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COATED GLASSES FOR THE INCREASING OF ENERGY EFFICIENCY

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ABSTRACT: The adequate doors and windows especially affect the insulation properties of a building, namely significant quantities of heat escapes through the glass surfaces. However, considering that today the second most important building material is the glass, it becomes increasingly important for the continual development of the glass products. There was an opportunity to investigate the float technology and magnetron sputter deposition technology of coated glasses and their physical, optical and thermal properties during the summer internship at the Guardian Orosháza Ltd. The complex parameters of insulating glasses structures were measured with Perkin Elmer Spectrum 100 and Perkin Elmer Lambda 950 spectrophotometers in case of differing coated monolithic glasses. The measurements and tests were performed according to the EN 410 and EN 673 standards, respectively the help of the Guardian Configurator program. Main objective of the research work is to help to be acquainted and choose energetically adequate glass structures (by comparison and analysis of the measuring results), which can satisfy the energy requirements of the buildings.
Keywords: glasses structures, coated monolithic glasses, properties, measurements and tests

1. INTRODUCTION

Nowadays one of the biggest challenges of the humanity means the reduction of the energy consumption and the elimination the wastage. The most important objective of Hungary is to become independent of its energy dependence and able to ensure the long-term sustainability of the energy-supply. To achieve this the National Energy Strategy 2030 and the National Building Energy Strategy documents record some main lines which enable among others the updating of the existing building stock, reduction of its energy consumption and the implementation of energy efficiency requirements of the new buildings. The main objective of the strategy is to reduce the heating and cooling energy demand of buildings by 30% to 2030. This would mean 111 PJ of the all saving. In Hungary, nearly 40% of the consumption primary energy is appropriated heating and/or cooling of the buildings. This high proportion is due to the most of buildings are not correspond to the technical and thermal requirements. In this way the heating energy, so of course the cost is much larger than they would be with modern technology. Most of the energy goes to waste through the building enclosure structures, for example through the glazing. The glass plays in important role in our daily lives, it is necessary raw material in lot of industry, it is the second most important material in the building industry. [1] [2]

On the other hand it is responsible for the thermal wastage in a large measure. Consequently one of the pillars of high-efficiency thermal insulation is the appropriate properties glass. Completely insulating, zero heat loss system can not produced (some heat loss always appears), however during the development of the glasses one of the most important energetic consideration that use of glasses results that the heat loss is reduced to the minimum. The insulation glass is able to hold the heat in the building (in winter) and outside the building (in summer), by reducing the direct air flow. The efficiency of the multi-layer structures can be increased by using coated glasses. The coats, also known as functional coats are constituted by that kind of metals which reflect the electromagnetic waves. These metals usually are silver, chromium, silicon, titanium, nickel and their compounds.

The thermal and optical parameters of each coated products widely changed compared to parameters of the base (float) glass. These parameters were defined by the measurements and calculations. [3]

2. MATERIAL AND METHOD

The flat glass manufacture has millennial history. During that time it went through lots of development by the time it became possible to use versatile. The present-day most modern technology is the float process. The float glass has high light transmittance and excellent optical properties. It is available in various thickness and sizes, respectively several colours. The end-products of the technology are used widely in the building industry, but moreover the main product is convertible to other functioned products, for example insulating, safety, laminated or heat- and light reflected glasses.

The technological steps of the process are seen in the Figure 1. The blended solid materials (sand, dolomite, sulphate, soda and others) are formed liquid molten glass in the furnace at 1400-1500°C temperature. This melt swimming spreads across the surface of the molten tin. Without technical intervention the molten glass would be 4 mm thick. Therefore, in the case of other thickness glasses here, in the tin bath the width and thickness of the glass ribbon have to be formed. The production speed is reciprocally proportional to the glass thickness. After this, the glass ribbon has to be de-energized. This is realized by regulated air-cooling. After the quality control, the ribbon is sheared to correct sizes. The process ends with the manual or mechanical skimming and the stocking. [3] [4]

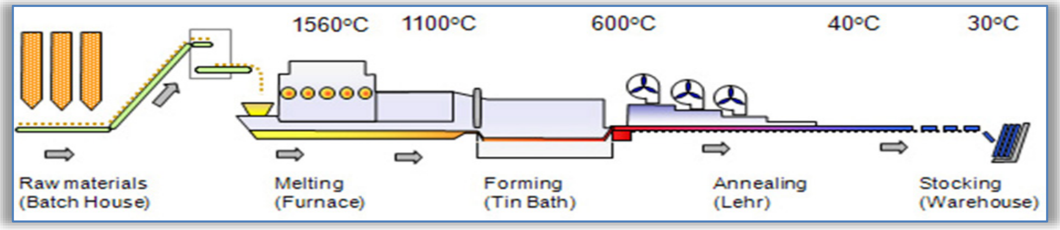

Figure 1. Float glass-manufacturing process [5]

