2.6. SIMPLE METHODS OF INCREASING THE ENERGY EFFICIENCY OF WINDOWS IN THE RECONSTRUCTION OF OLD BUILDINGS

Nikiforova Tetiana, Sopilniak Artem,
Radkevych Anatolii, Shevchenko Tetiana

Introduction. Considering that today energy resources are quite expensive and the prices for them are constantly growing, the building's enclosing structures should minimize the heat flow from inside the building. The enclosing structures must have resistance to heat transfer not less than the current requirements for thermal conductivity. In the construction of new building or its reconstruction, the windows should have the minimum permissible values of heat transfer resistance (for example, 0.75 (m2K)/W for the first temperature zone of Ukraine) [1, 2]. It is also necessary to take into account the fact that condensate can form on the surface of the insulating glass, and moisture can accumulate on the slopes of the window openings, leading to the destruction of the finish decoration and the appearance of mold.

Modern technologies allow producing almost hermetic windows, the quality of which is determined by the glass, fittings and profile, which is used to make the doors and frames. Thermal insulation of metal-plastic windows depends not only on the applied double-glazed windows, but also on the profile of the window unit itself, namely the cross-sectional width and the profile thickness. As for the climate of our country, a two-chamber or three-chamber profile with a special insert for thermal insulation could be effective. On practice, a 5-chamber profile with a 2-chambered double-glazed window (glass with energy saving) meet the new requirements for resistance to heat transfer.

Modern conditions of comfort and energy efficiency requirements for enclosing structures make it necessary to use new technologies and science based constructive solutions for window filling.

Objective. To increase the resistance to heat transfer for translucent structures filling of the window openings with the prevention of moisture condensation on their surface.

Main material. For enclosing translucent structures of buildings for various purposes, calculations of thermal conductivity were made using a software package «Elcut 5».

To determine the reduced heat transfer resistance for all variants of the structures, the following materials were adopted:

- material of the bearing wall - silicate brick with the thermal conductivity coefficient λ=0,76 W/(m·K) and λ=0,87 W/(m·K), for operating conditions A and B respectively [1];
- insulation made of 100% thick expanded polystyrene with a coefficient of thermal conductivity λ=0,04 W/(m·K) [1];
- window 3-chamber PVC profile - 0,63 W/(m·K) [3];
- air gap – 0,15 W/(m·K) according to Table 12 (with a width of a closed interlayer of 5-30 cm) [4] taking into account the convection and radiation;
- standard window glass has a coefficient of thermal conductivity λ = 1,0 W/(m·K) [5], but in the heat engineering calculations of light holes with a glass thickness of 0.004 m, this has almost no value in calculating the value of the heat resistance. The value of the heat resistance for glass 4 mm thick is R = 0,004/1= 0,004 (m^2·K)/W. At the required value R = 0.75 (m^2 / K) / W, glass has no effect.

As an initial constructive solution of the enclosing structure, it was accepted that the bearing wall is made of silicate brick 510 cm thick and translucent construction is window with a single-chamber double-glazed window (4-16-4 mm) and a three-chamber window profile.

Further, several options for heat insulation of the load-bearing wall and reducing heat loss through a translucent structure (window) were considered:

- load-bearing wall of silicate brick 510 cm thick without insulation;
- load-bearing wall with the insulation of expanded polystyrene plates with a thickness of 100 mm and density ρ = 25 kg/m^3;
- load-bearing wall with the insulation of expanded polystyrene plates (100 mm, ρ = 25 kg/m^3) and installation of the second window within the edge of the bearing wall, an air layer between the inner edges of the insulating glass units 100 mm thick;

- load-bearing wall with the insulation of expanded polystyrene plates (100 mm, ρ = 25 kg/m³) and installation of a second window block protruding beyond the face of the bearing wall, an air gap between the inner edges of insulating glass with a thickness of 130 mm

- load-bearing wall with the insulation of expanded polystyrene plates (100 mm, ρ = 25 kg/m³) and installation of the second window unit outside the thickness of the supporting wall in the layer of insulation, the air gap between the inner edges of insulating glass units 180 mm thick;

- load-bearing wall with the insulation of expanded polystyrene plates (100 mm, ρ = 25 kg/m³) and installation of the second window unit in the layer of insulation along the level with the outer edge of the insulation, the air gap between the inner edges of the double-glazed windows 200 mm thick;

