Section 3. Mechanics

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THE SCOPE OF APPLICATION OF DEVICES WHOSE OPERATION IS BASED ON TAKING INTO ACCOUNT THE CONNECTIVITY OF THERMOELECTROELASTIC FIELDS

Abstract. The work highlights devices whose operation is based on taking into account the connectivity of thermoelectroelastic fields. Sensors of various classes based on piezo- and pyroeffect are considered. The designated areas of application of the considered measuring instruments and calculation methods allow us to analyze the connectivity of temperature, electric and elastic fields.

Keywords: piezoelectric elements, thermoelectroelasticity, piezoceramic cylinder.

Currently, devices whose operation is based on taking into account the connectivity of fields of different physical nature are widely used. At the same time, the piezo- and pyroelectric effect based on the coupling of thermoelectroelastic fields is used as the basis for the operation of temperature sensors.

The scope of application of such sensors is very wide in medicine. For example, cylindrical actuators of reinforced type are used in microdosing devices, in scanning microscopy, in microsurgical and ocular operations for accurate instrument feeding.

Multilayer piezoactuators, which are used for internal combustion engines, are widely used in the automotive industry, thereby ensuring the smooth operation of the engine. A multilayer piezoelectric actuator can be used to manufacture a generator that converts mechanical forces into electrical signals.

Shell-less piezo-package actuators, manufactured in the form of a disk or ring, are widely used in industry, in high-frequency positioning systems for instrumentation, as well as optoelectronic systems for monitoring and controlling technological processes in microelectronics at the submicron level; in manipulators of various robots, in optomechanical devices for micro-displacements of the slide table (control of gas analyzers-dosimeters) [1; 2].

The elements based on the piezoelectric effect have high performance, are less susceptible to interference, and are technologically advanced in manufacturing. The use of piezoelectric materials in electronics makes it possible to reduce the geometric characteristics of device elements and contributes to the creation of efficient energy converters. The use of pyroelectric elements allows you to measure the temperature and analyze other characteristics of devices and structures. The effects of temperature stresses must be taken into account in the designs of aerospace technology, for example, in solid-fuel charges of rocket engines, which are thick-walled hollow cylinders, etc. The pyroelectric effect belongs

to a wide class of thermoelectric phenomena that manifest themselves externally as the electrification of dielectrics when their temperature changes. To date, pyroelectric converters of various types, such as thermal radiation detectors, chromatographic detectors, anemometers, shock wave sensors, etc. are used in industry.

Thermal imaging and thermography methods are used to remotely measure the temperature of objects [3]. Thermal imaging is based on determining the location of objects and recognizing their shape (even in complete darkness), but without taking into account temperature. Thermography performs the functions of thermal imaging and provides quantitative radiometric measurements of the temperature of this object. Therefore, the devices used in industrial and medical diagnostics are divided into two main classes: thermal imagers and measuring thermographs. Thermal imagers (infrared cameras) are most often used as night vision devices. For accurate diagnostics in engineering and medicine, measuring thermographs are used, with the help of which data of the thermal field of the object is obtained. Thermal imaging devices help to identify dangerous defects that show a violation of the normal operation of the object by identifying hot or cold places in the temperature field. Thermal imaging is of great importance: in industry, medicine, military equipment, transport, scientific research and everyday life. Pyroelectric thermal imagers are used in aerial photography of fires. Miniature pyroelectric X-ray generators find applications in radiography and radiation calibration.

Thermometric converters are used to measure thermal parameters. These include pyroelectric temperature meters (pyro-thermometers), heat capacity and thermal conductivity meters (pyrocalorimeters), heat content and heat exchange meters with the medium (catarometers, anemometers), etc. The pyro-thermometer, depending on the circuit of its inclusion, determines the temperature or the rate of its change. Pyroelectric catharometers are used in gas chromatographs to analyze gas mixtures by the thermal conductivity of the components of the mixture, pyroelectric anemometers are used to study the features of the movement of liquid or gas media, in particular, in metallurgy.

In modern practical medicine, respiratory parameter sensors are used, which are designed for non-contact recording of the frequency and intensity of breathing and understanding the state of the respiratory system, the operation of which is based on the pyroelectric effect.

The development of space engineering contributed to the creation of pyroelectric shock wave sensors that experience two thermal effects – convective and radiation and mechanical effects, the exposure time does not exceed 1 ms. Such pyroelectric sensors provide simultaneous measurement of all types of impacts with direct reproduction of the form of convective and radiative heat flows.

Based on the above, it can be concluded that applied research has led to the widespread practical use of pyroelectrics in many areas of modern science and technology. Currently, these studies are also continuing to develop quite actively. In order to expand the functionality of devices of this type, there is a need for an in-depth analysis of non-stationary processes, which makes it possible to understand the effect of the interaction of electric, temperature and elastic fields. To do this, various theories are used that analyze this problem with varying degrees of accuracy. At the same time, as a rule, thin elastic systems are used as computational models of the structures under consideration when performing kinematic hypotheses. The task becomes significantly more complicated when studying the construction of finite rigidity in a three-dimensional formulation. In this case, a system of non-conjugate differential equations is formed, the integration of which is associated with great mathematical difficulties, but only such an approach allows us to fully take into account the connectivity of electroelectroelastic fields [4].

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