Energy saving properties and development products of low radiation glass

Lidan Sheng*

Department of Applied Chemistry, Shandong University, Weihai, China

*Corresponding author: 202000700182@sdu.edu.cn

Abstract. With the development of modern society, more and more buildings have appeared, and the problem of building energy consumption has also attracted people's attention. The problem of building energy consumption really needs to be solved. It needs to work together from many aspects to reduce energy consumption, including the use of energy-saving glass. This article analyzes and summarizes the existing literature on energy-saving glass to explain the energy-saving principle and manufacturing process of low radiation glass in detail. The method of data analysis is adopted to compare the energy-saving effect of different energy-saving glasses based on the existing data, and the energy-saving effect of low radiation glass is objectively analyzed. The research found that the low radiation glass has strong heat insulation ability and heat preservation effect, and has significant energy saving effect, which is very suitable for the concept of energy-saving buildings in contemporary society.

Keywords: Low-E galss, energy saving, characters, process.

1. Introduction

Today, the international energy situation is grim, and there are energy shortages and other problems around the world. From the analysis of the proportion of global energy consumption, building energy consumption accounts for about 40% of the global total energy consumption, and will eventually exceed 50%, becoming the largest part of energy consumption. If the building energy consumption is not significantly reduced, the climate change caused by energy consumption will bring unimaginable harm to human beings by the middle of this century. Therefore, the energy conservation of building materials has become the focus of social attention. And building energy consumption is relatively high in China, about 50% of which comes from building doors and windows [1]. The unit energy consumption level of civil and public buildings is four times that of Europe and three times that of the United States [2]. More than 93% of the existing buildings are not equipped with energy-saving glass doors and windows. In order to achieve the important goal of energy conservation and emission reduction and reduce building energy consumption, it is imperative to use energy-saving glass.

In this paper, we will choose one of the energy-saving glasses, low radiation glass, to analyze in many aspects, to show the importance of the use of low radiation glass in the actual society. In this paper, the principle and manufacturing process of low radiation glass are explained theoretically, and the advantages of low radiation glass in energy saving are proved with data by comparing the energy saving effects of different kinds of glass and low radiation energy saving glass. Finally, the selection of low emissivity glass is analyzed from the aspects of energy consumption, region and economic effect.

2. Energy saving principle of low radiation glass

Low radiation glass has two-way energy saving function. Low radiation glass has low reflectivity to near-infrared radiation (wavelength 0.8-3mm), and high reflectivity to far-infrared radiation while maintaining good light transmittance (visible light transmittance 80%~90%). Low-E glass has low emissivity because there is a layer of metal or metal oxide with very low emissivity in its film, which can effectively reduce the thermal radiation through the glass. The low radiation film of Low-E film

is very thin, and other auxiliary films generally use materials with high visible light transmittance to ensure sufficient visible light transmittance. The coating material of low emissivity glass has high infrared reflectance, does not absorb heat, and has the performance of reflecting far infrared [3].

The low radiation glass has high visible light transmittance, which can effectively control the visible light transmittance and reflectivity. It can not only meet the energy saving requirements, but also meet the comfort requirements of appropriate lighting. It can simultaneously reflect up to 90% of the far infrared ray. As far as the heat insulation effect in summer is concerned, Low-E film can make the visible light in sunlight enter the room through the film, block the long wave radiation generated by sunlight, roads and outdoor surrounding buildings, and effectively reduce the cooling load and cooling energy consumption of indoor air conditioners; In terms of thermal insulation effect in winter, Low-E film can enable near-infrared radiation and visible light in sunlight to enter the room through the film, and reflect the long wave radiant heat energy emitted by indoor objects, walls, air conditioners, heating and personnel, so that it can stay indoors, prevent it from losing to the outside through the maintenance structure, form a more appropriate indoor temperature, and save heating energy consumption.

Therefore, the low radiation glass can play a role of two-way regulation, which greatly reduces the cost of air conditioning and heating of buildings. Low radiation glass is usually used as insulating glass. Low radiation insulating glass can not only greatly reduce the heat transfer of heat conduction and heat convection, but also greatly block the transmission of heat insulation radiation. Its thermal insulation performance is twice that of ordinary insulating glass. Compared with ordinary single glass, 60% of energy is saved in summer and 70% in winter. The energy-saving effect of high-quality low radiation insulating glass is more than 90%.

3. Comparison of energy saving properties between different types of glass

The main photothermal properties of several commonly used glasses are shown in Table 1. Sc and U are the shielding coefficient and heat transfer coefficient of glass respectively.

