Definition of the coefficient of blackness for inhomogeneous surfaces under conducting thermography

Olha Kletska* , *Anatoliy* Falendysh, *Oleh* Vasylenko and *Andrii* Onyshchenko

Ukrainian State University of Railway Transport 61050 Feerbach Square 7 Kharkov Ukraine

Abstract. The paper considers the possibility of determining the coefficient of blackness or the degree of radiation for inhomogeneous surfaces during thermography. Such approach will allow increasing the accuracy of the analysis of the level of qualitative heat losses during the energy audit of the facility. As a rule, when conducting an energy audit, reference values are used which are given only for one type of material, which introduces an additional error both in the measurement and in the processing of the material.In the majority of cases, thermography is carried out on inhomogeneous surfaces that have different physical characteristics and correspondingly different values of the blackness coefficient. The proposed dependence makes it possible to take into account the heterogeneity of the surface according to the type of material and their ratio to the overall surface of the object under study.The use of this approach will increase the accuracy of the study in thermography and, accordingly, the quality of processing of the thermograms obtained.

1 Introduction

Infrared (IR) survey of infrastructure facilities is a relatively new direction in the assessment and revealing of heat losses and the detection of hidden shortcomings. At present, a wide range of IR research methods have been developed, described in article 1. In article [2], the authors analyzed the main errors and shortcomings of IR research methods at the construction sites for various types of infrastructure. In work [3] the authors considered a wide range of applications of IR research not only in construction but also considered the possibility of using this method for diagnostics of various electrical and heat engineering equipment

At present, when processing the thermogram, a number of difficulties arise with the explanation of the obtained temperature values on the surface of the enclosing structures. Programs that process thermograms allow you to select each site separately and assign the appropriate degree of blackness to it. Such an approach is very time-consuming both in terms of time and in the presence of relevant experience in the researcher.

For the IR survey use technical thermal imagers. Technical thermal imagers produce a fully radiometric image, this allows you to determine the temperature of any point selected

* Corresponding author: gurao@ukr.net

on the thermogram. Higher sensitivity makes it possible to use this type of thermal imagers for temperature measurements and control of temperature drops on the surface of any object with a degree of blackness ***e*** of more than 0,7.

The degree of blackness of the objects under study is determined from the reference data [4] provided by the manufacturer of IR equipment. The world manufacturers of such research systems are firms "Fluke", "Testo" and when using data systems they offer calibrating tables of values of ***e*** [5, 6]. If we compare the values given, we can note their deviations with each other, which is determined primarily by the temperature of the surface under study. On the other hand, when conducting research, there is often a question of the correct choice of the values of e, since in most cases the study surfaces are not homogeneous in their physical parameters.

The aim of the paper is to obtain an approximating dependence that allows one to take into account the non-homogeneity of the surface and take into account the influence of the temperature factors of the environment.

2 Theoretical and experimental studies

In our work we used the thermal imager Testo-871, this model belongs to professional thermal imagers and has a resolution of 180x240, and the built-in SuperResolution technology increases the resolution to 480 x 360 pixels.

As a test object wall of the new three-storey building has been chosen, which is presented in Figure 1.

Fig. 1. The wall of the residential building under study.

The external conditions under which the object examined. The temperature during the environmental study was 4 °C, and the external relative humidity was 83%. Studies conducted in the absence of sunlight for 12 hours before carrying out thermography. The average heat thrust was 16 °C based on the power of the heating system. Thermal control conducted in the absence of precipitation, fog at a wind speed of less than 2 m/s.

When carrying out thermography, a number of recommendations pertaining to the correct use of the instrument observed.

First of all, the thermography is carried out at a right angle to the surface of the building, there were no aging objects on the surface of the building that could distort the results. The shooting conducted from the left to the right and from the top to the bottom. This approach allows you to remove the surface of enclosing structures of large dimensions.

Based on the recommendations which the producer provides of the e value provides, it was set at 0.93. Based on the obtained initial data, these parameters introduced into the device and the survey was performed, and the results are shown in Figure 2.

