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INFLUENCE OF THE COMPONENTS OF THE WINDOW ON THERMAL CONDUCTIVITY

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ABSTRACT

The purpose of the windows as a construction product is to provide the building with natural light and the opportunity to ventilate the interior and at the same time providing protection to the room against external influences such as wind and rain, as well as to prevent uncontrolled cooling or heating of the room or the whole building in which they are built in. A window is a complex product which is constructed of different parts that could be made of different materials. In addition to providing light and protection from external influences such as rain and wind, the window has a key part in the energy efficiency of buildings. Energy efficiency as a term is usually associated in with two separate approaches, energy effects of devices and energy efficiency measures. When it comes to an energy-efficient device, then it is the device that has a high degree of energy utilization, while measures related to energy efficiency are all that we can do to reduce energy consumption. In order to protect the energy of the buildings, among other things, well-chosen windows of good quality and their proper installation play a key role in it. This research is focused on how much the component parts of the window have an influence on the thermal conductivity of the entire window, in fact, how different combinations of profiles that are used and glass packages affect the coefficient of thermal conductivity of the windows.

Key words: construction carpentry, window, thermal conductivity, energy efficiency.

INTRODUCTION

A window is a structural element of a building or construction product that consists of a fixed structural part or a fixed and movable structural part with a light-transmitting surface, built into an opening in a wall or roof, significant for aesthetic lighting or lighting and ventilation of the room (Kuchukov 2009). To select the most suitable combination of materials for the construction of a quality window that meets all required functions, it is necessary to know the properties of the built-in materials and how they affect the quality of the window. From the small windows of the past with barriers between them, the windows evolved and now they are constructed with large glazing areas (Rozman 1987). Windows have a pivotal role in the energy efficiency of buildings. Energy efficiency as a concept is most often associated in two ways: as energy efficiency of devices and as energy efficiency measures. When it comes to an energy-efficient device, it can be defined as a device that has a high degree of energy utilization. When it comes to energy efficiency measures related to energy efficiency, it is defined as everything we can do to reduce energy consumption. For the protection of energy in buildings, besides other things, well-chosen windows and their proper installation play a key role. Of course, when choosing the appropriate quality level of windows, it is necessary to be well acquainted with the climatic conditions in which they will be installed. A thorough study of all climatic conditions is a basic requirement for designing an energy-efficient building (Hassouneh 2010).

Architects are chosen as a key target group because they are the key decision-makers in the selection of materials in the construction sector. Architects communicate with all other

contributors in the project at every stage. Moreover, some studies show that architects are environmentally conscious when choosing building materials and, as such, are an important target group for research, especially when environmental and sustainability issues are becoming more common (Singhaputtangkul 2014). In addition to architects, designers of living, working, and all interior spaces should be informed about the importance and impact of the components of the window on its final quality. The decision to choose the materials and components of the window needs to be established on the requirements of the building. This research will provide data on the optimal use of materials for window manufacturing.

Of course, the final consumers of windows need to be educated about their function and maintenance, as well as the benefits of appropriately chosen windows. Consumers play a significant role in energy efficiency, as only with appropriate and proper use of buildings can the planned and designed balance level be achieved by engineers (Ber 2017, Leskovar 2012).

EXPERIMENTAL METHODS

In this research, a calculation of the thermal conductivity coefficient of windows with different built-in materials and different combinations of materials was made. The collected data on the coefficients of the built-in materials was mathematically calculated according to the standard method EN ISO 10077-1:2017 Thermal performance of windows, doors, and shutters — Calculation of thermal transmittance — Part 1: General. Since the tests were performed on glass packages consisted of two or three glass sheets, before the mathematical calculation was made to obtain the thermal conductivity of the entire window, a calculation of the thermal conductivity of the used glass packages has been made. The calculation of the glass packages was conducted according to the standard method EN ISO 52022-3:2017 Energy performance of buildings – Thermal, solar, and daylight properties of building components and elements – Part 3: Detailed calculation method of the solar and daylight characteristics for solar protection devices combined with glazing. For the calculations of the thermal conductivity of the glass packages as well as the thermal conductivity of the entire windows, software from Sommer Global was used, specifically WINSL Experte. This software provides data on the coefficients of the installed window parts, which are later used for the purpose of the calculation. For the thermal conductivity of the entire window, the part of the software WinUw was used. The software is licensed and confirmed to meet the requirements of the standards EN ISO 10077-1:2017 and EN ISO 52022-3:2017.