Table 1. Main Photothermal Properties of Several Commonly Used Glasses [4]

Project	Structure	Transmittance	Sc	U/[W/m^2*K]
Single transparent glass	6c	89	0.99	5.58
Single colored	6F-green	73	0.65	5.57
Transparet insulating glass	6c+12A+6c	81	0.87	2.72
Low-E glass	6CEF11+12A+6c	35	0.31	1.66

Note: 6c represents 6mm transparent glass, CEF11 is Low-E glass model. U value is measured according to ISO 10292 standard. Sc value is measured according to ISO 15099 standard.

The shielding coefficient of single transparent glass is 0.99, and the heat transfer coefficient is 5.58W/ (m ^ 2 * K), both of which are relatively high, indicating that it has poor solar radiation blocking ability and poor thermal insulation performance. Therefore, such glass should not be directly used in buildings with HVAC or air conditioning.

The sunshade coefficient of monochromatic glass is lower than that of monochromatic transparent glass, and the difference in heat transfer coefficient is not significant, indicating that it can reduce its entry into the room by absorbing solar energy, and its thermal insulation performance is slightly better than that of single transparent glass, while its thermal insulation performance is the same as that of single transparent glass.

Transparent insulating glass is composed of 2 or 3 pieces of ordinary glass and air layer. Some insulating glass air interlayer is vacuum or filled with inert gas. Compared with single-layer transparent glass, the shielding coefficient of transparent insulating glass has little difference and the heat transfer coefficient has a large difference. Therefore, it has excellent thermal insulation and

sound insulation characteristics. Since the glass surface is not coated, its shading coefficient is not improved much, and direct sunlight cannot be limited. Therefore, its comprehensive energy saving effect is also limited, and it should be used to develop strengths and avoid weaknesses. It is applicable to northern areas where heating is the energy consumption.

Low-E glass changes the performance of the glass through coating technology, so that the glass can reflect far infrared light, block the flow and radiation of heat from high temperature environment to low temperature environment, block the inflow of heat energy in summer, and block the outflow of heat energy in winter, with a two-way energy-saving effect. The low radiation insulating glass, which is composed of low radiation glass and insulating glass, combines the advantages of low radiation glass and insulating glass, and has a wider screening coefficient (0.2-0.7) and a lower selection range of heat transfer coefficient. It is the most effective energy-saving glass at present. In addition, Low-E glass is divided into high permeability type, sunshade type and double silver Low-E glass according to different use regions and design requirements. The performance parameters of each kind of low radiation glass are different, and the applicable environment is also different.

4. Structure and manufacturing process of low radiation glass

Low radiation glass is processed by online or offline coating. The film has extremely low surface emissivity, which is very consistent with the social development requirements of energy conservation and consumption reduction. Low radiation glass produced by online low radiation coating and offline low radiation coating have their own characteristics and different market coverage, which is a long-term coexistence and complementary relationship.

4.1. Offline Low-E glass

Offline low emissivity glass refers to the coated glass produced by coating low emissivity film on the glass surface by magnetron sputtering, vacuum evaporation, etc. The quality of sputtered coating film is good and it is firmly combined with the substrate. It is easier to get a film with uniform thickness than vacuum evaporation. The range of substrate materials that can be used is very wide, the operation is simple, the process repeatability is good, and the automation of process control is easy to achieve. Especially when multilayer films are plated, they can be continued, which is suitable for the production of large area high-quality coated glass [5].

The basic structure of offline low radiation glass consists of three parts: dielectric film, functional film and outer dielectric film, as shown in Figure 1. The first layer of dielectric film plays a role in blocking visible light and partial infrared reflection in sunlight, and adjusting the optical performance and color of the film system; The functional film can reflect the indoor heat and block the destructive ultraviolet ray in the sunlight. It is one of the important films that determine the transmissivity and reflectivity of low radiation glass; The outer medium layer can not only play the role of antireflection, but also play the role of protective film. According to the composition and performance of the film system, it can be divided into single silver low radiation film, double silver low radiation film, sunlight controlled low radiation film and improved low radiation film.

The surface radiation coefficient of offline low radiation glass shall be less than 0.15, which has the advantages of good film thickness controllability and repeatability, strong adhesion between film and substrate, high purity of film that can be made of special materials, and high film forming rate. However, the abrasion resistance and firmness of the low radiation glass produced by the off-line coating process are not enough, and the storage period is relatively short, so it must be processed into hollow, sandwich and other composite products. Moreover, the offline low radiation glass cannot be heat treated, otherwise the metal layer will be damaged.

Outer dielectric film
Functional membrane
First layer of dielectric film
Glass

Figure 1. Offline Low-E glass film system [6]

4.2. Online Low-E glass

On line low emissivity glass film is composed of three kinds of oxide films The outer functional film is the key to determine the far-infrared radiance and reflectivity of low emissivity glass; The inner medium film can effectively prevent the precipitation of metal alkali ions on the glass surface; The intermediate transition film is mainly used to adjust the color and sunlight transmittance of the film.

