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Insulation glass 0.4

Folly or innovation – suggestions for a sensible approach to the U-value Olympics

The requirements for buildings relating to energy conservation and climate protection have led to a significant improvement in the thermal insulation of buildings. Good energy efficiency and comfort levels require primarily high-quality windows with insulating glazing in addition to efficient services installations and facade insulation. In the past, improvements in the thermal transmittance U_W of windows were mainly the result of the development of insulating glazing. Today, in view of EnEV 2014 that stipulates further upgrades with effect from 01.01.2016 and public grants available for energy upgrades and new buildings, triple glazing represents the current state of technology.

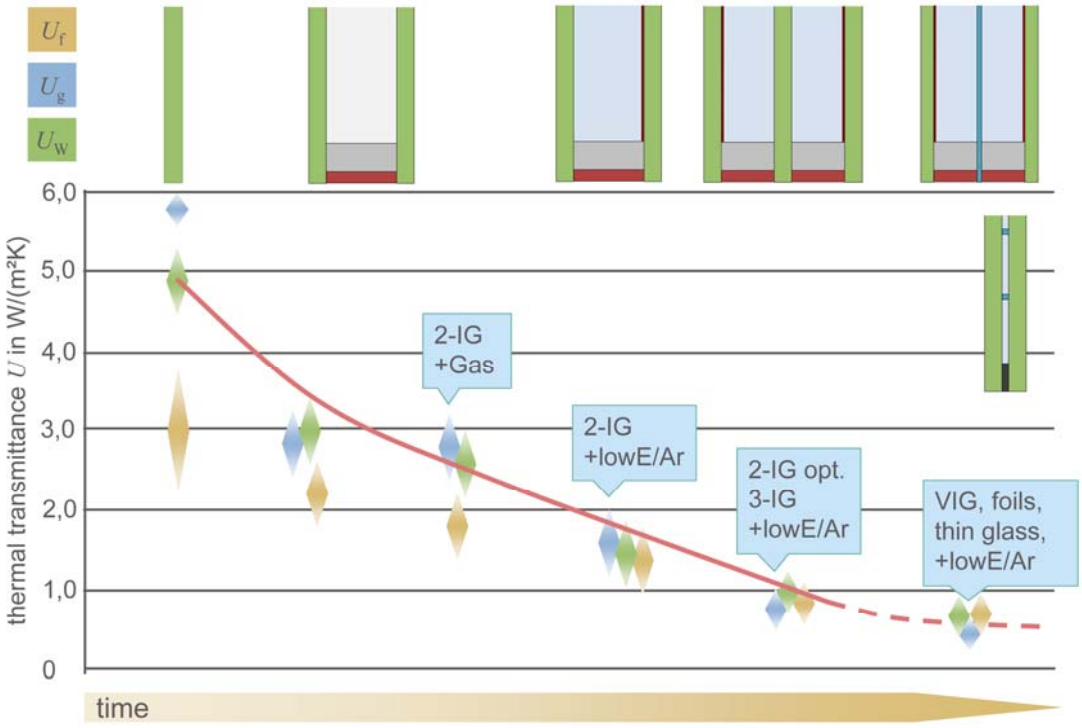

Fig. 1 Development of thermal transmittance based on the development of insulating glass units over time

Market analyses [1] show that more than half of the windows produced today are fitted with triple glazing. The system providers of frame profiles and manufacturers of building hardware have adjusted their product portfolios to the thicker and heavier glass units. Nevertheless, the handling of the windows – especially those with special glazing – still presents a challenge to the manufacturing companies and their installers. In view of the fact that the requirements for windows are set to increase further, the question arises as to with what technology the new targets can be achieved. Again, the development of insulating glass units plays an important role. In professional journals and at trade exhibitions you can currently see insulating glass units with more than two cavities/three glass panes. However, although this jump in technology is hailed as "easy", one has to ask what the actual benefits of the extension to quadruple insulating glass units are.

Tab. 1 Overview of properties of insulating glass units

Property	2-IG	3-IG	4-IG	Trend
Configuration in mm	4/16/:4	4:/18/4/18/:4	4:/20/4/20/:4/20/:4	
Thickness in mm	24	48	76	↗
Cavity (ideal) in mm	16	18	20	↗
Weight in kg/m²	20	30	40	↗
Gas infill / type of gas	90 % Argon	90 % Argon	90 % Argon	
Coating	0,03	0,03	0,03	
Thermal insulation Thermal transmittance U_g in W/(m²K)	1,1 (1,13)	0,5 (0,53)	0,3 (0,34)	↘
Comfort level (T_e=-10°C / T_i=20 °C) Surface temperature	16,7 °C	18,5 °C	19,1 °C	↗
Daylight Light transmittance τ_v	0,80	0,72	0,64	↘
Solar energy Total energy transmittance g	0,62	0,49	0,43	↘
Thermal load Temperature of central pane(s)	30,0 °C	37,7 °C	48,9 °C	↗
Mechanical load on edge seal due to climatic conditions, without wind (WxH, 0,250 m x 1,500 m)	100%	136%	155%	↗
Mechanical load on glass pane due to climatic conditions (1 m² of floatglas, max. utilisation)	45%	89%	160%	↗

