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Experimental Installation to Determine the Heat Loss of a Construction Object

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Abstract

This article notes the important role of experimental research in order to determine more accurate information about the thermal properties (TPP) of the object under study, which significantly affect the thermal regime. The analytical review of the known methods of determination of thermos physical properties of construction objects is carried out. The limitations of the methods of determining the TPP of the investigated object described in this article are analyzed. Presented the necessary formulas for calculating the TFS of the object under study, developed by the installation of nondestructive testing.The developed installation is capable of determining the thermo physical properties of an object, as well as the spatial pattern of the distribution of heat fluxes inside the object, by non-destructive testing, in a shorter period of time compared to existing analogues.

Keywords*: Thermophysical properties, methods,heat loss, review,methods,heat loss determination.*

I. Introduction

Up to date one of the most pressing problems in improving energy efficiency is to use easy and reliable methods to check up on external heat loss through the enclosing structures of the facility and to assess thermophysical properties (TPP) massively affecting the thermal behavior. A decrease in external heat loss of a construction project has a great impact on its energy performance. To reduce the external heat loss of any construction project requires knowing its TPP. The properties of materials are known to change over time. More accurate information on external heat loss makes it possible to assess with greater reliability the required capacity of the heat supply system. The key source of information for the definition of the TPP enclosing structures is provided by an experiment. The methods to assess the TPP of construction projects and (or) materials are divided into three main types: non-stationary, stationary and complex [1-3]. Non-stationary TPP determination methods are the most challenging owing to its simplicity and short experiment time etc. [4-8]. Stationary methods are based on creating special boundary conditions on both sides of the structure (walls) under study during the experiment [1-5]. Compared to stationary methods, non-stationary methods are the most promising since less time and heat is spent in determining the TPP. The major constraints of stationary methods are complex equations for calculating the TPP as well as difficulties in

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determining the mutual conformity of real boundary conditions with theory. More authentic information about TPP as a result of one experiment can be provided by complex methods. Furthermore the research methods used in the study of the TPP materials are split into absolute and relative methods. The most promising methods of TPP research are absolute. For the analysis of TPP material they also adopt methods of temperature waves [2-4]. TNDTM (temperature nondestructive testing methods) from the listed above rank the top when determining TPP. According to [2-10] TNDTM have a diverse functionality, high performance, authenticity and the required efficiency. The methods and measurement instruments (MI) applied therein are split into groups. The first group refers to contact methods and measurement instruments, the second group refers to non-contact methods and measurement instruments. Compared to non-contact methods, the contact method applies to direct contact of measurement instruments with the surface of the sample section under study.

II. Main part

Based on the analysis of literary sources, an automated installation was developed to determine the TPP of an object using non-destructive testing.We have studied the designed installation to determine the TPP with a preset action algorithm at three sites. The first one was the model presented in Figure 1.

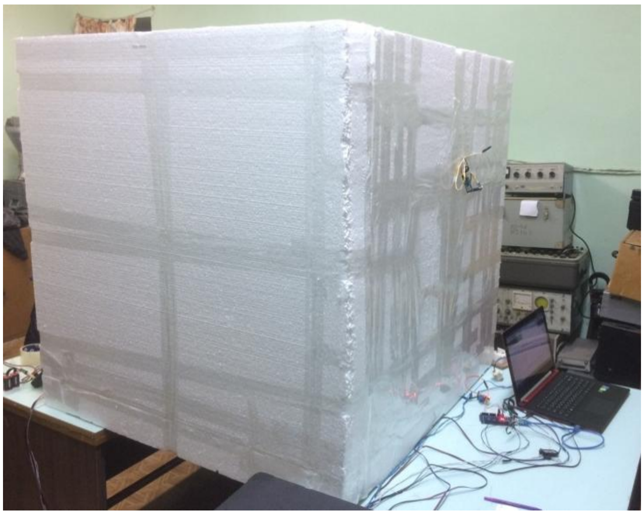

Figure 1 - Subject matter model

The research object is shaped into a cube of polystyrene foam - S25 and has a declared by the manufacturer heat conductivity of 0.039 W/(m·°C), the surface area of 1.09 m^2, layer thickness of 0.1 m. After carrying out the preliminary procedures, we maintained the set temperature in the object, the ambient temperature was detected by using the manufactured portable module.

More accurate readings of the object's heat losses were obtained using the electric energy quality analyzer, the latter taking into account the electric power consumption and other factors as a result of the experiment.

Figure 2 illustrates the diagram of changes in supply voltage of the heat supply unit within the time of the experiment.