RESULTS AND DISCUSSION

THERMAL CONDUCTIVITY OF THE GLASS PACKAGES

Glass package 1 (4 mm Planiclear / 16 mm (Argon 90%) / 4 mm Planiclear)

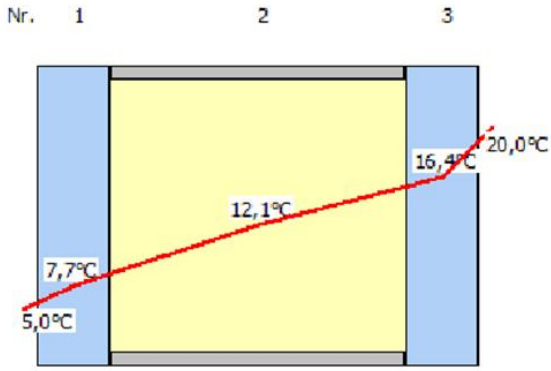

Figure 1: Glass package – 4 mm Planiclear / 16 mm (Argon 90%) / 4 mm Planiclear

T_V = 0,83 (light conductivity)
g_{tot} = 0,80 (total energy conductivity)
Ug = 2,6 W/(m^2K) (thermal conductivity coefficient)

Glass package 2 (4 mm Planiclear / 16 mm (Argon 90%) / 4 mm Planiclear + Planitherm one)

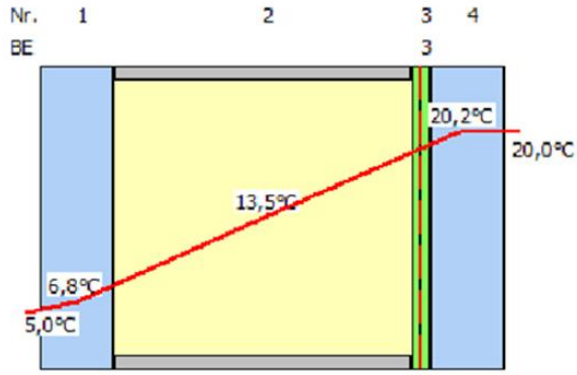

Figure 2: Glass package – 4 mm Planiclear / 16 mm (Argon 90%) / 4 mm Planiclear + Planitherm one

T_V = 0,72 (light conductivity)
g_{tot} = 0,73 (total energy conductivity)
Ug = 1,0 W/(m^2K) (thermal conductivity coefficient)

Glass package 3 (4 mm Planiclear / 12 mm (Argon 90%) / 4 mm Planiclear / 12 mm (Argon 90%) / 4 mm Planiclear)

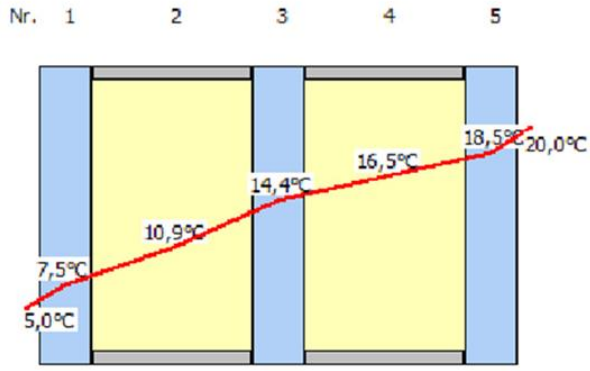

Figure 3: Glass package – 4 mm Planiclear / 12 mm (Argon 90%) / 4 mm Planiclear / 12 mm (Argon 90%) /4 mm Planiclear