To achieve the favourable energetic properties these base float glasses have to be coated. Nowadays the coated glasses are produced by several methods. The coats are configured by more different thin layers, the thickness of these layers are in the nanometre size range. The examined products by the article are made by the PVD (Physical Vapor Desposition) magnetron sputter-coating technology. The most important and most requiring attention part of the technology is the taking up of the coat to the glass plate. However, to get favourable thin layers during the coating process, the base glass have to be completely pure. In favour of this, after the hacking the glass plate goes through the washing equipment and just after this can come in the first chamber of the sputter line. The sputter line is constituted by more chambers, and there are 3-4 cathode units in every chamber. These cathodes contain the so-called targets from which each layers of the coat can be separated off. The coating process is a physical method which comes into existence in high vacuum, therefore 10-1 Pa pressure has to be provided in the chambers. The sputtering process takes place by ionizing argon atoms in the plasma. The plasma is created by the effect of the electric field strength under the target. The ionizing argon slams to the surface of the negatively charged target, from where it knocks out atoms and atom groups, in this way forming a layer of the functional coat. The structure of the complete coat is showed in Figure 2. At first a resistant bottom layer is got into the glass plate which influences the transmission, reflexion and colour of the glass. The top of this layer a metal layer, also know protective layer is located. Its function to protect the functional layer from the mechanical and chemical effects, respectively it reflects and absorbs the short wavelength rays. The functional layer (usually silver and/or chrome) reflects the long and the short wavelength rays too. [4] [6]

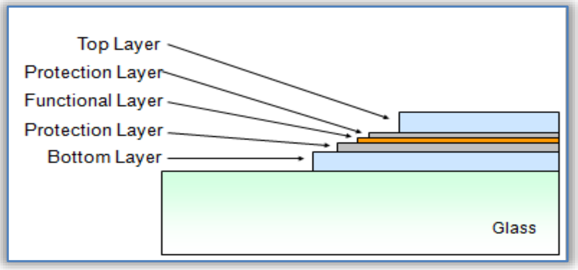

Figure 2. The structure of the coated glass [6]

3. EXAMINATION OF COATED GLASSES

During the repeating measurement six Guardian products were tested, five samples of every product types: ClimaGuard Neutral (CG N), ClimaGuard Solar (CG S), SunGuard High Performance

Neutral 60/40 (SG N60/40), SunGuard SuperNeutral 70/30 (SG SN70/30), SunGuard High Performance Neutral 41 (SG N41), SunGuard Solar Silver Grey 32 (SG SG32). During the subsequent examinations, the averages of optical and thermal parameters were used. There was an opportunity for this because the obtained values were located near each other. The sampling was happened as described in the EN 1096:2004 standard. The objective of the measurements is to ascertain the two most important properties of the building glasses - the heat transfer coefficient and the total solar energy transmittance factor. The first pass of the investigation to the light transmittance and the energy efficiency's power of the monolithic glasses have to be defined. This can be achieved by using the Perkin Elmer Spectrum 100 and Perkin Elmer Lambda 950 spectrophotometers. These parameters are listed in Table 1. After this, using the received values, respectively by the help of described coherences (which are found in the EN 673 and EN 410 standards) and applying the program of the name of Guardian Configurator the complex characteristics of a given structured glass surface can be calculated. [4]

One of the most important properties of modern glasses is the heat transmittance coefficient. This article deals with just the definition and examination of heat transmittance coefficient ($U_g \left[\frac{W}{m^2 \cdot K}\right]$) of the different structured glass surfaces. The heat transmittance coefficient gives the quantity of heat that flows through 1 square metre surfaced glass plate in every seconds in case of the maintained temperature difference is continuously 1 K between the both sides of the glass. Consequently the higher U_g value of the glass, in other words the more per unit of time flowing quantity of heat impairs the insulating properties of the structure. The heat transmittance coefficient of a flat glazing can be ascertained primarily by the emissivity of the glass surfaces. The emissivity of the different coated glasses can be found in the table 1.

