Research on Green Technology for Energy-saving and Emission-reduction of New Gymnasium Building Construction

Tianbo Yu *, Xin Chen and Wei Liu *
Sports Department, Shenyang Jianzhu University, Shenyang 110168, China

*Corresponding author e-mail: Lweiw63@126.com, *ytb527528@163.com

Abstract. In recent years, the continuous development of China’s science and technology has built a large number of sports venues. In order to ensure the high performance of the construction venues and environmental protection requirements, we have improved the construction of the stadium in this article, and the buildings with excessive energy consumption Parts and building facilities have been trimmed and improved, and at the same time, through improvements to the lighting system and air conditioning system, the overall energy-saving performance of the gymnasium building has reached a new high-tech technical venue, which has played a role in the later construction. Good reference.

Key words. Gymnasium construction project, energy saving and emission reduction, environmental protection construction, green technology.

1. Introduction
Nowadays, China's natural environment is affected by the rapid economic development in the early days, and it has deteriorated seriously, threatening the normal lives of residents. Therefore, people began to attach importance to the application of green environmental protection concepts in various work. For construction projects, the main cost input of the project is the use of construction materials, and the use of construction materials will cause a certain degree of pollution to the surrounding environment, which in turn deepens the negative pollution effect of construction projects. Therefore, seeking the application of green environmental protection in construction projects is the primary problem to be solved in the current development of construction projects. In the actual use of building materials and the application of building technology, it is necessary to analyse its economy, enter an evaluation system for green construction, and apply green building technology and energy-saving building materials to practice [1].

2. The application category of green energy saving in the stadium building

2.1. Selection of building materials
New construction materials have been developed rapidly in line with the requirements of the times. It can play a good role in building energy saving. In the process of building construction, attention should be paid to selecting building materials with energy-saving properties. For example, new wall insulation
materials: expanded perlite, mineral wool, glass wool, foamed plastic, etc., all have thermal insulation properties, making buildings warm in winter and cool in summer, which greatly saves energy consumption. Whether it is an important element of civil engineering construction such as ordinary walls and foundation supports, or details such as door and window installation and interior decoration, the selection of waterproof sealing materials can play a good role in sealing, to achieve the purpose of energy saving. Therefore, from design to construction, attention should be paid to the application of energy-saving materials.

2.2. "Pay attention to the protection of water resources"
In building construction, the use of water resources is indispensable. From the perspective of green energy conservation, it is necessary to scientifically protect and recycle water resources, and integrate the concept of sustainable development into the project construction. Small flow equipment can be used to reduce project water consumption through repeated use of rainwater or construction waste water, or foundation pit precipitation can be used for machine scouring and domestic washing, etc., to achieve the recycling of water resources.

2.3. "Solar thermal utilization technology"
As an emerging energy source, solar energy is extremely remarkable in its pollution-free characteristics. Because solar energy is greatly affected by weather and geographical environment, there are still great difficulties in the popularization of applications.

1) In the architectural design, it is necessary to combine the natural environment of the building itself, reasonably deal with the influencing factors of the building, and design the materials and orientation of the doors and windows and the roof form, wall materials, etc. according to the actual lighting conditions.

2) In the rational design and planning of the building itself, the orientation of the building is determined according to the actual natural environment of the building, and the spatial distribution of the building needs to be determined according to the sun's irradiation status, as far as possible in the selection of materials Select some materials with large thermal resistance. Although passive solar energy has good development in practical applications and low cost, it is very limited in the actual adjustment of the indoor environment.

2.4. "Insulation energy-saving technology"
During the construction period, it is necessary to reasonably adopt thermal insulation energy-saving technology to strengthen the thermal insulation performance of the building. In the process of selecting insulation and energy-saving technology, not only human factors and natural factors but also the characteristics of the building must be considered, and then the insulation and energy-saving technology should be selected to enhance the insulation performance of the building. At the same time, the physical properties of the building should be improved to ensure the insulation performance of the building and reduce the energy consumption of the building. Under normal circumstances, the exterior wall of the building will adopt the structure shown in Figure 1 to achieve thermal insulation effect.