T_V = 0,76 (light conductivity)
g_{tot} = 0,52 (total light condctivity)
Ug = 1,8 W/(m^2K) (thermal conductivity coefficient)

Glass package 4 – (4 mm Planiclear / 12 mm (Argon 90%) / 4 mm Planiclear / 12 mm (Argon 90%) /4 mm Planiclear + Planitherm one)

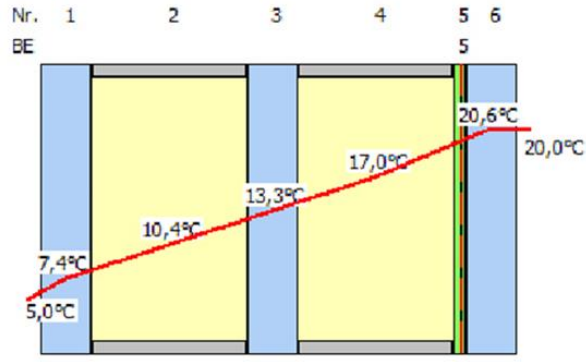

Figure 4: Glass package – 4 mm Planiclear / 12 mm (Argon 90%) / 4 mm Planiclear / 12 mm (Argon 90%) /4 mm Planiclear + Planitherm one

T_V = 0,66 (light conductivity)
g_{tot} = 0,49 (total light condctivity)
Ug = 1,0 W/(m^2K) (thermal conductivity coefficient)

THERMAL CONDUCTIVITY OF DIFFERENT WINDOW COMPOSITIONS

Window 1 with glass package 1: A calculation of the thermal conductivity coefficient has been made for a single-wing window with a width of 1230 mm and a height of 1480 mm, made from a PVC profile ROLOPLAST 7500, with a thermal conductivity coefficient U_f=1.2 W/(m^2K) and a profile area A_f=0.579 m^2, glazed with a glass package 4 mm Planiclear /

16 mm (90% Argon), with a thermal conductivity coefficient U_g=2.6 W/(m^{2}K) and an area A_g=1.241 m^2, a spacer with a length of 4.484 m, and a coefficient Ψg=0.077 W/(m^{2}K).

U_w=2.344 W/(m^{2}K)=2.3 W/(m^{2}K)

Window 1 with glass package 2: A calculation of the thermal conductivity coefficient has been made for a single-wing window with a width of 1230 mm and a height of 1480 mm, made from a PVC profile ROLOPLAST 7500, with a thermal conductivity coefficient U_f=1.2 W/(m^{2}K) and a profile area A_f=0.579 m^2, glazed with a glass package 4 mm Planiclear / 16 mm (90% Argon) / 4 mm Paniclear + Planitherm one, with a thermal conductivity coefficient U_g=1.0 W/(m^{2}K) and an area A_g=1.241 m^2, a spacer with a length of 4.484 m, and a coefficient Ψg=0.077 W/(m^{2}K).

U_w=1.253 W/(m^{2}K)=1.3 W/(m^{2}K)

Window 1 with glass package 3: A calculation of the thermal conductivity coefficient has been made for a single-wing window with a width of 1230 mm and a height of 1480 mm, made from a PVC profile ROLOPLAST 7500, with a thermal conductivity coefficient U_f=1.2 W/(m^{2}K) and a profile area A_f=0.579 m^2, glazed with a glass package 4 mm Planiclear / 12 mm (90% Argon) / 4 mm Paniclear / 12 mm (Argon 90%) / 4 mm Paniclear, with a thermal conductivity coefficient U_g=1.8 W/(m^{2}K) and an area A_g=1.241 m^2, a spacer with a length of 4.484 m, and a coefficient Ψg=0.075 W/(m^{2}K).

