доступа: http://drama.eserver.org/plays/modern/arms_and_the_man.html/document_view
4. Shaw, Bernard. Misalliance [Электронный ресурс]. – Режим доступа: http://drama.eserver.org/plays/modern/misalliance.html/document_view
5. Wilde, Oscar. An Ideal Husband [Электронный ресурс]. – Режим доступа: http://drama.eserver.org/plays/modern/an_ideal_husband.txt/document_view
6. Wilde, Oscar. The Importance of Being Earnest [Электронный ресурс]. – Режим доступа:http://drama.eserver.org/plays/modern/importance_of_being_earnest.html/document_view
7. Biggs, John. Sun Country [Электронный ресурс]. – Режим доступа: http://drama.eserver.org/plays/contemporary/sun-country.txt

DEVELOPMENT OF AN AUTOMATED SYSTEM FOR THE DETERMINATION OF THERMAL PROPERTIES OF MATERIALS

A. A. Tahanova, V. V. Medvedev
Tomsk Polytechnic University

Introduction

The development of many industries requires the creation and application of new structural, electrical, heat and cold-resistant materials with over known higher performance.

One of the main indicators of quality of most materials is their thermal characteristics (TPC). Therefore, for the reliable determination of these parameters new methods are developed.

These are the pulse methods to determine the thermal diffusivity, thermal conductivity and specific heat of the material in a short period of time. The simplest method for implementing is a laser pulse.

It is known that there is a fixed installation, which provides an implementation of the laser pulse. However, for the greatest convenience, the development of a portable automated system for determining the TPC materials with minimal time and material resources is required.

1. Thermal pulse method for the determination of thermal properties of materials

The essence of the method of the laser pulse (pulse laser heating method) is in absorption of the pulse energy in a thin layer heated ("hot") surface of the sample and registering of temperature changes in time in inverse ("cold") surface. An experimental data obtained on the basis allows to calculate the thermal characteristics of the test material (TPC): specific heat c, thermal conductivity coefficients λ and thermal conductivity a using expressions [1]

$$a = 1{,}37\frac{L^2}{\pi^2 \tau_{0,5}},\ m^2/s\ ;$$

$$c = \frac{Q}{T_{max}\rho L},\ J / kg \cdot K;$$

$$\lambda = ac\rho,\ W / m \cdot K,$$

where L – sample thickness, m; ρ – material density, kg/m^3; $\tau_{0,5}$ – the time to reach half of the maximum temperature overheating of the "cold" surface of the sample, s; Q – energy is absorbed by the sample, J / m^2; T_{max} – maximum heating temperature of sample, K.

The disadvantages of the method [1] are the assumption of an infinite magnitude of the heat flux of the laser radiation to the heated surface and restrictions on the conditions of heat exchange on the "hot" and "cold" borders.

Changing the characteristics of the materials during operation causes some changes in technological equipment processes. It is therefore necessary to periodically clarify TPC of materials.

For an operational definition of TPC of structural materials in objects of power is preferable to use a pulsed thermal method. Modifications of the heat pulse method (double-sided method in which the temperature is measured on the surface opposite the surface on which the heat flux of impulse heat source is directed, and a pulse-sided thermal method in which the temperature is measured on the same surface on which the heat flux is directed from the heat source) can significantly speed up the process of determining the TPC and reduce its error [2].

2. Error and conditions of use of pulsed methods of determining the TPC materials

The laser pulse heating method is constantly improving, and there is an expansion of the list of materials for which with its use is defined TPC (metals and alloys, insulation, biological, anisotropic, film, partially transparent materials, as well as liquid metals, liquids and molten salts, two-layer system) [1].

However, the practical implementation of the laser pulse method does not correspond to its mathematical model, which is based on an approximate solution of one-dimensional non-stationary heat conduction problem for a plate with an infinitesimal duration of exposure to the laser beam at her with a uniform energy density and in the absence of heat exchange with the environment. Analysis of the literature on this problem has shown that the mathematical formulation of the problem underlying the laser pulse heating method is the source of systematic errors that need to be considered in a real experiment.