Table 1. Outcomes of the spectrophotometric measurements [4]

	Float	CG N	CG S	SG SN70/41	SG N41/33	SG SG32
ε_c [%]	78.7	4.46	2.09	12.49	6.23	49.8
τ_v [%]	90.7	85.7	69.7	75.3	44	31.8
ρ_v [%]	8.4	5	18.6	4	4.2	14.6
	8.4	5.1	22.1	6.5	17.2	20.5
τ_e [%]	86.6	62	44.9	59.5	31.1	25.8
ρ_e [%]	7.9	25.2	43.2	16.1	25.5	22.5
	7.9	20.3	37.7	13.2	21.4	19
α_e [%]	5.5	12.8	11.9	24.4	43.4	51.7
τ_{UV} [%]	74.5	51.8	26.7	53.2	29.4	28.8
g [%]	87.9	63.7	46.5	63.1	37.2	35.9

For the definition of the U_g value the executed measurements and calculations began with the uncoated glass structures. The objective was to determine an optimal glass structure, which does not include coated glass surfaces. In view of the obtained results from calculations clearly stated that changing the thickness of the glass plates, the heat transmittance coefficient shows only minimal difference. Therefore, the thickness of the glass plates does not influence materially the thermal transmission process. On the other hand in case of dual and trial glazing structures expressly have influence of the thickness between two glass plates. During the measurements, the thickness of gas layer varied between 4 mm and 22 mm. The results are shown in Figure 3. It can be noticeable that increasing the thickness of the gas layer, the reduction of U_g value is not linear but has dependence with a minimum value. This is due to the too thick gas layer increases the thermal loss from the convective flow. [4]

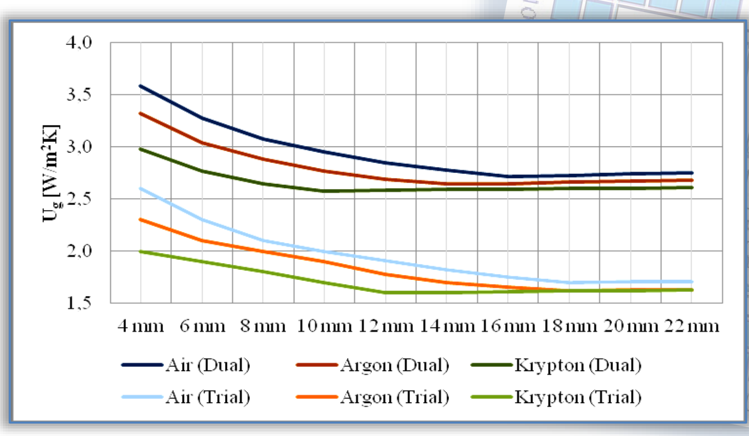

Figure 3. The thickness of the gas layer's effect on the U_g value [4] (with 4 mm thick glasses)

The U_g value is influenced not only by the thickness of gas layer but it is influenced there through what kind of gas is put in the glass structure. Figure 4 shows how to change the heat transmittance coefficient of the dual and trial glazing, if air, argon, or krypton gas is used as fillers. Using argon as gas layer, we get 5% lesser U_g value as compared to air layer, while the krypton gas reduces this value by 9-10%. This is due to the argon and krypton gases are worse heat conductors as air, in this way the losses from the heat conduction are reduced. However we have to take notice of the price of krypton is disproportionately high compared to the argon, so the application of krypton is not economical. [4]

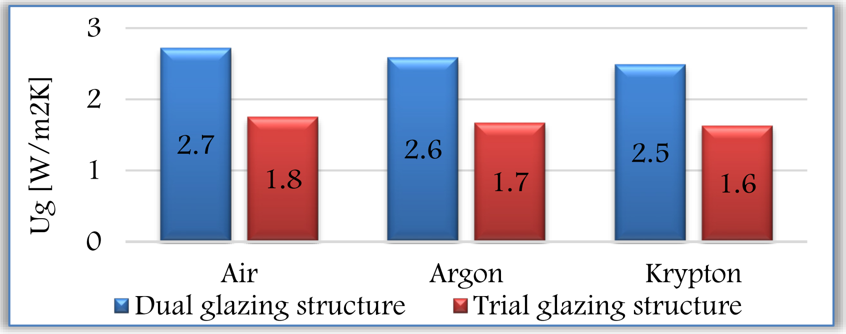

Figure 4. The different heat conductor gases' effect on the U_g value [2]
(with 4 mm thick glasses and 16 mm or 2x12 mm thick gas layer(s))

The optimal glass structure (which does not hold coated glass plates) is defined already by the help of the received values so far. The best insulating glass structure contains 4 mm thick glass plates at all events. In addition, in dual glazing structure the gas layer is 16 mm air or argon gas, respectively if we use krypton gas, this thick will be 10 mm. In case of trial glazing structure more difficult to define the optical status. Although, the gas layer which results in the least heat transmittance coefficient is 18 mm (with air or with argon), even so the optical glass structure is defined 12 mm in case of all of three gas. This is follows from the too heavy and too thick structures worsen the strength of windows, at the same time the thinner layers can own corresponding properties (the difference of U_g value between the two glass plates is not significant).