U_w=1.793 W/(m^{2}K)=1.8 W/(m^{2}K)

Window 1 with glass package 4: A calculation of the thermal conductivity coefficient has been made for a single-wing window with a width of 1230 mm and a height of 1480 mm, made from a PVC profile ROLOPLAST 7500, with a thermal conductivity coefficient U_f=1.2 W/(m^{2}K) and a profile area A_f=0.579 m^2, glazed with a glass package 4 mm Planiclear / 12 mm (90% Argon) / 4 mm Paniclear / 12 mm (Argon 90%) / 4 mm Paniclear + Planitherm one, with a thermal conductivity coefficient U_g=1.0 W/(m^{2}K) and an area A_g=1.241 m^2, a spacer with a length of 4.484 m, and a coefficient Ψg=0.075 W/(m^{2}K).

U_w=1.248 W/(m^{2}K)=1.2 W/(m^{2}K)

Window 2 with glass package 1: A calculation of the thermal conductivity coefficient has been made for a single-wing window with a width of 1230 mm and a height of 1480 mm, made from a PVC profile Salamander greenevolution, with a thermal conductivity coefficient U_f=1.1 W/(m^{2}K) and a profile area A_f=0.579 m^2, glazed with a glass package 4 mm Planiclear / 16 mm (Argon 90%) / 4 mm Paniclear, with a thermal conductivity coefficient U_g=2.6 W/(m^{2}K) and an area A_g=1.241 m^2, a spacer with a length of 4.484 m, and a coefficient Ψg=0.077 W/(m^{2}K).

U_w=2.312 W/(m^{2}K)=2.3 W/(m^{2}K)

Window 2 with glass package 2: A calculation of the thermal conductivity coefficient has been made for a single-wing window with a width of 1230 mm and a height of 1480 mm, made from a PVC profile Salamander greenevolution, with a thermal conductivity coefficient U_f=1.1 W/(m^{2}K) and a profile area A_f=0.579 m^2, glazed with a glass package 4 mm Planiclear / 16 mm (Argon 90%) / 4 mm Planiclear + Planitherm one, with a thermal conductivity coefficient U_g=1.0 W/(m^{2}K) and an area A_g=1.241 m^2, a spacer with a length of 4.484 m, and a coefficient Ψg=0.077 W/(m^{2}K).

U_w=1.221 W/(m^{2}K)=1.2 W/(m^{2}K)

Window 2 with glass package 3: A calculation of the thermal conductivity coefficient has been made for a single-wing window with a width of 1230 mm and a height of 1480 mm, made from a PVC profile Salamander greenevolution, with a thermal conductivity coefficient U_f=1.1 W/(m^{2}K) and a profile area A_f=0.579 m^2, glazed with a glass package 4 mm Planiclear / 12 mm (Argon 90%) / 4 mm Planiclear / 12 mm (Argon 90%) /4 mm Planiclear, with a thermal conductivity coefficient U_g=1.8 W/(m^{2}K) and an area A_g=1.241 m^2, a spacer with a length of 4.484 m, and a coefficient Ψg=0.075 W/(m^{2}K).

U_w=1.761 W/(m^{2}K)=1.8 W/(m^{2}K)

Window 2 with glass package 4: A calculation of the thermal conductivity coefficient has been made for a single-wing window with a width of 1230 mm and a height of 1480 mm, made from a PVC profile Salamander greenevolution, with a thermal conductivity coefficient U_f=1.1 W/(m^{2}K) and a profile area A_f=0.579 m^2, glazed with a glass package 4 mm Planiclear / 12 mm (Argon 90%) / 4 mm Planiclear / 12 mm (Argon 90%) /4 mm Planiclear + Planitherm one, with a thermal conductivity coefficient U_g=1.0 W/(m^{2}K) and an area A_g=1.241 m^2, a spacer with a length of 4.484 m, and a coefficient Ψg=0.077 W/(m^{2}K).