The main error in determining the TPC of materials by pulsed laser action due to the explicit and implicit assumptions made in the formulation of the problem. This limitation on the conditions of heat exchange at the borders; the assumption of unlimited magnitude of the heat flux of the laser radiation to the heated surface, infinitesimal duration of the heat pulse, the spatial uniformity of the heat flow; dimensional process of heat transfer in the sample.

The influence of the pulse duration and the heat sink from the "cold" and "hot" surfaces of the sample studied previously, but uses mostly one-dimensional models, in which the multidimensional process of heat transfer in the sample, locality of impulsive action and other relevant factors are not taken into account. Mathematical modeling of temperature fields in the sample in terms of real experiments can become the main method of analysis as the error in the determination of TPC by pulsed laser heating so highlight the actual range of variation of the experiment parameters, in which reliable estimate of TPC.

All studies were conducted by numerical modeling of heat conduction in materials samples. The solution of all tasks is performed by the method of finite differences.

Analysis of influence factors on the group error in the determination of thermal properties of materials was based on one-dimensional, two-dimensional and three-dimensional models of heat conduction for field solutions with heterogeneous and unsteady boundary conditions.

3. The analogue of measuring system

The determination of thermal properties of materials has practical implementation. There are real big installations that are used for thermal properties determination of small piece of material, i.e. this facility is stationary. Figure 1 illustrates a form of one of this installation [3].

Figure 1 – Laser Flash Apparatus

The standard single layer flash diffusivity method can easily be applied to materials such as heat sinks, heat spreaders, substrates, die, molding compounds, adhesives and interface materials [4].

The flash method (see Figure 2) involves rapidly heating one surface of a small disk or slab of the material with a single pulse from a laser or other flash energy source, and monitoring the arrival of the resulting temperature disturbance as a function of time on the opposite surface [4].

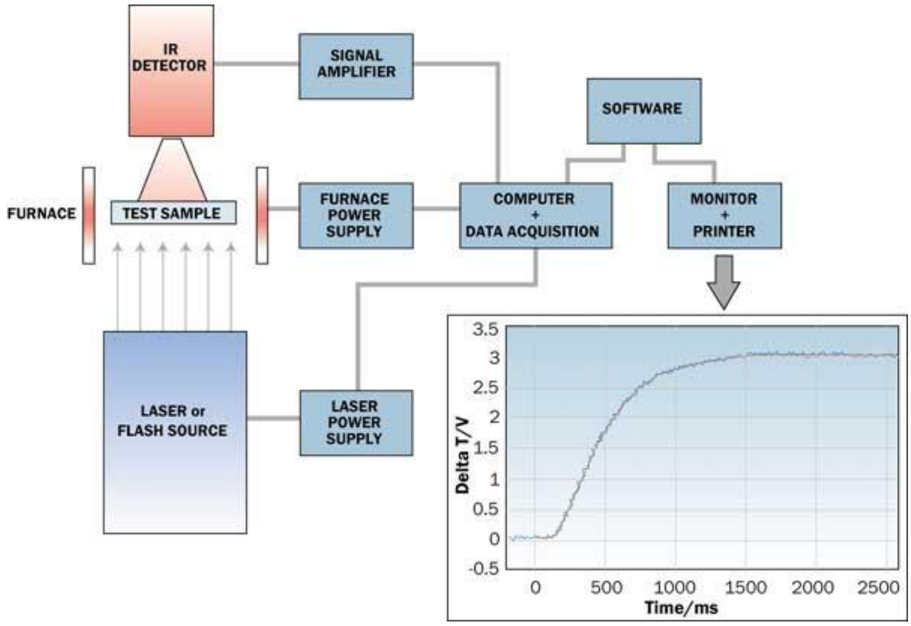

Figure 2 – Schematic of flash diffusivity measurement and temperature rise curve.

Sample geometry is normally a disk 6 to 25 mm diameter, or squares 6 to 25 mm on a side, with thickness ranging from 0.02 to 4 m, depending on the thermal conductivity of the material and the equipment being used.

