Journal of Engineering Mechanics and Machinery (2021)
Clausius Scientific Press, Canada
DOI: 10.23977/jemm.2021.060205
ISSN 2371-9133 Vol. 6 Num. 2

Energy saving analysis of residential building envelope based on characteristic parameters

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Keywords: Energy saving, Wall temperature, Building envelope

Abstract: Building energy conservation is not only the trend of the world, but also the need of the world. With the rapid development of economy and the continuous improvement of people's living standards, comfortable air-conditioned residential buildings have been popularized rapidly, and the energy consumption of air-conditioning has increased significantly. China is a large energy deficient country, the high energy consumption of air conditioning is bound to restrict the economic development and the improvement of people's living standards in this area. How to improve the thermal performance of building envelope to make the building have good indoor thermal comfort, so as to reduce the dependence on artificial cold and heat sources and reduce building energy consumption has become an urgent topic. In this paper, the relationship between the three most important components of building envelope and building air conditioning energy consumption is studied by using dynamic simulation method according to climate characteristic parameters. Based on the comprehensive understanding of relevant materials of building envelope and some experimental research, the thermal performance and structure of building exterior window are analyzed, At the same time, the importance of roof energy saving to improve the temperature environment of the top room is also discussed. Based on the analysis of the energy consumption of building envelope and building air conditioning, the extensive practice of building envelope energy saving technology has been actively carried out, and good results have been achieved.

1. Introduction

Energy is the blood and driving force of the national economy, which is related to the normal operation and development of society, national security, ecological environment and the survival and development of future generations. Energy security directly affects national security, sustainable development and social stability [1]. In 1973, the world broke out the oil crisis, and the global energy awareness was aroused. Countries all over the world, especially the western developed countries, realized more deeply than ever that energy is not only related to economic development, but also related to the rise and fall of countries and nations [2]. At the United Nations Conference on science and technology for development held in Vienna in 1979, energy and food issues, Population problems and environmental problems are listed as the four major problems facing mankind [3]. Human survival is inseparable from energy. With the development of economy, the growth of population and the improvement of people's living standards, human demand for energy is also increasing [4].

As the basic living space of human life, it needs a lot of energy to maintain a good living environment. In the growing energy consumption all over the world, building energy consumption accounts for a considerable proportion of a country's total energy consumption in both industrial developed and developing countries [5]. Building energy conservation is the need of economic development and the need to reduce air pollution, It is the need to improve the building thermal environment. From a worldwide perspective, building energy conservation has inevitably become a global trend, and it is also a basic trend of the scientific development of modern building technology [6].

2. Analysis on the current situation and research content of building envelope transformation

2.1 Main features and characteristics

The technical strategy of transformation shall refer to the latest industry specifications and design standards, form transformation schemes that can be selected according to different use parts and different building types, and improve the existing standard technology. The research on the current preferential selection of materials, other thermal insulation materials and empirical evaluation of transformation effect can form sustainable technical measures and evaluation strategies for energy-saving transformation of existing buildings by establishing a scientific, easy to operate, identify and detect platform [7].

2.2 Promotion of technology strategy and establishment of empirical evaluation system

The problems of weak links such as energy-saving transformation design, construction quality and acceptance standard of envelope structure are analyzed, and the solutions to the conflict between engineering design and actual transformation are discussed; Combining theory with practice, further detect and experiment the current weak links of energy-saving transformation, and formulate corresponding evaluation standards and systems according to the data [8]. According to different building properties and different structural parts, referring to the energy-saving standards of new buildings and different construction projects, this paper puts forward the energy-saving transformation scheme of envelope structure with advanced, ordinary and individual standards from the aspects of shape coefficient, building window wall ratio and roof practice. According to the classification of building nature, use function, capital situation and modeling requirements, put forward technical strategies for modifying and perfecting technical guidelines.

3. Relationship between wall heat transfer performance and building energy consumption

3.1 Relationship between window wall area ratio and building energy consumption

The units of heat transfer reaction coefficient and endothermic reaction coefficient of inner and outer wall are, w / (m2, y). In the symbol brackets, J, = 0, 1, 2,..., n indicates J Δ after the action time of unit disturbance τ, Hours, general, Δ τ, Therefore, x, (5) represents the heat absorption reaction coefficient of the outer wall 5h after the action time of the unit disturbance. The calculation of the reaction coefficient can refer to the special data or use the special computer program. After having the reaction coefficient, you can use the following formula to calculate the heat transfer and heat gain of the indoor through the plate wall enclosure at the nth time. Hg (n) is shown in formula (1).

$$HG(n) = \sum_{j=0}^{\infty} Y(j) t_z (n-j) - \sum_{j=0}^{\infty} Z(j) t_\tau (n-j) \tag{1}$$

Where TZ (n-j) is the outdoor comprehensive temperature at time n-j, t τ (n-j) is the indoor temperature at time n-j, especially when the indoor temperature T τ the invariant tense (1) can also be simplified to (2).

$$HG(n) = \sum_{j=0}^{\infty} Y(j) t_z (n-j) - K t_\tau \tag{2}$$

Where k is the heat transfer coefficient of the plate wall

The solar radiation received by the same facing wall is different even at the same time. Therefore, the thermal insulation performance of the wall has a great impact on building energy consumption. However, the impact of different facing walls on different performance walls is a very worthy discussion in today's building energy-saving technology. This paper also makes a simulation analysis on this, as shown in Table 1.