U_w=1.216 W/(m^{2}K)=1.2 W/(m^{2}K)

Window 3 with glass package 1: A calculation of the thermal conductivity coefficient has been made for a single-wing window with a width of 1230 mm and a height of 1480 mm, made from a PVC profile Aluplast energeto 8000, with a thermal conductivity coefficient U_f=0.94 W/(m^{2}K) and a profile area A_f=0.579 m^2, glazed with a glass package 4 mm Planiclear / 16 mm (Argon 90 %) / 4 mm Planiclear, with a thermal conductivity coefficient U_g=2.6 W/(m^{2}K) and an area A_g=1.241 m^2, a spacer with a length of 4.484 m, and a coefficient Ψg=0.077 W/(m^{2}K).

U_w=2.261 W/(m^{2}K)=2.3 W/(m^{2}K)

Window 3 with glass package 2: A calculation of the thermal conductivity coefficient has been made for a single-wing window with a width of 1230 mm and a height of 1480 mm, made from a PVC profile Aluplast energeto 8000, with a thermal conductivity coefficient U_f=0.94 W/(m^{2}K) and a profile area A_f=0.579 m^2, glazed with a glass package 4 mm

Planiclear / 16 mm (Argon 90%) / 4 mm Planiclear + Planitherm one, with a thermal conductivity coefficient U_g=1.0 W/(m^{2}K) and an area A_g=1.241 m^2, a spacer with a length of 4.484 m, and a coefficient Ψg=0.077 W/(m^{2}K).

U_w=1.170 W/(m^{2}K)=1.2 W/(m^{2}K)

Window 3 with glass package 3: A calculation of the thermal conductivity coefficient has been made for a single-wing window with a width of 1230 mm and a height of 1480 mm, made from a PVC profile Aluplast energeto 8000, with a thermal conductivity coefficient U_f=0.94 W/(m^{2}K) and a profile area A_f=0.579 m^2, glazed with a glass package 4 mm Planiclear / 12 mm (Argon 90%) / 4 mm Planiclear / 12 mm (Argon 90%) /4 mm Planiclear, with a thermal conductivity coefficient U_g=1.8 W/(m^{2}K) and an area A_g=1.241 m^2, a spacer with a length of 4.484 m, and a coefficient Ψg=0.075 W/(m^{2}K).

U_w=1.1711 W/(m^{2}K)=1.7 W/(m^{2}K)

Window 3 with glass package 4: A calculation of the thermal conductivity coefficient has been made for a single-wing window with a width of 1230 mm and a height of 1480 mm, made from a PVC profile Aluplast energeto 8000, with a thermal conductivity coefficient U_f=0.94 W/(m^{2}K) and a profile area A_f=0.579 m^2, glazed with a glass package 4 mm Planiclear / 12 mm (Argon 90%) / 4 mm Planiclear / 12 mm (Argon 90%) /4 mm Planiclear + Planitherm one, with a thermal conductivity coefficient U_g=1.0 W/(m^{2}K) and an area A_g=1.241 m^2, a spacer with a length of 4.484 m, and a coefficient Ψg=0.075 W/(m^{2}K).

U_w=1.165 W/(m^{2}K)=1.2 W/(m^{2}K)

CONCLUSIONS

In the research, windows of the same dimensions, made from three different PVC profiles, were analyzed. Calculations were performed on all three profiles with four different glass packages. The thermal conductivity U_g of the glass packages was calculated. Based on the research, the following conclusions can be drawn:

- The most significant factor affecting the thermal conductivity coefficient of the glass U_g is the protective film used.
- The number of glass sheets in the glass package affects the coefficient, but not to the extent of the protective film.
- The variation in glass packages significantly influences the thermal conductivity coefficient U_w.
- The thermal conductivity coefficient of the profile U_f impacts the overall thermal conductivity of the entire window, but not as much as the glass package.
- The spacer for the glass package has a minimal effect on the overall thermal conductivity of the window.

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