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Original Contribution

THE EFFECT OF TRANSPARENT SURFACE ASPECT TO SAVING HEAT ENERGY

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ABSTRACT

The scrap used materials cause environmental problems in modern communities. Besides, a very high percentage of the energy consumed for cooling, heating and lighting is generated by consuming materials such as coal, petrol, LPG and natural gas. Savings from these energy sources are very important for the national budget and for preventing related environmental problems. Glazing materials conform to the recently developing environmental consciousness due to their non-pollutant reusable, chemical resistant and non-toxic character. However, traditional glazing used in building envelopes cause environmental problems and increase fuel consumption because of their low thermal resistance. Nevertheless, today, by using glazing with U-values as low as that of an insulated opaque wall can be produced by using high technology.
In this paper, using different technologic materials on the transparent surface at a sample building, calculations of heat insulation is done, annual requirement of the heating energy is calculated and is compared with the usage of standard air leakage doubled glazing. Furthermore, the rate of the transparent surface area to the opaque surface area is converted on the building facade and the results are evaluated.

Key Words: Transparent surface; Honeycomb; Thermal insulation; advanced glazings; Solar thermal systems; Glazing

INTRODUCTION

In architecture, transparent surfaces play an important role to reduce energy demands in respect of heating and cooling loads and lighting requirement and responsible for a disproportionate amount of unwanted heat gain and heat loss between buildings and the environment [1]$_1$.

At the thermal envelope of buildings, the transparent surface area is the weakest part with respect to heat loss, but at the same time, this area also provides advantages, e.g., solar energy gain. Solar heat gain plays a major role in determining the thermal performance of a building and increasing or decreasing solar gains can be of crucial importance in design problems.

An energy efficient transparent surfaces should provide good lightning during the day and good thermal comfort during both day and night with a minimum demand for paid energy. This implies that overheating as well as excessive cooling should be minimized and that draught and cold surface should be avoided. It should be emphasized that good thermal insulation improves energy efficiency directly by lowering the U-value.

DIFFERENT TECHNOLOGIC MATERIALS USED ON THE TRANSPARENT SURFACE

The use of energy efficient transparent surface is steadily increasing in Europe, although many new buildings are still equipped with uncoated standard glazing. This is unfortunate since for every standard uncoated glazing fitted in new production,

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large amounts of energy will be wasted during the lifetime of this glazing [3].

Well-oriented, high performance transparent surfaces are a major part of energy efficiency in buildings. Some of the factors, which can strongly influence energy conservation and glazing sustainability, are the use of low-emissivity coatings, inert gases and frame materials and design. Improvements in the thermal performance of glazing can be achieved by using spectrally selective low-emissivity (low-e) coatings. In the hunt for low U-values, many combinations of glazing have been suggested and sometimes glazing with triple panes and two low-e coatings are proposed. Sometimes such a combination leads to a light transmittance which is lower than what is desired. Low-e glazing, the refractive indices of coating 1 and 2 were determined from measurements on coated float glass.

Table 1. *The results for calculations of DGU and TGU configurations [3].*

Pane 1	**Pane2**	**Pane 3**	**Tvis**	***g***	***U***
(a)Float	Float	-	0.817	0.786	2.93
(b)Float	Low-e	-	0.743	0.743	1.92
(c)AR float	AR low-e	-	0.893	0.833	1.92
(d)Float	Float	Float	0.746	0.713	1.95
(e)Low-e	Float	Low-e	0.619	0.572	1.14
(f)AR low-e	AR float	AR low-e	0.818	0.689	1.14

It is seen in Table 1 that using an AR treated low-e configuration instead of a standard DGU or TGU float glass configuration increases the *g* value and the T_{vis} value while decreasing the *U* value. It also shows that it is even possible to construct a low-e TGU configuration with the same visible transmittance as a float glass DGU configuration.

Further improvements in thermal coefficient or U-values can be achieved by replacing the air in glazing cavities with low conductivity gases, such as argon or krypton and by optimizing the gap between glass panes in double or triple glazed transparent surfaces [4].

Recent research has concentrated upon the application of thermo chromic films, transparent insulation materials and the use of vacuum or inert infill gases within appropriate double-glazed units. Even lower U-values may be achieved by using so-called transparent insulation materials (TIM). Glass is the oldest transparent insulation used in buildings. This material is a transparent insulator as it transmits light so that objects behind it can be seen clearly and it limits heat transfer [5]. TIM represents a new class of thermal insulation where in air gaps and evacuated spaces are used to reduce the unwanted heat losses. It consists of a transparent cellular (honeycomb) array immersed in an air layer. The air layers are similar to conventional insulation materials with regard to the placement of air gaps in the transparent solid media. TIM are solar transparent, yet they provide good thermal insulation [2].

