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DEVELOPMENT AND RESEARCH OF THE AUTOMATED ADAPTIVE SYSTEM STABILIZATION AND INCREASE OF ELECTRODYNAMIC SHAKING TABLES CHARACTERISTICS

ABSTRACT

of PhD thesis for the degree of philosophy doctor on the speciality
6D071600- "Instrument making"

The relevance of the research. Vibration, bump, thrust are an integral part of the operating conditions of machines, mechanisms, instruments and devices. It is not a secret for anyone that, with rare exceptions, the influence of these factors leads to an increase in entropy and the aging of materials. To better understand the essence of the phenomenon, conducted a huge amount of vibration research. Many company and research centers offer methods for analyzing, evaluating, classifying the influence of dynamic effects. It is clear that the best way to "find out" how a particular harmful factor affects a product is to operate the product in actual conditions during its entire life cycle. But this solution, in addition to a very important and unique advantage, has many shortcomings of an economic, temporary and functional nature. As a result, a complex action is laid out into components, determine the degree of their influence for certain specific conditions and conduct targeted research in selected areas. The created techniques allow to more fully investigate the effect of vibration under given conditions on equipment specially designed for their imitation. The equipment created for this purpose is being investigated for the effect of vibration under various operating conditions:

1. Vibration and acoustic noise;
2. Fatigue materials;
3. Destruction at resonance.

The reasons for specifying these areas are the presence of characteristic features of various machines, mechanisms, devices and devices, which accordingly requires a certain approach in each case.

In this work, we consider the third case of destruction at resonance. The life of the product is significantly reduced, and the stresses in the materials and compounds increase by orders of magnitude when excited in the product resonance. For most products, accurate determination of natural frequencies is a vital task. There are many indirect analytical and numerical methods for determining the natural frequencies of parts and structural elements. But with the increasing complexity of the object and the impossibility of taking into account all the features of products, accuracy (and sometimes adequacy), of course, decreases. In such cases, it is simpler, more economical and more expedient to carry out measures to determine the product's own resonant frequencies experimentally. Experimentally obtained data with correct measurements are more true than the data obtained by manipulating its description. Further, based on the information received, the design is adjusted to change the natural resonant frequencies of the product, or amendments are made to the technical conditions of its operation, transportation and storage.

At present, high requirements are placed on the reliability parameters of electronic equipment (ES) operating in harsh environments. The most important destabilizing factor leading to ES failures is external vibration impact (up to 30% of failures are due to vibration effects). In this regard, in the process of developing and producing an ES, it is envisaged to carry out laboratory and bench tests for the effects of vibration using special test methods and tools.

Despite significant achievements in the field of bench tests, the modes of operation of ES in actual operating conditions are significantly different from the test modes, which is the cause of up to half of the failures caused by vibration effects.

Consider the example of sensors. A significant number of sensor failures installed in rocket-space and aviation equipment are caused by the impact of intense mechanical vibrations. In addition, issues of durability and reliability when exposed to vibrations have long become crucial in the development of such equipment. sensors, as a rule, contains various structural elements and components, the reaction of which to the action of vibrations is different. During operation, sensors may be exposed to vibrations of a different nature, periodic, close to harmonic, shock, or random.

There are two categories of causes of failure (failure) that determine the reliability of sensors:

- fatigue failure of sensor elements;
- the deviation of the main parameters beyond the limits characterizing the proper functioning.

Thus, during vibration tests, 2 main tasks arising from the requirements formed in the process of development and creation and the requirements of operation are solved — assessment of the service life of the test object and development of test methods that correspond to typical cases of vibration exposure during the operation of the object and are suitable for mandatory applications. - Fair tests.

Therefore, in the general problem of improving the characteristics of electrodynamic vibration tables (EVT), improving methods and means of improving the measurement accuracy, degree of compliance of test modes with operating modes and information of the results of EDT tests is an actual scientific and practical task.

The purpose of this work is: to improve the operational characteristics of the EDT based on the model of prediction control based on the models using modern computer technologies and create a virtual laboratory base for vibration testing and the development of an automated adaptive system to stabilize the EDT.

To achieve **the goal**, the following research objectives are formulated:

– conducting exploratory research on the state and prospects of the development of shakers and vibration test control systems.

– analysis of the main technical characteristics and functionality of existing vibration tables and control systems.