After this, the measurements continued with examination that kind of structures which in one of a glass plate is coated. To define the differences between some coats similar measurements are taken as previously read. The insulation properties of the glass structures are ensured by the low emissivity of the glass plates. These values are found in Table 1. The measurements and calculations are executed in such a way that keeps the optical structures in mind. That is means that the equipments have 4 mm thick glass plates and 16mm or 2x12 mm thick gas layers.

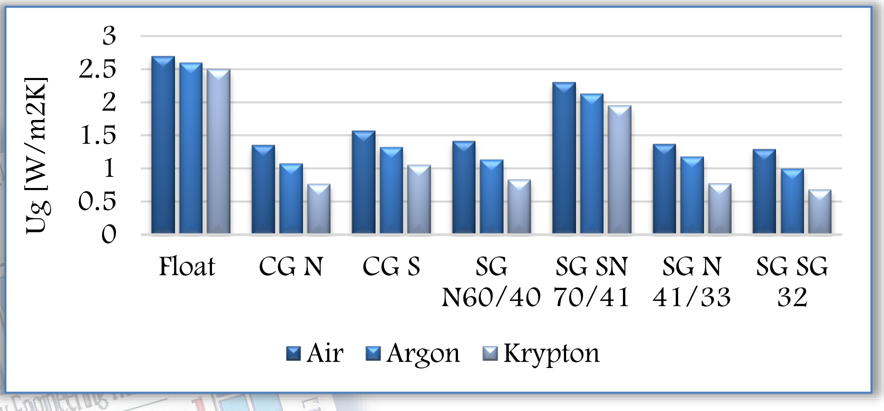

Figure 5. The coat's effect to the U_g value [4] (with 4 mm thick glasses and 16 mm thick gas layer)

In dual glazing structures the different coated glasses own variant heat transmittance coefficients. The SG SG32 has the highest U_g value of the six products. The reduction is only 20% with krypton gas too (compared to uncoated glass structure). The SG SN70/41 has better values. The coated glass plates - filled with air by 40%, filled with argon by 50% and filled with krypton by 56% - reduce the Ug value. The CG N has lower emissivity as the previous product, for a reason its Ug value becomes definitely lower too. The reduction comes at even the 68%. A similar characteristics to the SG N60/40 and the SG N41/33 as well. The best of tested product is the CG S, it gave the top values in the course of the examination. Filled with argon gas the heat transmittance coefficient is 1.0

[W/m²K], this is 60% lower as a same structure float glass. On the other hand, this reduction can be 72% with krypton gas. (Figure 5) [4]

With regard to the trial glazing structures during the examinations the coats gave almost similar values. It can be concluded that in trial glazing structure the reduction of U_g value does not depend on the emissivity of the coat, but it does the heat conduction of gas layer. (Figure 6)

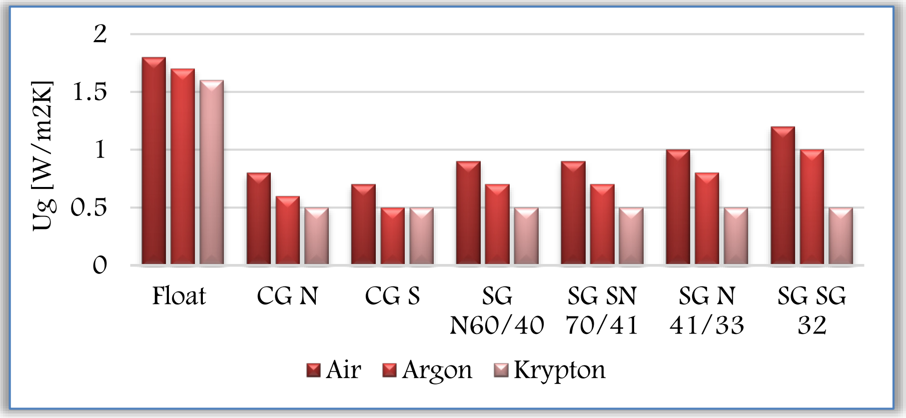

Figure 6. The coat's effect to the U_g value [4] (with 4 mm thick glasses and 12 mm thick gas layers)

