NEW GENERATION WINDOW GLAZING AND OTHER SOLUTION IN LOW ENERGY BUILDINGS

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Summary

Development of the building industry in Poland is aimed to the constructions that fulfil more and more restricted requirements for thermal protection. Nowadays the passive buildings appear in Poland and from 2018 nearly zero energy buildings will be designed. Building materials market reacts to the future needs. The new innovative materials are presented in the paper. In particular the authors describe the super-modern glass façade produced, in the form of prototypes, by the SuperWindows company. This façade achieves excellent heat-transfer coefficient values so it gives hope that in future designing a large glazing will not result in unnecessary heat loss.

Keywords: energy efficiency, thermal protection rules, Hi Tech materials, Superwindows

1 Introduction

Building materials market varies depending on the development needs of the economy. With the changing standards of thermal protection new solutions of solid and transparent partitions appear in the market. These partitions are characterised by better thermal insulations of the solid wall and the glazing.

In Poland the thermal protection standards were formulated in the 50's mainly to prevent condensation of water vapour in the partitions and moisturing the surfaces. The walls built in those years were usually constructed of solid brick. In the market of building materials hollow masonry units and concrete were also very popular. Heating energy was cheap and easily available so until the 70's it was no needs, impulses or even awareness to take action to reduce demand on energy consumption of the buildings.

In the 70's crisis and the collapse of the energy market were the impulses for the development of new legislation of thermal protection of buildings. But major changes occurred in the 80's. The maximum value of U coefficient changed in 1983 from 1,16 to 0,75 W/m^{2}K. Because of these changes the thickness of the external walls built from the brick or structural tiles increased considerably. Therefore a new materials appeared on the market. Buildings were erected in a variety of technologies (slag concrete blocks, aerated concrete units). Also windows and doors had better thermal parameters.

At the end of the 90's the more complicated problem was noticed in the building designing. The rules of seasonal energy demand were set. It was a tool for determining the heat balance of the building and thus drew designers and investors attention to the other parameters of the building. It was possible to make initial calculations of the influence of the windows size and building orientation on the heat demand of the building. Year 2008 brought the next reduction of U value to 0,3 W/m^2K and a new approach to energy requirements in thermal protection. A coefficient of primary energy demand was introduced, specifying the amount of energy extracted from natural sources for heating the building. EP coefficient indicates a new direction of designing in a sustainable way and shows efforts to minimize interference with the human environment. It started the market of new installation systems based on the use of renewable energy sources. A new solutions using solar energy and soil heat started to become more and more popular.

In 2010 the Council DIRECTIVE 2010/31/EU introduced into the Polish law the definition of nearly zero energy buildings. This is a great challenge for the government, which task is to define the standards of this type of buildings, for project teams that has to verify the existing design process by introducing advanced computer simulations and integrated design process and finally for contractors, users and building materials manufacturers. The last mentioned has to ensure that thermal qualities of the products are on the best possible level and has to develop new innovative technologies. Some examples of these new, even space, technologies are presented in this paper. It will influence the shape and structure of the houses in near future – nearly zero energy buildings, energy--self-sufficient building and also zero and plus energy building.

2 New generation materials – Building technologies

The current Polish standards force upon the designers to maintain the thermal requirements for the external partitions of the building or fulfil the condition of primary energy. The Polish requirements for the heat transfer coefficient by the external walls until this year were $U < 0.3$ W/m^2K, while for the Passive House the maximum value of U coefficient is 0.15 W/m^2K. According to new rules the maximum values of U coefficient will be changing gradually. For the external walls from this year Umax = 0,28 W/m^2K, while from 1.01.2014 Umax = 0,25 W/m^2K. In 2017 it will change to Umax = 0,23 W/m^2K and finally we will reach the value of Umax = 0,20 W/m^2K in 2021 year. The same standards will reduce gradually the maximum U value for the other external building partitions (roofs, windows).

Depending on the chosen energy standard the user decides about the external partitions of different insulation thickness. The thickness of external walls in low energy buildings is about 50 cm. The development of innovative materials will bring a better thermal standard with reducing at the same time the thickness of the partitions.

2.1 Structural layer

The smallest technological changes can be observed in the construction materials. The main task of this part of the wall is to provide suitable structural strength. Of course, the better is the thermal conductivity coefficient, the smaller can be the total thickness of the partitions. It is why nowadays the most widely used construction materials are aerated concrete, porous ceramics (the coefficient λ is about 0.09 W/mK) and frame work. Among the new, innovative construction materials used nowadays, the high-tech transparent concrete should be mentioned. This material in addition to its good structural feature also fulfil an aesthetic function in the forming of the interior and also can be used as a heat accumulating wall which support the heat balance of the building.

2.2 Thermal insulation layer

Currently the most popular and the most often used insulating materials are: extradited polystyrene, expanded polystyrene, mineral and glass wool (λ = 0.04–0.032 W/mK). In the future thermal insulation will change and may also include: aerogels (λ = 0.018 W/mK) and nanogels – laminates with high thermal insulation aerogel. It is the material which is a type of rigid foam of extremely low density, consisting in 90–99,8% of the air. This material is used as granules in the spaces between the window panes. The other material is called the vacuum insulation (λ = 0.007 W/mK – 0,002 W/mK) – it is vacuum sealed in a special laminate with the pressure controlled by a built-in pressure sensor. The next interesting insulation is called transparent insulation – the structure designed in the way which allows the penetration of solar radiation, while at the same time reduce the heat loss to the environment by convection and radiation of long-wave radiation and conduction.