– development of a number of mathematical models of the basic elements and units of the control system of the vibrating table.

– implementation of management system optimization based on selected criteria.

– experimental studies of an automated adaptive system for stabilizing and enhancing the characteristics of an electrodynamic shaker.

Object of research. Virtual laboratory technology and adaptive management, aimed at improving the technical characteristics of the automated laboratory bench.

Subject of research. Numerous enterprises in Kazakhstan use a large number of vibrating tables, which cannot satisfy the descriptions of their use due to their physical and moral deterioration of the control system and, therefore, the subject of the research is to solve these problems.

Scientific novelty of research: Scientific novelty of the results obtained in the dissertation work is as follows:

– Identification of software and hardware for electrodynamic shakers and substantiation of the methodology;

– Creating an accurate dynamic model of electrodynamic shakers, necessary to control the model;

– Obtaining the results of the synthesis of control systems for electrodynamic shakers using predictive control methods;

– Using advanced computer control technologies to develop the system software and hardware of the system.

The practical significance of the work. The theoretical concepts and methodologies developed in the thesis formed the basis of the ASCV developed, which made it possible to increase the efficiency of the ET bench tests, which are the acts of implementation in the research and development work of the Scientific and Production Center “Measuring and Measuring Technologies” LLC and “ODK-STAR” JSC.

Personal contribution of the author in the study. The results of the thesis submitted to the defense were obtained by the author independently. The results, published in collaboration with other authors, belong to the co-authors in equal shares. The results of other authors, which are used in the presentation, contain links to relevant sources.

Approbation of work. The main results of the work were reported and discussed at: International Satpaev Reading - 2015 “The role and place of young scientists in the implementation of the new economic policy of Kazakhstan” (2015, Almaty, Kazakhstan); III Annual Intercollegiate Student Scientific-Practical Conference Information Technologies in Science and Education. Problems and prospects. (2016, Penza, Russia); International Scientific and Practical Conference - Youth. The science. Innovation (Youth. Science. Innovation). (2016, Penza, Russia); Satpaev International Reading - 2017 “Scientific heritage of Shakhmardan Esenov” (2015, Almaty, Kazakhstan); at scientific seminars of the University K. Satpayev KazNRTU (2014-2017, Almaty, Kazakhstan); at scientific seminars of the department "R&ETA" SIE, K. Satpayev KazNRTU (2014-2018, Almaty, Kazakhstan).

The structure and scope of the thesis. The thesis consists of an introduction, five chapters of the main content, conclusion, list of references and applications.

The introduction is devoted to the relevance of the thesis, the purpose of the study, the objectives of the study, the subject of the research, the subject of the research, the scientific novelty of the work, the practical significance of the work, the approbation of the work.

In the first part, a literary review of the current state and future development of shakers and its control systems is made. Existing analysis of electrodynamic shaking tables. Analysis of the existing control systems of electrodynamic vibration tables. APC-control system for electrodynamic shaker. Automated test management system. Prospects for the development of existing methods and means of determining the dynamic characteristics of the structure.

In the second part, the main technical characteristics and functionality of existing vibration stands and control systems are analyzed. Modeling of structures and elements of control systems. Equivalent equivalent circuit and the dynamic equations of an electrodynamic vibrator. Parametric identification of the model of an electrodynamic shaker. The choice of the type of model and method of identification. Using the System Identification Toolbox GUI to identify a mathematical model of the shaker. Synthesis of the control system using the ACOR procedure. Creating a SCADA-project system with APC-management.

The third part - the active control of vibration and its application. Smart materials. Electro - and magnetic fluids. Electrical and magnetic materials. Damping. Analysis of materials, components and tools for testing resources, methods and acceleration using instruments.

In the fourth part is computer and mathematical modeling. Creating a mathematical model of the object. Presents an experimental study of the system and an assessment of its characteristics. Parametric identification of the TIRA shaker. Synthesis and analysis of vibration control systems. Synthesis of the PID controller. Optimal synthesis of ACOR. Creating a mathematical model of the control system. Computer simulation of the mathematical model of the control system. The choice of technical and software. The choice of equipment. Selection of software. SCADA - ASCV Design.

In the conclusion of the thesis, the main results of the work were summarized as a result of the presented and discussed research and analysis.