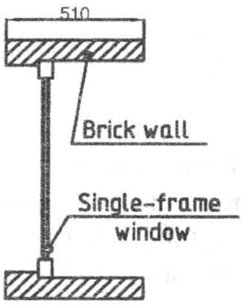
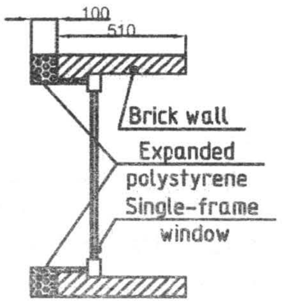
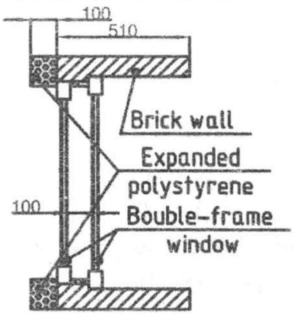
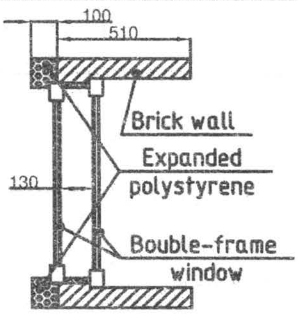
- load-bearing wall with the insulation of expanded polystyrene plates (100 mm, ρ = 25 kg/m³) and installation of the second window unit in the layer of insulation along the level with the outer edge of the insulation, and also with an addition insulation layer of expanded polystyrene plates with thickness of 50 mm and width of 100mm by perimeter of window; the air gap between the inner edges of the double-glazed windows 200 mm thick;

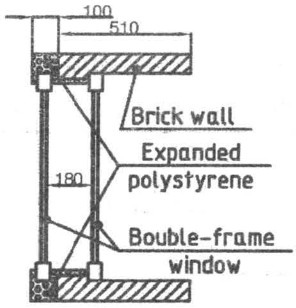
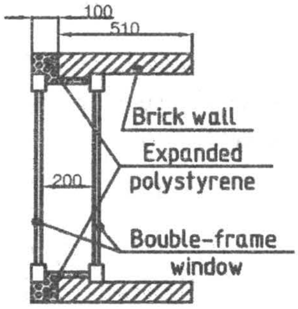
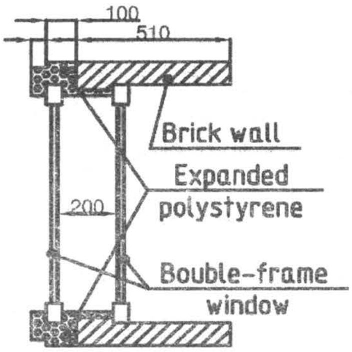
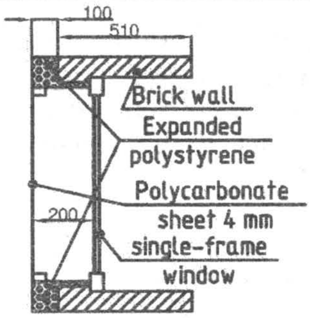
- load-bearing wall with the insulation of expanded polystyrene plates (100 mm, ρ = 25 kg/m³) and installation of the second window block with one layer of polycarbonate in a layer of an insulation along with an its external side; the air gap between the inner edges of the double-glazed windows 235 mm thick;

Table 1 shows the schemes of constructive solutions for filling a window opening with one frame and for a variant with the installation of an additional window frame, as well as the distribution of temperature fields and the results of calculations of the reduced resistance of heat transfer obtained in the program complex «Elcut 5».

To confirm the data obtained in the program complex «Elcut 5», for the second and last version (according to Table 1) of the enclosing structure with the installation of an additional window frame with polycarbonate (4 mm), a thermal imaging was performed in the winter period at an ambient air temperature of -10 (fig. 1).

Table 1. Comparison of thermal resistance of constructive solutions translucent structures for mass application

№ п.п	Sketch of a wall cross-section with a translucent structure	Structure	Heat transfer resistance, m²•°C/W
1.		Brick wall 510 mm, single-frame window	0,46
2.		Brick wall 510 mm, single-frame window, expanded polystyrene 100 mm ρ = 25 kg/m3	0,50
3.		Brick wall 510 mm, double-frame window, expanded polystyrene 100 mm ρ = 25 kg / m3, air gap 100 mm	1,53
4.		Brick wall 510 mm, double-frame window, expanded polystyrene 100 mm ρ = 25 kg / m3, air gap 130 mm	1,84