2.3 Glazing

Windows and glass facades have always been the part of the external envelope of the building with the worse insulating properties than the solid wall. In Poland Umax for windows is 1,7 W/m^{2}K. However nowadays quite often windows with U = 1.1 W/m^{2}K are used in the typical buildings while in passive or low energy buildings it is recommended to use windows with the U coefficient below 0.8 W/m^{2}K. These requirements also will be changing gradually till the compulsory value of U coefficient of 0,9 W/m^{2}K in 2021 year. It is why there is a lot of work and many changes should be made in this area. Windows are an important element in carrying out passive solar energy into the building, improving its energy balance. Unfortunately, it can be a problem, especially in the summertime, when due to the large glazing on the south side of the building, the rooms are sometimes overheated. Modern windows react to different weather conditions by changing their parameters.

Modern windows solutions, even not available on the market yet, and research directions in windows technology are presented below. These new solutions show a huge, sometimes surprising, technological possibilities of windows constructions. In modern buildings we can used "smart windows" with chromogenic glass. Chromogenic windows are divided into photochromic, thermochromic and electrochromic. In thermochromic glass the amount of radiation through the windows depends on the air temperature on both sides of the glass. The important part of the window structure is the polymer coating, that changes the properties of structural geometry, which allows or blocks the visible light of different wave lengths. Electrochromic glass changes its properties under the influence of given electrical pulse. All sets of smart windows mentioned above limit the flux of solar radiation through the glass due to changes in the internal structure of the glass. The visible effects are changes in colour of the glass and the degree of matting, which of course influence the clarity and visual comfort of the window.

One example of new, innovative windows technologies for low-energy buildings is called SuperWindows. This new solution, which is currently still in the prototype phase of the researches, achieves thermal protection parameters closed to the parameters of solid walls of passive buildings – about 0.15 W/m^{2}K. Construction of insulated window glass units is based on nanotechnology. The project involves creation of such windows and glazing facade with the thermal resistance greater than 10 m^{2}K/W and the transmission of visible sunlight above 70 %. In SuperWindows the heat transfer by radiation is minimized by using the low-emissive coating on the inner surfaces of the window glass. This reduced the radiation in the far infrared. Designers have also tried to reduce the conduction by filling the space between the window panels with the gas characterized by lower thermal conductivity than air. However with the widening of the prototype windows set the heat conduction started to increase due to the intensity of convective motions. The use of thin polymer foils, that are invisible for the observer, has been the solution of this problem. In this way the SuperWindows allow to achieve a value of Ug coefficient below 0.05 W/m^{2}K and solar radiation transmission coefficient close to one-chamber window sets with, at the same time, high optical parameters.

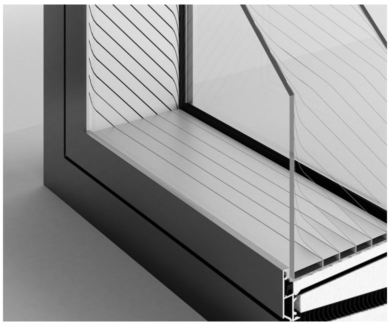

Fig. 1 *Cross-section through an insulated glass window set of enlarge width INVIS160tweed.[1][2]*

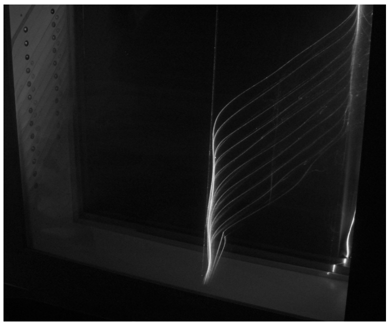

Fig. 2 *A prototype of the insulated glass set of 160 mm thickness with the foils set arranged at an angle of 45° visualized by the use of a laser beam.[1][2]*

During the researches of prototype windows, the space between the windows panels was filled with air instead of dry inert gas, so the results of other models will be different than those obtained in the study of a prototype model. The results of these researches show the difference between the heat transfer coefficients for the two positions of insulated glass in the measuring chamber. These two positions, differ by 180 degrees, represent so-called summer and winter setting of the window. For the tested prototype, the surface of inclined sets of chamber was about 60 % of the entire surface of the window tested and the difference in the value of U coefficient between these two positions was about 40 %.

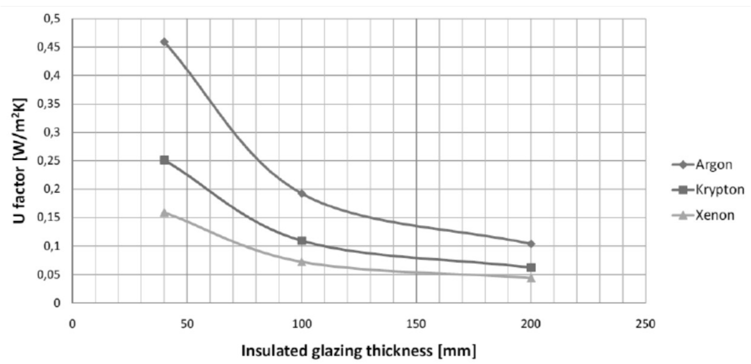

Fig. 3 *The calculation of U coefficient for windows, depending on the gas used.[1][2]*

References

[1] International Application Published under the Patent Cooperation Treaty (PCT). A system of gaseous thermal insulation, especially of insulated glass units for Paszkowski Mariusz.

[2] “Super windows” przełom w technologii okien ekstremalnie termoizolacyjnych. M.Paszkowski, A.Kostka. www.superwindows.eu