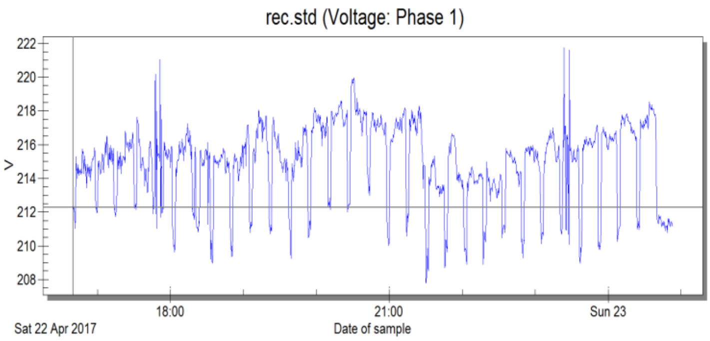

Figure 2 - Diagram of change in supply voltage of the heat supply unit within the time of the experiment.

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Figure 3 provides a diagram of discrete change in the supply current of the heat supply unit within the time of the experiment.

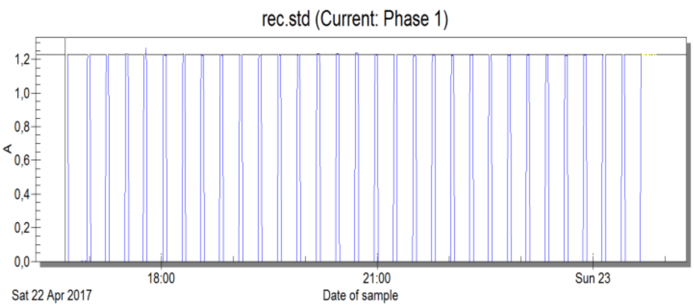

Figure 3 - Diagram of change of supply current of the heat supply unit within the time of the experiment.

Figure 4 illustrates the diagram of heat consumption from the active power source throughout the experiment.

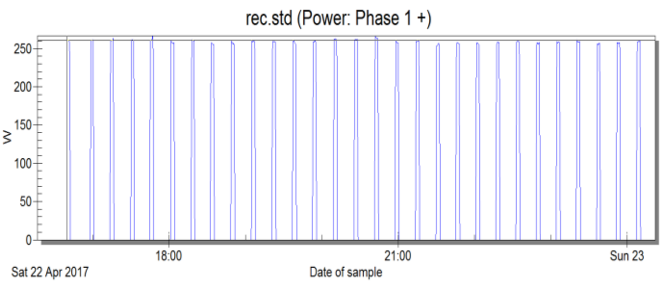

Figure 4 – Diagram of power consumption from heat supply source throughout the experiment

The experimental study obtained the following values: maintenance time of the set temperature $t_{maintenance.}$28880 seconds, active operation time of the heat supply source $t_{active\ work}$5023 seconds. The average power consumption for a heat source as read by the analyzer is 258 W. The average power consumption required to maintain the set temperature for an hour over the experiment period was 44.87 W. The average temperature within the object of study – 32.69 °C, the average ambient temperature over the study – 17.35 °C. The total area measured outside the study object is 7.13m^2. The total volume of the outer measurement of the object of study - 1,295 m^3[7].

Applying experimental data, the specific thermal characteristic $q_{0\exp}$ of the tested object is specified by the formula:

$$q_0 = \frac{P_{spent.}}{V \cdot (T_{inside} - \overline{T}_{ambient})}. \qquad (1)$$

Average $P_{spent.}$ power consumption to maintain the set temperature during the survey (W):

$$P_{spent.} = P_{source.} \cdot \frac{t_{\text{active work}}}{t_{\text{maintenance}}}, \qquad (2)$$

where $P_{source.}$– rated power of a heat supply source, $t_{\text{active work.}}$– time of active operation of a heat supply source, $t_{\text{maintenance.}}$– set time of maintenance of the set temperature T_{inside}. $T_{ambient}$ – is the ambient temperature.

It was $q_{0\exp}$ = 2.26 W/(m^3·°C).

The estimated heat transfer resistance for the object under study was calculated by the formula [6]:

$$R_{\text{estimated}} = \frac{1}{\alpha_B} + \sum \frac{\delta_i}{\lambda_i} + \frac{1}{\alpha_H}, \qquad (3)$$

where α_B - heat transfer coefficient of the inner surface of the enclosing structure; α_H - heat transfer coefficient of the outer surface of the enclosing structure; λ_i - heat transfer coefficient of the enclosing structure layer i; δ_i – thickness i of the enclosing structure layer; $\alpha_B = 8{,}7$ W/(m^2·°C).

Thermal conductivity of the material as declared by the manufacturer $\lambda_i = 0{,}039$ W/(m·°C).

The coefficient α_H according to [6,7] was calculated by the formula:

$$\alpha_н = 1{,}16 \cdot (5 + 10\sqrt{\upsilon}), \qquad (4)$$

where υ is the outdoor air speed, in the experiment is equal to 1 m/s, then α_H = 17.4W/(м2·°C).