Table 1: Orientation distribution table

South	Southwest	West	Northwest	North	Northeast	East	Southeast
0	45	90	135	180	225	270	315

Window wall area ratio refers to the ratio of window opening area to room facade unit area (i.e. the area surrounded by building floor height and bay positioning line). The window wall area ratio of a building is related to the daylighting and building energy consumption value of the building. How to better match the window wall area ratio with building energy consumption on the premise of meeting the daylighting requirements of the building is an important technology of building energy conservation, The daylighting standard is shown in Table 2 below.

Table 2: Regulations on indoor daylighting in residential design code [9]

Room name	Side daylighting	
	Minimum value of daylighting coefficient (%)	Window to ground area ratio (AC/AD)
Bedroom, kitchen, living room	1	1/7
stair case	0.5	1/12

The ratio of bedroom window opening area to room floor area shall not be less than 1 / 7. According to this lower limit limited by natural daylighting, the following window wall area ratio window is used in this paper for energy-saving analysis, and other analysis conditions are determined according to the actual analysis object. According to the above, the curve of building orientation and building refrigeration energy consumption is obtained, as shown in Figure 1.

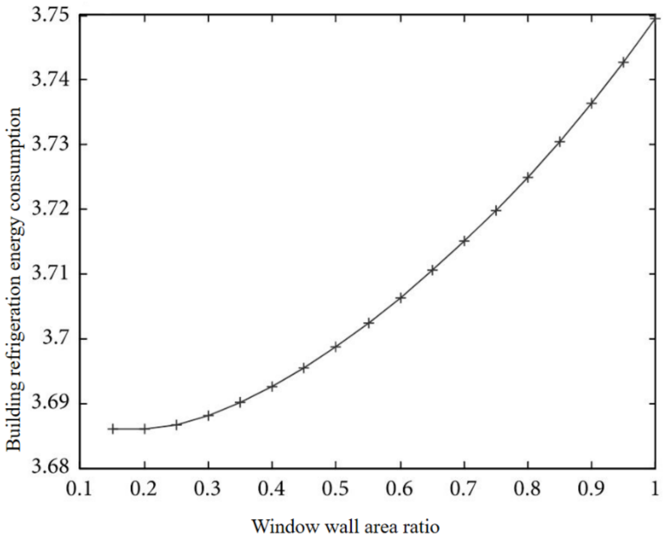

Figure 1: Curve of window wall area ratio and building refrigeration energy consumption

It can be seen from Figure 1 that under the same orientation, the smaller the heat transfer coefficient, the lower the air conditioning energy consumption, and the change trend of refrigeration and cooling energy consumption tends to become smaller. However, the larger the heat transfer coefficient, the greater the fluctuation of refrigeration energy consumption with the orientation of the building, while the fluctuation of cooling energy consumption is smaller. It can also be seen from the figure that with the decrease of heat transfer coefficient, the building refrigeration, the decrease of cooling extraction is getting smaller and smaller, which also means that the wall energy conservation is getting closer and closer to the saturation value. From the change trend shown in the figure, it can be seen that when the heat transfer coefficient of the wall reaches 3.75 or less, the reduction of building energy consumption will be smaller and smaller. If the heat transfer coefficient of the wall is strengthened, it will certainly be beneficial to building energy consumption, but its investment efficiency will be significantly reduced.

3.2 Relationship between solar radiation absorption performance of wall and building energy consumption

Solar thermal radiation has a great impact on building air conditioning energy consumption. From the requirements of building energy conservation, we can know that the solar radiation absorption performance of building surface has a great impact on the increase and decrease of building air conditioning energy consumption. In order to better analyze, this paper selects four extreme directions as the analysis object for simulation analysis, and carries out regression analysis according to the results in Table 1, the specific results are shown in Table 3 below.

Table 3: Regression equation between wall solar radiation absorption coefficient and air conditioning energy consumption

Orientation (angle)	0	90	280	270
Heating energy consumption	y=33.2-49x	y=32.95-2.32x	y=32.89-2.02x	y=33-2.42x
Refrigeration energy consumption	y=6.42+3.66x	y=6.49+4.24x	y=6.33+3.33x	y=6.46+4.42x
Air conditioning energy consumption	y=39.42+2.27x	y=39.44+2.83x	y=39.22+2.32x	y=39.52+3.02x

From the above group diagram and regression equation table, it is clear that the increase of wall solar radiation absorption coefficient will affect the growth of building cooling energy consumption, while building heating energy consumption will decrease because of this, but the total building air conditioning energy consumption will increase. Building cooling energy consumption is strongly affected by wall solar radiation absorption coefficient, especially towards, 90° and, For the wall with two 270° orientations, the building heating energy consumption is less affected by the solar radiation absorption coefficient of the wall, and the influence degree of the four orientations is not different.

