Method of Automated Research of Sound-Proofing Building Materials

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Abstract. There is a problem of effective organization and conducting experimental research in special situations. In scientific research, it is not uncommon to perform long and time-consuming experiments, when one experiment takes a relatively long period of time, when a complete factor plan of experiments is needed. The article describes an approach to organizing and conducting experimental studies of building materials on an automated stand with software control. An example of a stand for studying the sound-proofing properties of flat samples of building sound-proofing materials is given. The authors have shown that automation of the experimental research process increases the accuracy and reliability of research results; expands the boundaries of research and provides an opportunity for preliminary evaluation of primary results with further adjustment of the research plan. The method under consideration can be the basis for various experimental studies on stands that perform research according to a given program.

1. Introduction

There are numerous recommendations and methods for organizing, planning, and conducting scientific research, such as [1,2,3]. The theory of engineering experiment [4] emphasizes the importance of proper organization of experimental work. In recent years, there have been more and more publications devoted to various recommendations for improving the technique of experimental research, for example [5,6,7]. The paper [8] shows that the modern innovation industry requires new flexible production equipment using robots and complex workstations, as well as robotic testing equipment, and the publication [9] shows the importance of the theory and technical equipment of a physical experiment. A method for experimental research of small refrigerating machines using a robotic system is described [10]. A method for programming experimental studies using a microprocessor controller is also described [11]. It is also known to use the method of studying heat and energy indicators of compression refrigerators using automatic research tools [12]. In these studies, the transition from one steady-state regime to another occurs over a long period of time. Therefore, in the practice of using this method, automated experimental studies have proved to be very effective. The need for robotic experimental studies of refrigerating machines is due to the long process of establishing a steady state of operation of the refrigerating unit when its operating conditions change [13].

We have studied well-known approaches and methods for automating the process of experimental research to develop an automated method for studying sound-insulating materials. In this direction, the approach to automation of experimental research in [14] is of interest. Automation in the specified source mainly consists in automated processing of experimental results using special statistics programs.
The authors propose and develop the concept of robotic experimental research without the direct participation of an experimental operator, but under the control of a programmable controller.

To implement this method, we have developed a stand with software control and the ability to independently conduct individual experiments without human participation for the study of sound-proofing materials. The results of using a similar stand, which has been tested in practice [12] and taking into account the capabilities of modern programmable controllers during experimental studies [10], are used.

There are often situations when it is relatively time-consuming to maintain stable conditions for conducting an experiment, or there are other reasons for the need for faster measurements and faster execution of each experiment [13]. Then the researcher abandons the full factor experiment and uses simplified schemes for planning experiments. For example, experimental studies are carried out according to plans, such as planning for the Greek or Greek-Latin square or other abbreviated research schemes [15]. In the situations listed above, the research results are less accurate and reliable [16].

It is obvious that the automation of experimental research is an urgent direction for improving research methods.

The described method is an aspect of the development of automation of the research process. This method solves a particular problem, but its significance and prospects can be attributed to experimental research in many areas of science.

2. The essence of the research method

The method of automated experimental research consists in the fact that part of the functions of the researcher is performed by a computer program, and it is possible to use a software-controlled manipulator, or feeder, or other robotics device with command control. For example, to change or rotate the test sample. Unlike a human, a system that implements the described method can work around the clock, without direct human involvement. The method provides for automatic exclusion of gross errors from processing [17].

The results of performing individual stages, both in theoretical and experimental research methods, may lead to the need to make corrections to the General plan of knowledge, to the goals and objectives of theoretical and/or experimental research [18]. That is, the initial goals and objectives of the research are not dogmas, and in the process of conducting research, they can be corrected, supplemented, reduced or changed [19]. The above method is the basis of robotic experimental research.

As you know, when studying the properties of various materials, in various scientific and practical tasks, an experimental research method is used. In this case, the experiment is planned with subsequent experiments with varying parameters under study. The study uses measuring sensors, secondary devices, and means of converting and recording measured values. Errors and inaccuracies accumulate in this chain of factors, so it is often necessary to perform several experiments of the same type. Each experiment, experiment, or group of experiments has a specific research plan. This is described in detail and repeatedly in various sources, for example [20].

Sometimes it is necessary to maintain constant values of experimental conditions. Often the research material has certain features that affect the content and sequence of research.