Honeycombs and capillaries including absorber- perpendicular structures. These materials guide the incoming beam by reflection and transmission towards the absorber, so optical losses are very small. The big disadvantage of honeycomb structure is that they need an un-usually large thickness if the U-value is to be in the order of 1,0-1,5 $W/m^{-2}K^{-1}$. 60-120mm thick materials must be accommodated [5].

The most intriguing class of glass is the chromomeric one. These glasses change their optical properties according to irradiance, temperature or an electrical signal. Photo chromic glasses change their transparency if they are exposed to a certain radiation level. The principle is successfully used for adaptive sun-glasses. However, cheap and efficient solutions for large flat glass areas have not been developed. Thermo chromic coating is well known for inorganic materials in the liquid and solid state as well as in many organic materials. Among the many thermo chromic transition metal oxides, vanadium dioxide stands out as particularly interesting for applications on smart glazing. Electro chromism is a multi-facetted phenomenon which is well known in transition metal oxides based on tungsten, vanadium, nickel, molybdenum, titanium, iridium etç. and in numerous organic substances [5].

The change in the optical properties is caused by the injection or extraction of modillions. An EC glazing has several advantages compared to conventional shading and solar control devices. It does not impede visibility through the glazing as with blinds and curtains, while it provides glare control and thermal comfort management. It has no moving parts and as a result, minimum maintenance costs. It requires low voltage power supply and it can be integrated into the central power management of the building. It has practically infinite coloration stages and can block both direct and diffuse solar radiation, unlike passive shading devices. Furthermore, it has a low energy consumption, which is nearly zero when the glazing is kept at constant conditions, due to the considerable open circuit memory it presents [6].

Development of glazing based on highly insulating aero gel glazing monolithic silica aero gel (aero gel) is a highly porous material with pore diameters in the range of 10 – 100nm. The porosity is >90%, which combined with the nanometer pore size makes aero gel a highly insulating material with a thermal conductivity lower than that of still air. A further decrease in thermal conductivity can be achieved if the aero gel is evacuated below ~50hPa, where thermal conductivity in the pore gas is essentially eliminated [7].

In addition to the low thermal conductivity of silica aero gels, a high solar energy and daylight transmittance is achieved, which makes these very interesting materials for use in highly energy-efficient glazing. Thermal and solar properties of aero gel glazing (15 mm aero gel) compared with typical commercially available low-energy glazing. The dots mark the values for specific glazing units. The solid curved line shows the trends in traditional glazing development [7].

The objectives of both projects were to improve the aero gel fabrication process with respect to materials properties (both thermal and optical)and process parameters (drying duration and safety) and to develop aero gel glazing prototypes with a total U -value <0.6 $Wm^{-2}K^{-1}$ and a total solar energy transmittance >75%. Despite the promising results already achieved, research is still focused on further improvement of the optical quality through detailed studies of the sol-gel process and a post-heat treatment aiming at an optical quality comparable to ordinary glass [7]. In table 2, the most significant material data are given for different transparent insulation systems.

Table 2. *Thermal and optical properties of transparent systems [5].*

Materials	d (mm)	U ($W/m^{-2}K^{-1}$)	τ_{dif} (-)	g_{dif} (-)
Double glazed with air filling	0	2,9	0,63	0,67
Double glazed with low-e coating and argon-gas filling	4-16-4	1,3	0,42	0,53
Triple glazed with low-e coating and kyrpton gas filling	4-8-4-8-4	0,7	0,28	0,35
Double glazed (low iron) with granular aerogel filling	4-24-4	0,8	0,45	0,50
Evacuated (laboratory status)	9	(0,3)-0,6	0,32-0,36	0,35-0,40
Double glazed (low iron) filled with PC honeycombs	4-50-4 4-100-4	1,3-1,4 0,8-0,9	0,65 0,57	0,67 0,64
(d = thickness of glass panes and gaps, U = heat transfer coefficient (T_m=10°C), τ_{dif} = diffuse solar light transmittance, g_{dif} = diffuse energy transmittance				

CASE STUDY

The heat insulations were calculated on the double floor detached house which parameters are Ap(transparent area)=23,12m², At (total area) = 109,71 m², Ap/At = %20, in the second degree day region, Edirne. When standard double glazing is used in transparent parts, annual heating energy requirement were calculate as 49,723 kWh/m². The calculations were done in the higher transparent area ratio and the results are evaluated as a graphics.

