic of Kazakhstan. - 2017. - №6. - P. 52-59.

In editions included in the database of Scopus:

Pavel Petrov, Yuliya Gerasimova, Viktor Ivel and Sayat Moldakhmetov. System of lifting and rotation of railway cars/ ARPN Journal of Engineering and Applied Sciences, Vol. 13(2), 2018. – P. 714-717.

In the materials of international scientific conferences, including foreign ones:

1. Gerasimova Yu. V., Petrov P. A. The Evaluation of some parameters of the control system of the asynchronous motor // Materials of the international scientific conference "KOZYBAYEV'S READINGS-2016: Modern trends of cultural and civilizational processes of Eurasia". - Petropavlovsk-2016. - P. 124-128.
2. Ivel V. P., Petrov P. A. The choice of the basic components for the implementation of computer system models control of an induction motor // Materials of international scientific-practical conference "Kozybayev's readings-2016: current trends of cultural and civilizational processes in Eurasia". – Petropavlovsk. - 2016. - Vol. 2. - P. 135-139.
3. Petrov P. A. Analysis of the current state in the field of automation of lifting and transport mechanisms for turning-lifting of large-size units / / Materials of MNPK "Kozybayev's readings-2016: Modern trends of cultural and civilizational processes in Eurasia", dedicated to the 85th anniversary of M. Kozybayev, Vol. 2. - Petropavlovsk: NKSU named After M. Kozybayev. - 2016. - P. 160-164.
4. Petrov P. A., Ivel V. P., Synthesis of adaptive control system of rotation-lifting of railway cars // Technical Sciences - from theory to practice: by materials on LXV international scientific-practical conference – Novosibirsk: Sibak. - 2016. - № 12 (60). - P. 21-27.
5. Petrov P. A. Method of synthesis of Matlab/Simulink software AND Arduino MEGA 2560 debugging Board // Technical Sciences - from theory to practice: by materials on LXV international scientific-practical conference – Novosibirsk: Sibak. - 2017. - № 2 (62). – Pp. 5-11.
6. Ivel V. P., Petrov P. A. Methods of control of asynchronous electric drive // International scientific-practical conference "Youth and Science - 2017". – Petropavlovsk. - P. 176-180.
7. Ivel V. P., Petrov P. A. Building a functional diagram of asynchronous motors with vector control // International scientific-practical conference "Youth and Science - 2017". – Petropavlovsk. - P. 180-184.

In the regional periodic Bulletin of NKSU named after M. Kozybayev:

1. Petrov P. A. the Use of hardware platform ARDUINO in the educational process of students of engineering specialties // Bulletin of NKSU named after M. Kozybayev. Pedagogical series. – Petropavlovsk. - 2016. – № 3(32) – P. 201-207.
2. Petrov P. A. Communication development Board ARDUINO MEGA 2560 with the MATLAB software // Bulletin of NKSU named after M. Kozybayev. – Petropavlovsk. - 2016. - № 4 (33) – P.98-104.