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$$R_{\text{estimated}} = \frac{1}{8{,}7} + \frac{0{,}1}{0{,}039} + \frac{1}{17{,}4} = 2{,}74 \text{ (m}^2\cdot\text{°C)/W.}$$

The thermal conductivity of the used foam polystyrene material PSB-C25 was determined to confirm the thermal properties of the facility material. The device HFDM2 - heat flux density meter, shown in Fig. 5, was used as a measuring instrument.

Figure 5 –HFDM2

A 0.032 m thick sample was stowed in a special compartment, Figure 6. The temperature sensors were mounted on both sides, with one heat flow probe. At the end of the time when the heat flux stopped changing, the temperatures on the both hot and cold sides and the heat flux were recorded [7].

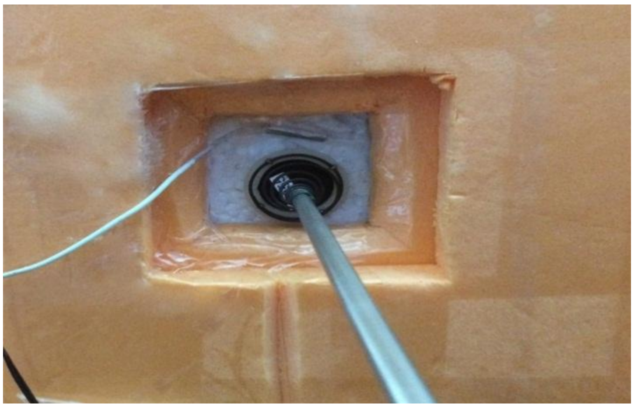

Figure 6 - The polystyrene foam sample PSB–S-25

Measurements of the temperature of the sides of the polystyrene foam sample PSB–S-25and heat flow are provided in Figure 7.

Figure 7 - Measuring thermal features of polystyrene foam PSB-S 25

We determined the heat conduction λ of the material by the formula:

$$\lambda = \frac{Q \cdot \delta}{\Delta t}, \qquad (5)$$

where Q is the heat flux through the sample material under study;

Δt - the temperatures on different sides of the sample.

The heat conductivity λ of polystyrene foam PSB-S25 according to the results of the experiment was 0,0395 W/(m·°C).

The obtained data are substituted in the formula of heat transfer resistance and given the obtained value of heat conductivity of polystyrene foam PSB-S 25, we get $R_{расч}$ =2.74 (м^2·°C)/W.

III. Conclusion

Analysis of the results of the experiments allows us to conclude that the proposed portable automated installation and the method for determining the TPP of objects are applicable.Compared with the known technical solutions, the proposed one allows you to set the heat transfer coefficient, specific thermal characteristic, heat transfer resistance for the studied object as a whole, taking into account all the heterogeneities of the enclosing structures, and also significantly reduce the duration and energy consumption of the experiment.

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References

[1] Kabanov O.V. Measuring the Thermo Physical Properties of Construction Projects. / S.A. Panfilov, A.A. Prokin, E. S. Sergushina // Journal of Computational and Theoretical Nanoscience. Volume- 16, Issue- 8, 2019. pp. 3121–3127.

[2] Kabanov O.V. Automated Portable Installation to Determine the Thermo Physical Properties of the Object. / S.A. Panfilov, A.A. Prokin, E. S. Sergushina // Journal of Computational and Theoretical Nanoscience. Volume- 16, Issue- 8, 2019. pp. 3115–3120.

[3] Kabanov, O.V., Panfilov, S.A. Method of a building object thermophysical property determination. Journal of Engineering and Applied Sciences, 12(11) SI, 2017. pp.9056–9060.

[4] 4.Kabanov, O.V., Panfilov, S.A. Determination of thermal physical properties of facilities. Journal of Engineering and Applied Sciences, 11(13), 2016 pp.2925–2929.

[5] Kabanov O.V., Lebedeva A. V.Energy-Efficient Autonomous System of Heating. Journal of Computational and Theoretical Nanoscience. Volume- 16, Issue- 1, 2019. pp. 145–150.

[6] Panfilov, S.A. Method for determination of the real heat losses of the existing construction objects / S.A. Panfilov, O.V. Kabanov // Vestnik South Ural State University. Construction and architecture" series. – 2017. –№ 4. – P. 52–61.

[7] Thermal protection of buildings, Construction Directives and Rules 50.13330.2012 apdated version instead of Thermal protection of buildings, Construction Directives and Rules (23-02-2003).

[8] Meysam, Davoodabadi Farahani and Hamid, Aghajani, 2013. Identification of potential groundwater zones using RS and GIS. UCT Journal of Research in Science, Engineering and Technology, 1(4), pp.4–6.

[9] Bogoslovsky, V.N. Construction thermos physics. ThermoPhysical Basics of Heating, Ventilation and Air Conditioning: Textbook for Higher Education Institutions, Publishing House: Book on Requirement.2013. p.416.

[10] Batalov, V.S. Simultaneous determination of the thermo physical parameters of the solid-phase substances. Engineering and Physical Journal, T42(6), 2013 pp.1026–1027.