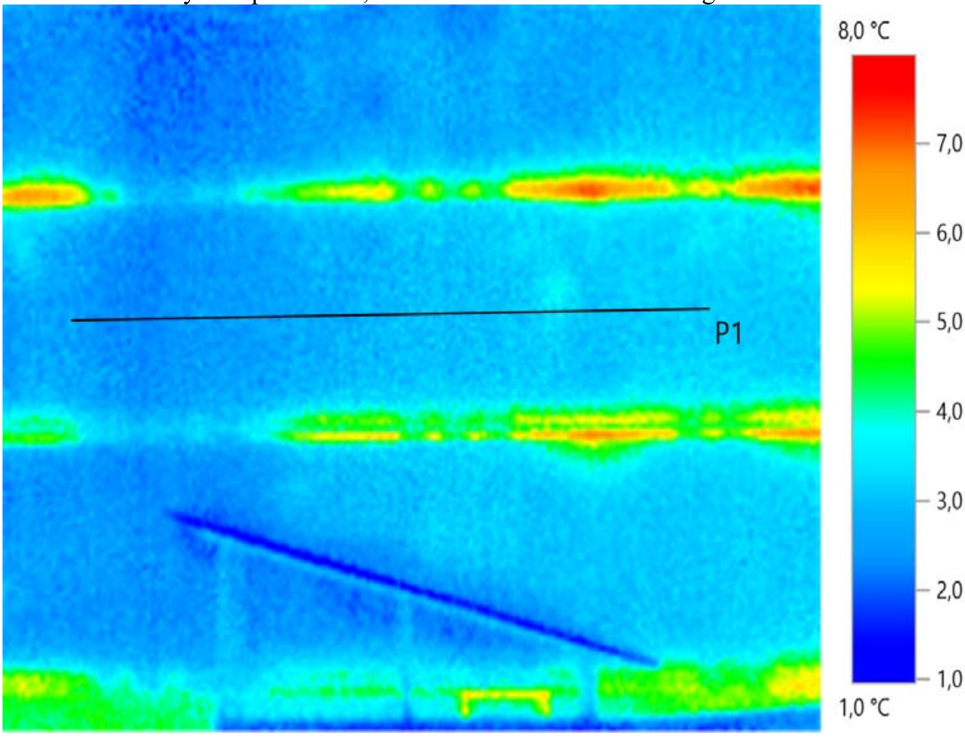

Fig. 2. Thermogram of the wall of a residential building.

Figure 2 shows that the temperature field in the areas that corresponds to the brickwork is uniform and an average of 3 °C.

Minor fluctuations in temperature over the surface of the brickwork are due to two factors. To the first factor is the presence of constructive bridges of cold, which is due to the presence of concrete overlaps between the floors (without taking into account the basement and the basement of the building).

Concrete floors have a temperature of up to 7 °C and heat the adjoining to them brickwork, which results in both additional thermal losses and an uneven temperature field over the surface. The second factor is the incorrect value of e. Figure 3 shows the thermogram where the correction of the value of e for concrete 0.85.

Therefore, concrete overlapping must be take a picture at a new value that differs from the originally specified. Figure 3 shows the thermogram where the correction of the value of e.

In Figure 3 sections with concrete overlap were allocated separate zones for which the value of e was set to 0.85. The site of the foundation of the building in the lower part of the building with a coefficient of e 0.54, as it has a higher density than the concrete inter-floor ceilings.This approach allowed to obtain a more contrast thermogram of heat losses of the residential building wall in the section of concrete overlaps.

In order to avoid manual adjustment of the values of e, it is necessary to draw up and obtain an approximating dependence of the value of e the material type, temperature, and ratio of areas.

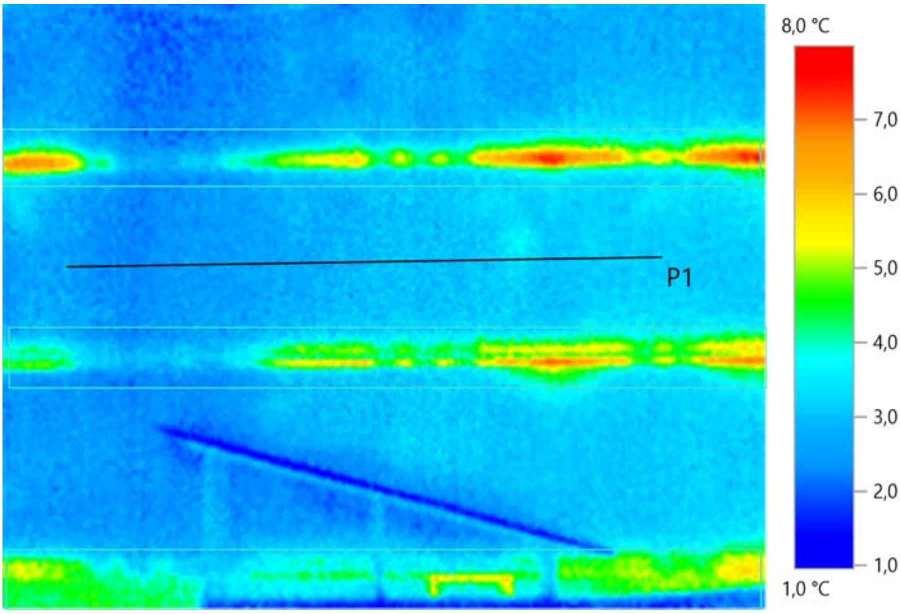

Fig. 3. Thermogram of the wall of a residential building with regions of correction of the value of ***e***.