Usually these tasks are solved by the researcher. The number of experiments of the same type, including the number of variations of the studied parameter, can be variable as the results of intermediate experimental experiments are obtained.

In scientific research, specialized research stands are often used, in which stable conditions are maintained and it is possible to change the conditions of the experiment. At the same time, the stand is controlled and the parameters are varied by the researcher.

Some functions of the researcher can be performed by an automated system for conducting experimental research, including:

- ensuring stable conditions during the experiments;
- change, variation of the studied parameters
- replacement of test samples ;
- control of experimental conditions;
- planned change in the conditions of a group of experiments;
- preliminary analysis of the results of individual experiments, for example, calculating deviations and detecting errors;
- adjustment of the research plan based on the results of preliminary measurements,
- adjustment of the required number of similar experiments;
- monitoring the process of recording measurement results;
- other function.

It is effective to adjust the research plan based on the results of the analysis of preliminary experiments. Traditionally, these and other research circumstances require operator involvement and more careful planning of experimental studies. Usually, the researcher performs the refinement of the experiment plan.

We propose to automate the process of conducting experiments in such a way that a number of functions of the researcher are performed automatically in offline mode. At the same time, it is not the operator who will vary the studied modes and parameters, but the research program embedded in the personal computer and installed using a programmable controller. The research program and Executive mechanisms will ensure the stability of the experimental conditions, and vary the parameters under study.

3. An example implementation of the method

The inclusion of manipulators in the automated research system will allow you to change the test samples, move devices or research objects. Let’s consider a variant of implementing the method of automated research of samples of sound-insulating materials in the form of flat rectangular panels on a stationary specialized stand. The influence of the thickness and other dimensions of flat acoustic panel samples, the material and construction of these panels, the frequency, spectrum and power of sound sources, air temperature and other working conditions of sound insulation must be investigated under identical conditions. For the automated process of conducting experiments, you need a program to control all the parameters and modes of the experiment, including the ability to change the sound power, frequency values and their spectrum, as well as to be able to check the accuracy of the experimental conditions, control the recording of measured data by microphones. The manufactured stand uses manual replacement of the test samples. However, it is possible to change the test samples using a movable carriage.

The scheme of the stand where the proposed method of automated research of sound-proof building materials is implemented is shown in figure 1.

The stand includes: a sensitive microphone -1, a hard case-2, a sound-proofing coating-3, a tray for installing test samples-4, low-frequency and high-frequency speakers-5. The work of the stand is provided by: system for changing the frequency and power of sound. It includes a sound oscillator (G) and an adjustable sound power amplifier (> ), as well as a software controller for changing the frequency and power of sound effects (MS). To control the measurement algorithm of the parameters under study and record the measurement results, a personal computer (PC) is used, to which the microphone output is connected and which controls the operation of the controller for software changes in the frequency and power of sound exposure.

During experimental studies of sound-proofing materials on a stand with software control, a stable frequency and stable radiated power of sound emitters are established. Under the control of a programmable controller, the steady-state mode is monitored and a command is generated to perform measurements and record individual experience indicators. According to the programmed research plan, generation is provided different sound wave spectra and their power (sound pressure) adjustment at different frequencies.

As a sound source, you can use an audio recording of the noise of a real machine.

In automated research, the measurement results are recorded in the memory of a personal computer and can be transmitted for analysis remotely.
The developed and considered method of experimental research provides a significant simplification of the process of long-term multiparametric studies, reducing research costs, and improving their quality. In the future, it is possible to conduct automated "intellectual research" using the student, Fischer, and other criteria.

The purpose of this research organization is to evaluate the results of preliminary experiments in order to optimize experimental studies and obtain their results more quickly, to determine the features of the objects under study at the stage of preliminary experiments and automatically adjust the content of the research plan, to determine extreme zones or areas of restrictions. The developed method is also applicable to other problems of building materials research.

4. Conclusions
1. the Developed method of experimental studies of sound insulation properties of building materials expands the experimenter’s capabilities at the stages of planning and conducting research, accelerates the conduct of experiments;
2. the method of automated experimental research will improve the accuracy and reliability of research results;
3. The developed method is useful for many types and directions of experimental research.
4. automation of experimental research is aimed at reducing labor and economic costs, as well as speeding up the solution of research problems.

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