5.		Brick wall 510 mm, double-frame window, expanded polystyrene 100 mm ρ = 25 kg / m3, air gap 180 mm	2,73
6.		Brick wall 510 mm, double-frame window, expanded polystyrene 100 mm ρ = 25 kg / m3, air gap 200 mm	3,01
7.		Brick wall 510 mm, double-frame window, expanded polystyrene 100 mm ρ = 25 kg / m3, air gap 200 mm	3,05
8.		Brick wall 510 mm, single-frame window, expanded polystyrene 100 mm ρ = 25 kg / m3, air gap 235 mm	3,15

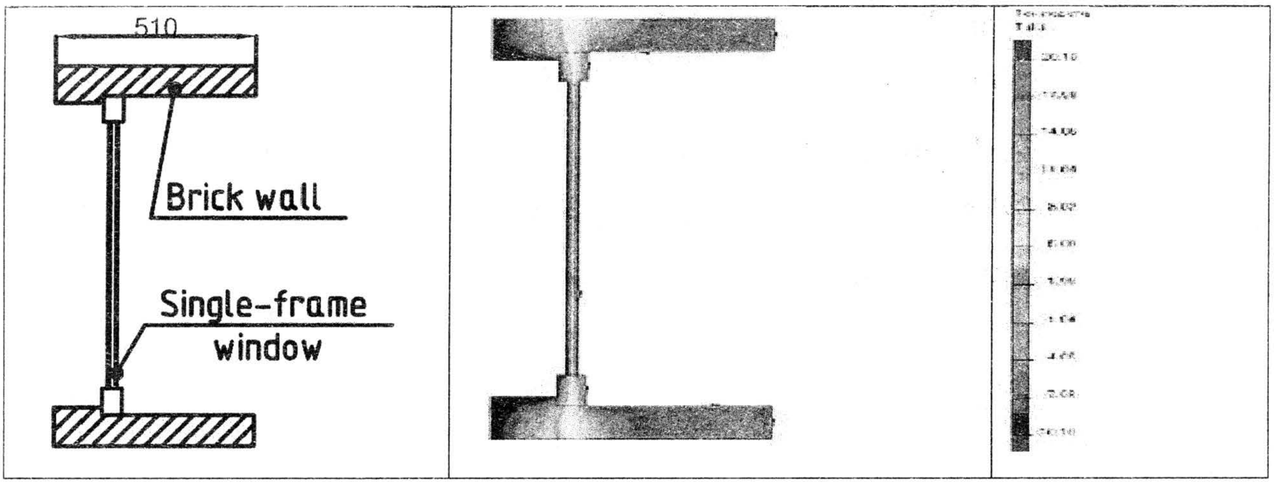


Fig.1. An example of the obtained results for the distribution of temperature fields along the thickness of the structure

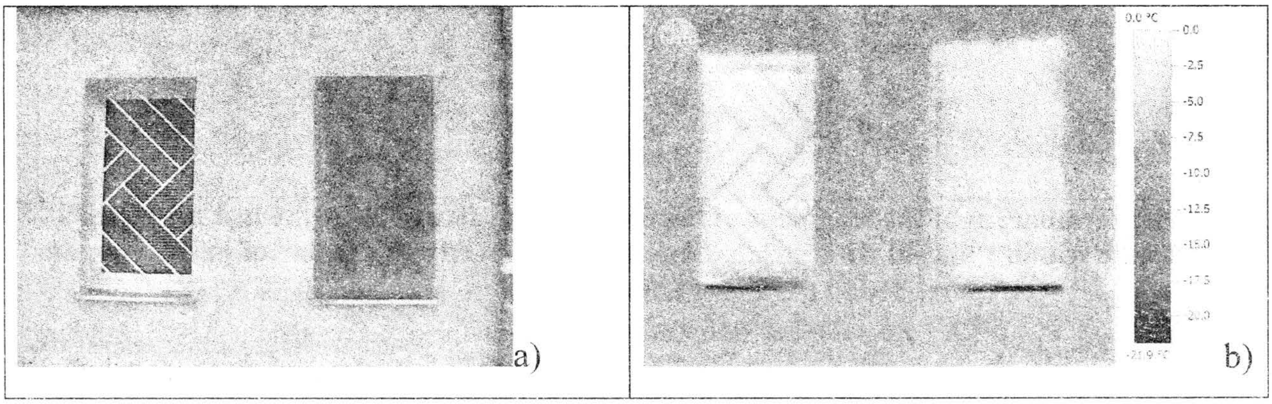


Fig. 2. a) Fragment of the enclosing structure with a single-frame window and installation of an additional window frame of polycarbonate (4 mm); b) Thermogram of the fragment of the enclosing structure with a single-frame window and the installation of the additional window frame made of polycarbonate (4 mm)

When the thermal imaging was performed, the temperature on the surface of the insulation (expanded polystyrene ρ = 25 kg / m3, 100 mm) of the bearing wall was -9 ° C. On the single-window window, in the middle part, the temperature on the surface of the glass was -3°C, and on the window (in the middle part), with an additional window frame made of polycarbonate (4 mm), the temperature on the polycarbonate surface was -6.5°C.