At this case study to accept as Q_{year} = annual heat energy requirement (kWh/m²), U-value of double glazed with 6mm air filling = 3,3 W/m²K, U-value of double glazed with 9mm-12mm air filling= 3 W/m²K, U-value of double glazed with low-e coating = 2,5 W/m²K, U-value of double glazed with gas filling=2 W/m^{2}K, U-value of Double glazed with low-e coating and gas filling=1,5 W/m^{2}K, U-value of triple glazed with low-e coating and gas filling or honeycombs =1 W/m^{2}K, U-value of aero gel=0,5 W/m^{2}K

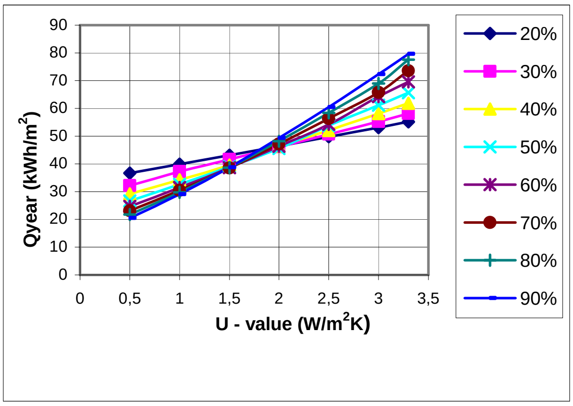

Figure1 *U-value and Q_{year} variation*

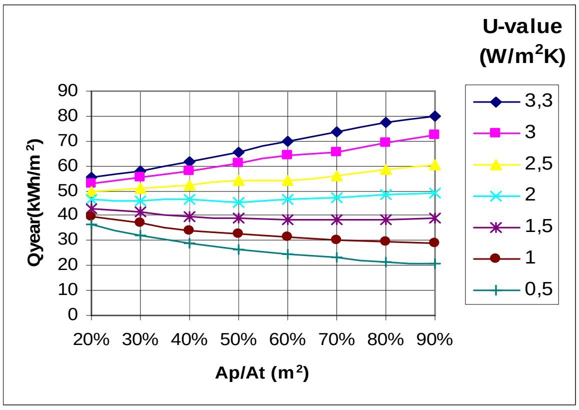

Figure 2. *Q_{year} and Ap/At variation*

When U value is increase at the figure1, Q_{year} is also increase. When U value is to be reduced from 3,3 W/m^{2}K to 0,5 W/m^{2}K, %23,3 decrease is to be seen at annual energy requirement. When Ap/At is %20, the size of change situation of the transparent area, It was evaluated below how the results could be. When Ap/At is to be increased from %20 to %90 by the gain of %10, the changing on the Q value can be seen in the figure 2.

Table 3. *Relative decreases on Qyear value*

Ap/At	Relative decreases on Qyear value (%)						
	U-value (W/m^{2}K)						
	0,5	**1,0**	**1,5**	**2,0**	**2,5**	**3,0**	**3,3**
0,20	54,0	50,0	45,9	41,7	37,5	33,3	30,7
0,30	59,6	53,01	47,7	42,1	36,3	30,5	26,9
0,40	63,4	57,0	50,3	41,9	34,5	27,0	22,4
0,50	66,4	58,9	51,0	42,8	32,4	23,2	17,6
0,60	68,9	60,5	51,4	41,8	31,8	19,3	12,7
0,70	71,0	61,7	51,6	40,7	29,3	17,4	7,6
0,80	72,7	62,6	51,5	39,5	26,7	13,3	2,5
0,90	74,2	63,4	51,3	38,1	24,0	9,2	0

While the transparent area is increased, the gain can be seen at Q_{year}, at the U-value is higher than the U ≤ 2 W/m^{2}K, the at the U > 2 value the reduction can be seen. When Ap/At is to be raised from %20 to %90 on the U=3,3 W/m^{2}K transparent area, %30,7 increase are calculated at Q_{year}. When Ap/At is to be raised from %20 to %90 on the U=0,5 W/m^{2}k transparent area, %20,7 benefit are calculated at Q_{year}. Because Ap/At is calculated %20 at examined building, %23,3 decrease is to be seen at Q_{year}, when U value is to be reduced from 3,3 W/m^{2}K to 0,5 W/m^{2}K.

When Ap/At is %90 and U value is to be reduced from 3,3 W/m^{2}K to 0,5 W/m^{2}K, %74,2 decrease is calculated at Q_{year}. This shows that heat gain is considerably increase when the transparent area increase at U≤ 2 W/m^{2}K. U glazing value, the ratio of the transparent area to the total surface area and the relative change on Q_{year} value is given in the table 3. Ap/At, %90, U=3,3 W/m^{2}K values are chosen as a reference points.

CONCLUSION

Considering that 60 % of the thermal losses buildings take place through glazing and that 60% of the energy in buildings is used for space heating, a reduction of 46% in the glazing U-value (possible by use of advanced materials), can cause a 17% reduction of the energy for heating of buildings, or a 6.8 % reduction of the net energy consumption. This can be translated to an equal reduction of GHG emissions by 14% [6]. It is seen from the results that the better heat performance is to be reduced at the heat energy consumption on the proportion of %40 - %70. When TIM are used, the solar energy gain can supply on positive manner. If the building numbers are increase, certain knowledge can be obtain on the determining of the heat energy consumption.

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