At the side of the heat transmittance coefficient the other value that decisively influence the efficiency of a glass plate, is the total solar energy transmittance factor, namely g value. This shows how much of the solar energy get through the added plate. The correlations, which are needed to determine the g value, are found in the EN 410:2000 standard. The measurements and calculations were executed for the optimal structures. The examinations exhibited that the g value is not influenced by neither the material of gas nor its thickness. The significant reduction only shows up when the coated glasses are used. Namely, the coats are constituted by that kind of metals, which reflect the electromagnetic waves. The received data demonstrate that the g value is reduced averagely with 51%, but in the optimal case even 71% by the coat (compared to the coated glass structures). (Figure 7) At the same time have to pay attention to in most cases the low g value effects low visible light transmittance too, because the coat reflect the near infrared and the visible light waves too. [4]

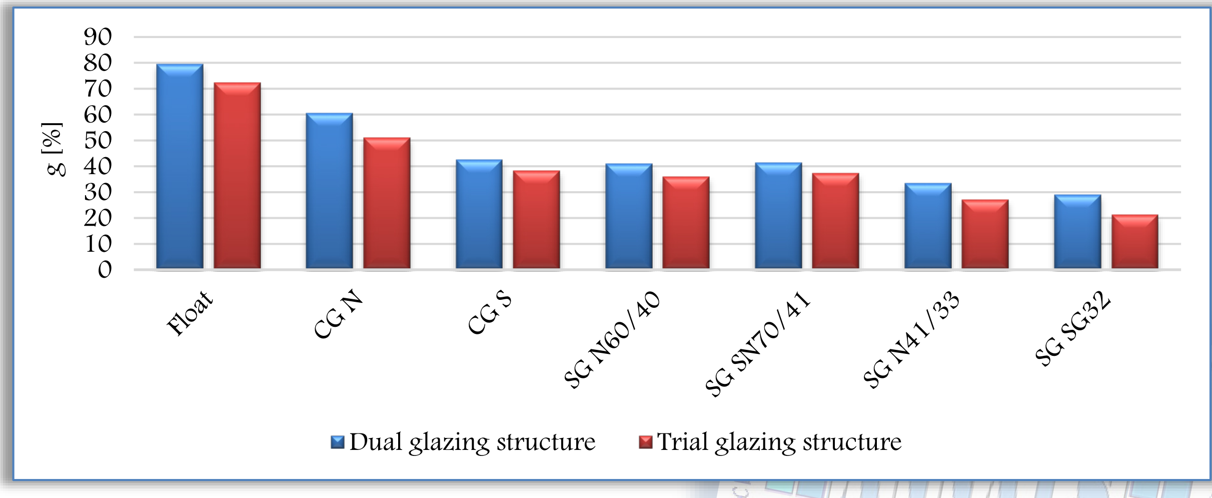

Figure 7. The coat's effect to the g value [4] (with 4 mm thick glasses and 16 mm or 2x12 mm thick gas layer(s))

4. CONCLUSIONS

The aim of the examinations was to help to choose the adequate coated glass, which meets the building energy requirements. Scilicet the buildings pertinent requirements become severer year by year; the manufacturers are constrained to continuously develop; like this for the user hard to make head or tail of supply. The tenable for energy efficiency of building record (2010/31/EU Energy Performance of Buildings Directive) prescripts minimum requirements, which aid to increase the energy efficiency. The heat transmittance coefficient of the glazing is determined in U_g= 1.0 [$\frac{W}{m^2K}$] by the directive. More types of the examined products meet these requirements.

In case of dual glazing the CG S comes up to the mark filled argon and krypton too. Besides this if krypton gas is used, the SN N60/40, the SG N41/33 and the CG N product will suit the requirements, but as it was mentioned, the krypton gas is not necessarily economical. In trial glazing structures - expect the air-filled SG SG32 - all coated constructions meet the criteria. On the other hand, if we want to make the decision cost-effectively and consistently, not enough to just the heat transmittance coefficient gets tone. During the choice have to take into account the climate and the climatic conditions, which are, typify the region, respectively have to consider the limit of the cost-investment. [4]

Note

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