COLLATION OF THERMAL IMAGING
AND COMPUTER SIMULATIONS USING METHOD OF FUNDAMENTAL SOLUTIONS FOR BUILDING ENVELOPES

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1. Introduction

The main advantages of testing with thermal imaging camera are: simplicity, non-invasive and contactless. Thanks to them tests using thermal imaging cameras are applicable in many fields such as electronics construction, gas, medicine, industry, forensics, metallurgy and the others [1].

In this paper, thermography is used to validate the numerical simulation using the Method of Fundamental Solutions (MFS) [3]. Computer simulation (obtained temperature fields) will be done for two envelopes. Next, they will be compared to the thermal maps that we got in thermal imaging camera test.

The obtained results can be the starting point for modeling the removal of unfavorable phenomena such as thermal bridges (which are small part of the entire wall, with much higher thermal conductivity coefficient than the remaining area of a given wall) [4].

2. Measurement equipment

The following thermal imaging camera Testo thermal imager 875i with the following features: detector 160x120 pixels, resolution technology SuperResolution - up to 320x240 pixels, thermal sensitivity of <50 mK was used.

3. Description of the test object and numerical example

In this paper two building envelopes of two different cottages are considered. In the first case the wall consists of two parts connected to each other. The first part was built earlier, the second part of this outer wall was built onto. The wall of the second cottage is a partition complex, which includes door. Infrared images of these envelopes are shown in Fig. 1 and Fig 2.

The equations describing the analyzed phenomenon takes the following form [2]:

$$\lambda_{Ii}\left(\frac{\partial^2 T_i}{\partial x^2}+\frac{\partial^2 T_i}{\partial y^2}+\frac{\partial^2 T_i}{\partial z^2}\right)=f_i(x,y,z),$$

in area Ω_i where: $\Omega_i = \{(x,y,z)|\, x_{mini} \le x \le x_{maxi}, y_{mini} \le y \le y_{maxi}, z_{mini} \le z \le z_{maxi}\}$,

and where $i = 1, \dots, m$, where *m* is number of regions of different thermal characteristics, n_i is the number of layers in *i*-th region and the total thermal resistance [5] is defined in following form: $\frac{1}{\lambda_i}=\sum_{j=1}^{n_i}\frac{d_{ij}}{\lambda_{ij}}$, where: λ_{ij} is thermal conductivity coefficient, d_{ij} is the thickness of the *j* - th layer in *i* - th region.

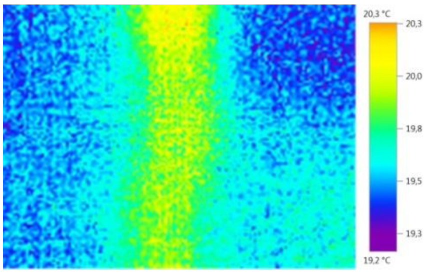

Fig. 1: Thermogram of first building envelope

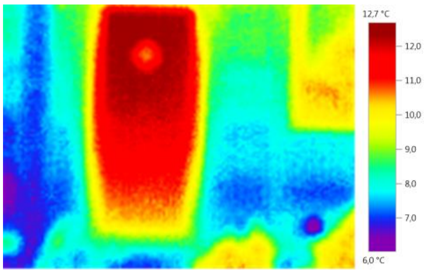

Fig. 2: Thermogram of second building envelope

The figures below show the results of computer simulation using the MFS for the envelope considered in the first case. Infrared image of these envelope is shown in Figure 1. Figures show in sequence: the temperature distribution on the inner (Fig. 3) and external (Fig. 4) surfaces of the outer wall.

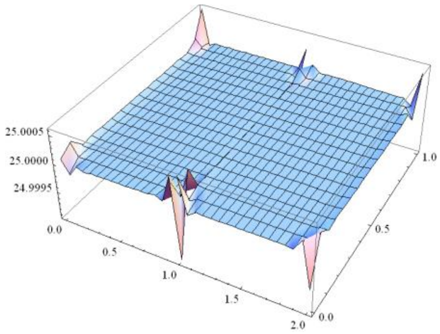

Fig. 3: The temperature distribution on the inside surface of the first outer wall

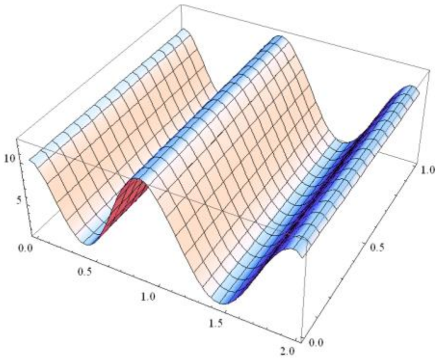

Fig. 4: The temperature distribution of the external surface of the outer wall

The comparison of simulation results (Fig. 3 and 4) and the real map of temperature (Fig. 1) shows a good agreement. The next step of simulation is the computer calculation for modified construction. The insulation is given on the outer surface of the wall. The results of simulation show that thermal bridge has disappeared. The details of computer calculation will be shown in the full paper.

Additionally, the same scheme of computer simulations will be applied for second case of envelope (Fig. 2).

References

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