When performing a thermal imaging from the inside of the room (on the same fragment of the enclosing structure) for the second and last variant (according to Table 1) of the enclosing structure with the installation of an additional window frame with polycarbonate, the room air temperature was + 20 ° C, and on the surface of the bearing wall + 18.5 ° C.

In the middle part of the single-frame window the temperature on the surface of the glass was +10 °C (Fig. 3), and on the window with an additional window frame of polycarbonate the temperature was + 16 ° C (Fig. 4)

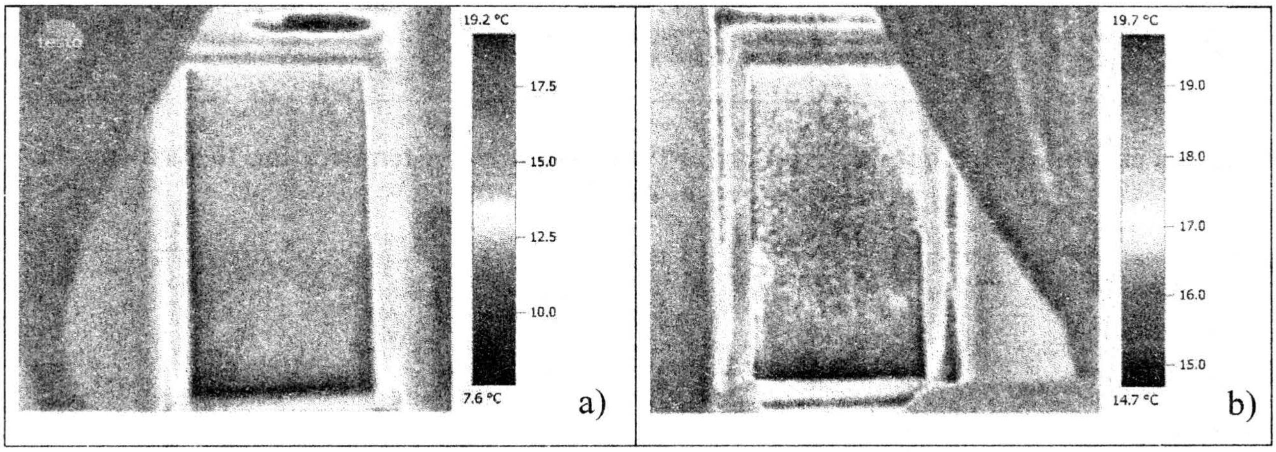


Fig. 3. Thermogram of the fragment of the enclosing structure from the inside a) with a single-frame window and b) with installation of additional window frame of polycarbonate (4 mm)

It is also worth noting that, there is completely no condensation on the window with an additional window frame made of polycarbonate, in contrast to a single-frame window where the condensate forms over the entire area of the glass unit/. Consequently, window slopes become wet and fungal formations appear in the form of black spots.

According to the obtained results of the distribution of temperature contour plots obtained in the PC "Elcut" and calculations of the heat transfer resistance (Table 1), the following conclusions can be drawn:

when the air gap between the window frames increases, the temperature contour plots become equalized to the contour plots of the bearing wall. This is due to the presence of an air gap having a small coefficient of thermal conductivity, as well as convection and radiation. Due to the phenomenon of the convention through the windows, about 30% of all heat losses occur. This effect can be minimized by installing roll blinds with a reflective coating into the air layer.

The results of the thermal imager have some differences in the calculated temperature data obtained from the PC "Elcut". This can be explained by the imperfection of the software package, as well as the error in the accuracy of the thermal imager.

Conclusions. Установка дополнительной оконной рамы для ограждающих светопрозрачных конструкций повышает сопротивление теплопередаче, снижает тепловые потери, предотвращает образование конденсата на окне и образование грибка на поверхности откосов. The installation of an additional window frame for enclosing translucent structures increases heat transfer resistance, reduces heat loss, prevents the formation of condensation on the window and the formation of fungus on the surface of slopes.

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