The obtained dependence makes it possible to obtain the corrected value of e. The proposed dependence makes it possible to take into account the heterogeneity of the surface by the type of material (brick or concrete) and take into account the influence of external factors such as climatic conditions which include air temperature and relative humidity.

$$e= f(M, t, \varphi)=b_0+b_1\bullet t+b_2\bullet \varphi+b_3\bullet M=0,92 \quad (1)$$

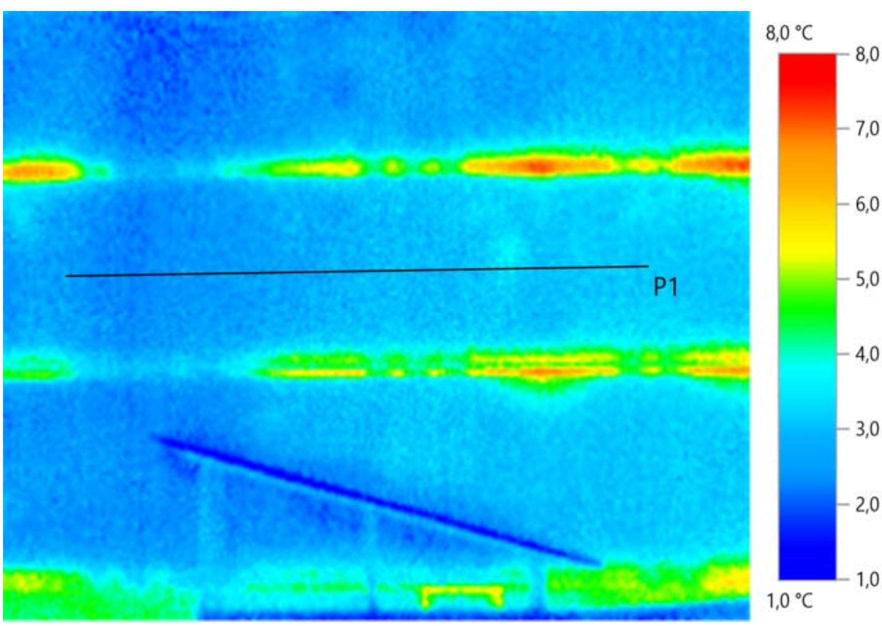

Fig. 4. Thermogram of the wall of a residential building with a common value for the entire wall ***e*** = 0.92.

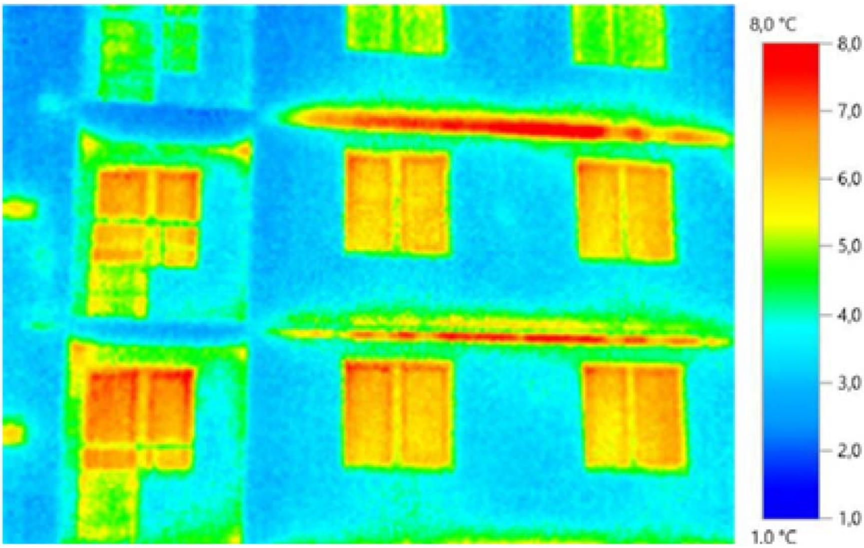

Fig. 5. The thermogram of the wall of a residential building with a total value for the whole wall is ***e*** = 0.9.

Where ***M*** - is the kind of material (brick, concrete and is taken into account through the density of matter);

t - is the surface temperature;

φ - is the ratio of the areas of materials;

b_0 - coefficients of linear approximation.

b - free coefficients of linear approximation for the solution of the problem

Fig. 6. The wall of the residential building under study with translucent structures.

Given the above conditions, can determine the optimal value of e which you can enter into the program for processing thermograms. In our case, the optimum value was 0.92. Taking this into account, a thermogram was obtained in Figure 4.

In the case where the building envelope consists of light-transparent structures, a more detailed analysis is necessary. The most common translucent structures are fiberglass windows. For this house, the facade glazing factor was f 0,165 with an acceptable value of 0.22. Such indicators for our climatic zone are normal, since the largest part of heat losses during the heating period are due to translucent structures.

In the reference literature, it recommended to choose e values for glass in the range of 0.85 to 0.88. Figures 5 and 6 show the thermal imaging of the building facade after finding the value of e by formula 1 and, accordingly, the normal image of the facade of the building.

3 Conclusions

1. The use of thermography is currently the most modern way of non-destructive method of determining the quantitative heat losses of enclosing constructions of buildings and structures.
2. The use of the approximating dependence of the value of e for inhomogeneous surfaces of the enclosing structures allows us to correctly analyze the heat losses, reduce the time for subsequent processing of the thermograms obtained, and, accordingly, reduce the financial costs when conducting energy audits.

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