This shows that the impact of building thermal bridge on building energy consumption is very large, and the impact of building thermal bridge on building energy consumption is very complex. Roof thermal bridge refers to the part where the roof intersects with the outer wall. The lintel and ring beam of the top room are close to the roof. It is classified as roof thermal bridge. The heating area at the roof is less than the heat release area. At the same time, the convective heat transfer and radiation heat transfer difference in the inner corner of the roof results in low temperature in the inner corner of the roof. Generally speaking, roof thermal bridge increases the heat load of the building, About 3% of the impact of the thermal bridge on the building heat consumption index is to increase the building heat consumption index [10], and the impact of the thermal bridge on the building heat load is not only to increase the building heating heat load, but also to change the load proportion between rooms, that is, the degree of heating heat load increase of each room varies according to the different thermal bridges included.

3.3 Energy consumption and thermal analysis of exterior wall energy-saving structure

There are a variety of building exterior wall thermal insulation structures in hot summer and cold winter areas, heat transfer before and after energy saving, temperature and heat flow outside the wall chamber, temperature and heat flow inside the wall chamber, and attenuation and delay of the structure. Figure 2 shows the temperature variation of different positions on the external wall with the temperature of 24 hours.

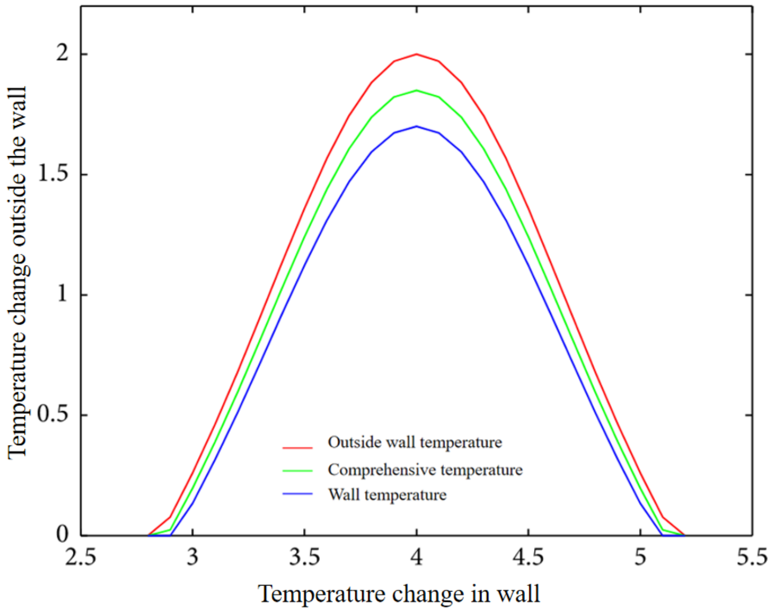

Figure 2: Simulation results of temperature and heat flow of external walls with different insulation forms

It can be seen from the figure that when the orientation is 0° to 90° and 180° to 270°, the air conditioning energy consumption and its composition energy consumption of exterior wall buildings have been increasing, the larger the heat transfer coefficient is, the greater the growth range is; when the orientation is 90° to 180° and 270° to 360°, the air conditioning energy consumption and its composition energy consumption of exterior wall buildings have been decreasing, the greater the heat transfer coefficient is, the greater the reduction range is.

The better the thermal performance of the wall, the lower the energy consumption of building air conditioning. However, with the strengthening of the thermal performance of the wall, the change of the reduction rate of building air conditioning energy consumption and its composition energy consumption shows a gradual decreasing trend. When the wall, K, value drops to 0.6, w / m2k and below, the reduction rate of building air conditioning and its composition energy consumption basically does not change, especially the reduction rate of refrigeration energy consumption.

4. Conclusions

Through the simulation characteristic parameters and theoretical analysis, the influence law of building envelope performance on energy consumption and indoor temperature environment is as follows. For the exterior walls with the range of 0° to, 90°, 180° to and 270°, the building air conditioning energy consumption and its composition energy consumption have been increasing. The larger the value of K, the greater the growth range. The direction is, 90° to, 180°, 270°, the energy consumption of building air conditioning and its components has been reduced for the exterior walls in the range of 360°. The greater the value of K, the greater the reduction.

The ultimate goal of building energy conservation is to reduce the energy consumption of air conditioning and heating while maintaining a comfortable thermal environment. The basic principle of suitability technology is the selection of technology and engineering materials [11], not the one-sided pursuit of high cost and high technology. For energy conservation transformation, the focus is the selection of transformation scheme, It is not only based on the energy-saving effect of the scheme as the only criterion, but should integrate the two factors of economy and energy-saving effect to make the best energy-saving scheme [12]. It is concluded that indoor thermal disturbance, outdoor air infiltration and air conditioning investment, and outdoor environment are the suitability factors affecting the thermal performance of building envelope.

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