On line low radiation glass production processes mainly include thermal spraying, chemical vapor deposition (CVD) and physicochemical thermal decomposition. Thermal spraying refers to spraying the coating material onto the formed float glass plate with a repeatedly moving spray gun on the float glass production line. The coating material is heated and vaporized to generate pyrolysis reaction, and the generated oxide is deposited on the metal surface to form the required film. This method is applicable to simple equipment, with good adhesion and wear resistance of the film. The disadvantage is that large area coating is easy to be uneven. At present, chemical vapor deposition (CVD) is widely used. Chemical vapor deposition (CVD) forms the required film on the surface of the just formed glass through the decomposition of the coating gas in the tin bath of the float glass production line. This method can be used to coat a large area on the production line, but the uniformity of the film is not easy to control, the equipment is complex, and the cost is high [7].Atmospheric chemical vapor deposition (CVD) is widely used in CVD, which is characterized by fast, low-cost coating and good film performance.

The surface radiation coefficient of on-line low radiation glass shall be less than 0.25, with good thermal stability and thermochemical stability. The film layer is hard, firm and wear-resistant. It can be stored, treated and cut like ordinary float glass. It can be tempered and bent. It can not only be used as a single piece when exposed to the air, but also be processed into hollow and laminated glass. The service life of the film layer is equal to that of the glass.

5. Selection of low radiation glass

5.1. Comparison and analysis of annual energy consumption

The annual energy consumption calculation results of different low radiation glasses are shown in the table 2 below. From the table below, it can be concluded that the annual energy consumption of high permeability glass is the highest, the annual energy consumption of double silver glass is the lowest, and the energy consumption of sunshade glass is between the two. Therefore, if other factors such as economy and environment are not considered, the use of double silver glass can achieve the best energy saving effect.

Table 2. Calculation results of annual energy consumption with different glasses [8]

Glass type	Heat transfer coafficient	Sunshade coefficient	Annual energy consumption/MkWh	Energy saving rate of relatively high permeability type/%
High permeability type	1.957	0.749	1.41	/
Sunshade type	1.853	0.564	1.3	7.6
Double silver	1.7	0.46	1.27	9.8

5.2. Selection of low radiation glass in different regions

High permeability Low-E insulating glass has relatively high visible light transmittance, and its lighting effect is good, which can reduce lighting energy consumption. High permeability Low-E insulating glass has a high solar energy transmittance, so that most of the solar energy can enter the room and reflect the medium and far infrared rays, playing an excellent thermal insulation performance. Therefore, the high permeability Low-E insulating glass is suitable for buildings with high lighting requirements in northern areas.

Sunshade Low-E insulating glass can block strong light and transmit suitable visible light, with moderate solar transmittance and high mid far infrared reflectance, which can greatly reduce solar thermal radiation. Therefore, the sunshade Low-E insulating glass is suitable for southern regions with high heat radiation intensity.

Double silver Low-E insulating glass has two silver plating layers, which has the characteristics of high permeability Low-E insulating glass and sunshade Low-E insulating glass. Therefore, this kind of glass has the best energy-saving effect and is applicable to all regions.

5.3. Economic analysis of different low radiation glass

Table 3. Economic analysis of different low radiation glass [9]

Type	Initial investment (10^3 yuan)	Annual operation cost of construction (10^3 yuan)	Life cycle cost (10^3 yuan)
High permeability	37.8	197.4	1717.677
Sunshade type	37.8	182.53	1591.139
Double silver	54.6	178.6	1571..615

The economic analysis adopts the life cycle cost method to deeply analyze the two main factors that affect the economic analysis: initial investment and annual operating cost [10].

It can be seen from the table 3 that the operation cost and life cycle cost of high permeability glass are the highest. Although its initial investment cost is the lowest, the total cost is still high, so its economic effect is poor. The initial investment of the double silver glass is high, but the operation cost and life cycle cost are low, and the overall economic effect is good. The initial investment of sunshade glass is low, the operation cost and life cycle cost are lower than those of high permeability glass, and the difference between sunshade glass and double silver glass is small. Therefore, if the initial investment is limited, sunshade glass can be selected.

6. Conclusion

Through research, it is found that low radiation glass combines the advantages of different glasses, has a larger selection range of shielding coefficient and a lower heat transfer coefficient, and is the most effective energy-saving glass at present. This study not only analyzed the energy saving effect of low radiation glass from the principle and manufacturing process, but also obtained data through experiments, and carried out data analysis to prove the energy saving effect of low radiation glass. At the end of the article, when analyzing the economic benefits of low radiation glass, it can be seen that the manufacturing cost of low radiation glass is relatively high.

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