Energy conservation and solar gain

By adding an extra cavity to glass units it is generally true to say that the thermal transmittance Ug is improved. In order to assess the improvement, it is necessary to investigate

the basic principles of heat transport in glass. A relevant parameter for the thermal insulation of an insulating glass unit is the heat exchange via radiation and convection in the cavity. When insulating glass units were compared, it was always assumed that they had a low-E coating and were filled to 90% with argon gas. The results show that the ideal width of the cavity increases with an increase in the number. This means that a glass unit with optimum thermal insulation increases in thickness.

In quadruple glazing, an additional glass pane with coating is added to the unit; this lowers the total energy transmittance and light transmittance, and hence reduces the solar heat gain and daylight penetration.

The improvement in the thermal transmittance U_W for windows from double glazing to triple glazing is $\Delta U_W \approx 0.4$, and from triple glazing to quadruple glazing is $\Delta U_W \approx 0.2$, based on the standard size with a frame ratio of 30% and thermally improved spacers.

Suitability for use

In addition to energy conservation, the suitability for use is important for ensuring that the unit is durable and can be used in different applications.

With increasing thickness and hence increasing weight of the glass unit it is not clear whether the unit can be used in applications with special requirements, e.g. fire resistance, sound insulation and/or burglar resistance. In view of the fact that the profile systems and hardware for triple insulating units are at their limits, the usefulness of quadruple insulating glass units is questionable.

In triple insulating glass units the thermal load, i.e. the temperature of the central pane, is already approx. 40° C and this may increase to 50° C in quadruple insulating glass units. This means that, in this case, the central pane can no longer consist of float glass, but must be replaced with a higher quality and more expensive product, e.g. toughened safety glass or strengthened glass.

In quadruple glazing with its additional cavity, the sum of the cavities increases which means that the mechanical load on the edge seal also increases. When the glass format is an unfavourable one, e.g. 250 mm x 1,500 mm, which is a typical application for door panels, the edge load increases by about 55% compared to double insulating glass units (IGU).

But it is not only the mechanical load on the edge seal resulting from climatic conditions that increases, but also the mechanical load on the inner and outer glass panes. Comparative calculations based on 1 m² show that the maximum utilisation of the glass tension of

quadruple insulating glass units is over 100%. This means that the inner and outer glass panes also have to consist of a higher quality and more expensive product, such as toughened safety glass or strengthened glass, in order to avoid glass breakage. [2]

Folly or innovation?

The research project on pressure-equalised insulating glass [3] investigates solutions that would address the issue of suitability for use. The research project offers two provisional solutions. One solution would be an insulating glass unit with pressure equalisation in which e.g. a capillary tube, a valve or a membrane is used to permanently balance the pressure. Another solution would be a pressure-adapted insulating glass unit in which the difference in altitude between the manufacturing and installation locations is balanced by a one-off pressure equalisation at the site of installation.

In order to reduce the heavy weight of insulating glass units, the development of thin glass technology may provide a solution. If it is possible to produce a lightweight triple insulating glass unit that weighs no more than a traditional double insulating glass unit, it would also be possible to produce lightweight quadruple insulating glass units.

Whether a triple insulating glass unit made of thin glass is an alternative to vacuum-insulating glass is an open question. The advantage of the vacuum technology is the reduced glass thickness, the reduced weight and very good thermal insulation as well as high solar heat gains. However, some practical problems have not yet been resolved satisfactorily. These include the visibility of the micro-spacers, the variety of available formats, requirements relating to fire protection and security/safety and the long-term integrity of the system.

Conclusion

Adding another cavity and glass pane with coating to a triple insulating glass unit cannot really be considered a leap in technology. There are research and development projects dedicated to the investigation of technologies in order to react to future increases in energy requirements. However, it is far more important to ensure that any proposed solution is suitable for use and is durable. Nobody gains from what looks – at the moment – like an ideal thermal insulation system if this product is more expensive and does not achieve the service life of double insulating glass units. With a view to future requirements, it is worth noting that windows and hence the insulating glass units have to fulfil additional tasks, such as thermal insulation in summer, daylight control and automation.

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