Heat loss through the wooden elements of windows

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Abstract. To analyze of the transmission heat losses through the wooden elements of windows are presented. As a result of studies, it was found that the losses of thermal energy can be more than 2 times higher current requirements depending on the different thickness of windows frame. Analysis of the thermograms and of the results of calculations of transmission heat losses determine the necessity of justification-oriented approach in selecting the elements of translucent walling, materials and execution of these elements depending on the geological and climatic characteristics of the region of operation.

1. Introduction
High rates of construction of a municipal, administrative and individual apartment buildings, renovation of existing buildings and structures in routine and emergency purposes require justify-balanced, selecting designs from an economic point of view [1]. In addition, it is necessary to take into account the energy efficiency of structural elements and the materials from which buildings are made. Known the energy efficiency of buildings and structures depends on a number of factors, which include geoclimatic and morphometric [2-4]. Substantial heat loss occurs through doors and windows frames. Energy efficiency largely depends on the properties of materials. Right evaluation of heat loss through the building elements gives the possibility to improve not only the energy efficiency of buildings and structures, but also reduce the cost of energy used in heating systems.

2. Experimental Part
Elements of the designs of houses were photographed before the research. The thermograms were recorded at the following conditions: outdoor air temperature - 0 ± 0.5 °C, its relative humidity - 60 ± 5%, air velocity - 1 ± 0.5 m / s; temperature (23 ± 0.5 ° C) and humidity (55 ± 5%) of indoor air. Thermograms filmed sequentially planned areas with time-lapse recording of thermal images to the memory imager Testo 875-2. When the operator moves along the objects in order to follow the correctness of calculation distance and the protective structures remained largely unchanged [5-7]. All the thermograms obtained were processed in a palette of 256 colors, allowing you to visualize the temperature distribution on the surface of the object. Obtained images were processed using specialized software Testo. Presents the temperature scale corresponding to the color palette of a point with a temperature and cut sections with a field of temperature distribution. To define the locations of thermal ano-

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malies (defects) when performing a qualitative analysis of infrared imagery is accompanied by photographs of the examined fragments.

3. Results and Discussion
Comparative analysis of the translucent walling energy efficiency of different types of buildings and structures (wood, panel) implement by methods as a thermal imaging survey and standard methods for determining heat losses. For comparison we have chosen wooden window unit. The thickness of frame is 110 mm for apartment house and 50 and 40 mm for temporary structures [8-10].

Image windows in the visible and infrared spectra, as well as some graphical changes in temperature are shown in figures 1-3. The analysis of the thermal images showed that the thermal insulation characteristics of the frame elements in many cases do not do meet the requirements of normative documents on differential (Δt) between the indoor air temperature and the temperature of the inner surface. In conditions when the temperature below zero tem (winter months) Δt grows much more, which can lead to freezing of the windows, significantly reduce the temperature of the indoor air, which is clearly seen in figures 2 and 3. Further analysis of thermal images show a violation of insulation layer between the frames and the partition wall, as well as increased heat loss due to incorrect closures. Temperature change in the thermograms along the length of sections of P1 and P4 (figure 3 c, d) allows to conclude that heat losses characteristic of the defective areas, re-formed in the result of variations in the process of manufacturing elements of windows frame.

As part of the research has been carried out a comparative analysis of the maximum permissible heat loss through the window wooden elements. Calculation was carried out without taking into account the heat loss through the mounting layer between the wall and the window. Calculation of heat loss is made subject to the maximum allowable temperature deviation on the Internal air and walling elements (regulated by relevant regulatory documents) and actual.
Figure 2. The image of the wooden window with a frame thickness of 50 mm in natural and infrared spectra, as well as the change in temperature over the length of section: a – photo picture; b - thermogram of the object; c - change of temperature along P1; d - change of temperature along P2.

Figure 3. The image of the wooden window with a frame thickness of 40 mm in natural and infrared spectra, as well as the change in temperature over the length of section: a – photo picture; b - thermogram of the object; c - change of temperature along P1; d - change of temperature along P4.
Some of the results of the integrated assessment calculation of heat loss through the elements of the windows frame per product and per 1 m$^2$ elements are shown in figure 4.

**Figure 4.** The results of the calculations of heat loss on one window: a – on the actual value of their area; b – on 1 m$^2$.

The dependence of the transmission heat losses on the thickness of the wooden frame can be described by the equations:

$$Q^T = -144.49 \cdot h + 22.181$$  \hspace{1cm} (1)

$$Q^F = 135.03 \cdot e^{-37.911h}$$  \hspace{1cm} (2)

where, $Q^T$ and $Q^F$ - respectively the maximum allowable by the standard method and actual transmission heat loss, W; $h$ - thickness of the frame, 0.11 ≤ $h$ ≤ 0.04 m.

The calculation results of transmission heat loss show that for windows with the thickness of the frame 110 mm actual loss of more than three times lower than allowable, which indicates significant excess thickness of the frame. When the thickness of the frame 50 and 40 mm admits transmission heat loss exceed ratios over 1.25 and 2 times, respectively, which requires additional energy consumption for heating.

4. Conclusion

Evaluation of thermal properties in the operation of various materials and wood structures will allow to justify their size and quality characteristics depending on climatic conditions of the region of operation, reduce energy costs during the heating season, to increase the efficiency of building envelopes, to carry out periodic monitoring of operational properties of structures.

Acknowledgments

The project results can be used design institutes and construction companies to implement technological calculations.

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