Normally the back face surface temperature is monitored with an infrared detector, making the measurement contactless. This is a significant advantage over other methods, especially for thin, low thermal resistance samples. Uncertainties in other methods related to the contact resistance between heating/cooling plates or probes and the sample, and to accurate measurement of surface temperature differences using contact sensors, can be essentially eliminated. Very thin samples and small thermal resistances can be accurately measured without stacking layers, allowing measurements at the application thickness [4].

4. The components of automated system for the determination of thermal properties of materials

It is assumed that the system will consist of the following devices: temperature sensors, connecting cables, controller, power supply and personal computer. An approximate form of the devices is shown in figure 3.

Figure 3 – Schema of exemplary apparatus of system

Fully automated, these research-quality instruments take accurate single- or multi-point measurements of surface temperature.

Each precisely calibrated sensor must be flexible and robust with a low-profile configuration that allows minimally intrusive mounting on the surface. These systems require a PC to operate and utilize the provided software for data acquisition and reporting.

Conclusion

In determining of substance's TPC by pulse methods set threshold of heat flow. As a result of the numerical simulation of the thermal conductivity it is shown that pulsed methods give correct results for materials with high thermal conductivity, what are the metals and alloys. Using pulsed methods for materials with low thermal conductivity is possible by limiting the pulse duration and the sample thickness. Nonuniformity of the spatial energy density of the laser flux at the material surface increases errors.

Research has shown that the theoretical error estimate of the laser pulse creates the conditions for a fair determination of TPC of any materials with the establishment of methodological errors, which can be called systematic. In addition, knowledge of the extent of these errors creates the prerequisites for setting new targets to reduce errors in the determination of TPC by this method [1].

The development of automated system for the determination of thermal properties of materials will have high importance as it is designed for operational use, when it is possible to determine TPC of materials on site. Of course there are different conditions and errors of system work, but it is expected some of them will be taken into account in the system.

The results of determining the values of TPC can be used in the calculation of the parameters of heat flow in the objects of power, and in the diagnosis of thermal fatigue of structural materials.

REFERENCES

1. Katz, M. D. Error and conditions of use pulse methods for the determination of thermal properties of materials. – Tomsk: Publishing House of TPU, 2009.
2. Kuznetsov, G. V., Katz, M. D. On the conditions of application of pulse methods for determining the thermal properties of structural materials // Bulletin of the Tomsk Polytechnic University. – 2008. – T. 312. – № 4. – PP. 10-13.
3. http://en.wikipedia.org/wiki/Laser_flash_analysis.
4. http://www.electronics-cooling.com/2002/05/flash-diffusivity-method-a-survey-of-capabilities.

THE USE OF HUMAN POWER TO GENERATE ELECTRICITY

V. S. Fatneva, E. Ya. Sokolova
Tomsk Polytechnic University

Introduction

The sources of energy available for harvesting are essentially of four forms: light, radio-frequency (RF) electromagnetic radiation, thermal gradients, and motion, including fluid flow. All have received attention, in varying degrees. Energy harvesting generators are attractive as inexhaustible replacements for batteries in low-power wireless electronic devices and have received increasing research interest in recent years. This article deals with new and unusual technologies used to harvest power and produce it at low scales.

Nanogenerator

Many scientists all over the world are concerned with the problem to create a nanogenerator converting mechanical energy into electrical one at the same voltage as batteries do. The first mini- device converting mechanical energy into electrical one was created in 2008. Professor Zhong Lin Wang of the Georgia Institute of Technology and his colleagues developed two nanogenerators, which were very thin and tiny. This generators were as small as a (paper) clip. After Zhong Lin Wang has introduced a basic configuration of VING (Vertical nanowire Integrated Nanogenerator (VING)). In 2006 where he used a tip of atomic force microscope (AFM) to induce the deformation of a single vertical ZnO nanowire, the first development of VING is followed in 2007.

Nanogenerator is the term researchers use to describe a small electronic chip or technology that can use mechanical movements of the body to generate electricity by small-scale physical change.

There are three typical approaches in nanogenerator technology: piezoelectric, triboelectric, and pyroelectric nanogenerators. “Both the piezoelectric and triboelectric nanogenerators can convert the mechanical energy