![Figure 1. External wall insulation](image-url)
3. Research on electrical energy-saving measures in gyms

3.1. Transformer energy saving

Transformer, as a kind of power conversion and transmission equipment, hopes that the smaller the power it consumes during operation, the better, that is, the transformer is required to save energy. Generally speaking, "transformer energy saving" has two meanings.

(1) Energy-saving transformer. When the two transformers with the same rated capacity are running at full load, if the loss \( P_1 \) of the transformer A is less than the loss \( P_2 \) of the transformer B, then the transformer A is more energy-efficient than the transformer B. (2) Transformer energy-saving operation. When two transformers of equal or equal capacity are loaded with the same capacity load, if the loss \( P_1 \) of the transformer A is less than the loss \( P_2 \) of the transformer B, then at this load level, the transformer A is more energy-efficient than the transformer B.

In either case, the energy saving of the transformer requires the sum of the no-load loss and the load loss to be as small as possible. To achieve the first meaning of transformer energy saving, the transformer manufacturer must take measures from the aspects of design ideas, calculation methods, raw material performance, structure type, manufacturing process, etc. to reduce the no-load loss and rated load loss of the transformer as much as possible, thereby Make low-loss or energy-saving transformers. To achieve the second meaning of transformer energy saving depends on the operating unit of the transformer. The operating unit must first choose a low-loss transformer, and at the same time, according to the number of transformers and their respective loss curves, adjust the operation mode of the transformer reasonably when the load changes, so as to achieve the minimum loss of the transformer at this load level, so as to achieve energy conservation [2].

3.1.1. No-load loss independent of load. When the transformer is no-load, the no-load current \( I_0 \) is very small, the copper loss \( P_{cu} \) caused in the winding is negligible, and the no-load loss \( P_0 \) can be regarded as equal to the iron loss \( P_{fe} \). The iron loss is composed of hysteresis loss and eddy current loss. These two losses are approximately proportional to the square of the primary line voltage \( U_1 \). If the operating voltage remains unchanged, the iron loss remains unchanged.

3.1.2. Load loss squared with the load. When the transformer is loaded, in addition to the fixed iron loss, there is also the resistance loss due to the current passing through the primary and secondary coils, that is, the copper loss \( P_{cu} \). Under different load conditions, the total loss of the transformer is the sum of \( P_{cu} \) and \( P_{fe} \). The active power loss of the transformer can be expressed by the following formula:

\[
\Delta P = P_0 + \beta P_k
\]  

Where: \( \Delta P \) is the active loss of the transformer; \( P_0 \) is the no-load loss of the transformer; \( P_k \) is the short-circuit loss of the transformer; \( \beta \) is the load factor of the transformer. Figure 2 shows the energy-saving method of the transformer.
3.1.3. Select the appropriate load factor. According to formula $\beta=S/S_N$, $S_N$ is the rated capacity of the transformer, $S$ is the actual capacity of the transformer in operation, and $\beta P_s$ is the load per kilowatt at $\beta=50\%$ when the differential is used to find its extreme value. At this time, the energy consumption of the transformer is the smallest, but at the $\beta=50\%$ load rate it only reduces the line loss of the transformer, but does not reduce the iron loss of the transformer. Therefore, it is not the most energy-efficient. Considering various factors, and considering that the transformer reserves appropriate margins during the service period, the load rate of the most economical and energy-saving operation of the transformer is generally between 75% and 85% [3].

3.1.4. Optimize the operation mode of the transformer. Reasonably distribute the load, choose a transformer with a capacity that is suitable for the electrical load, and make it work in a high-efficiency and low-consumption area. Transformers in the same substation should be operated in parallel as much as possible. Adjust the number of parallel-operated transformers according to the load changes.

3.2. Improve the power factor of the power supply and distribution system
The loss of line reactive power mainly depends on the power factor. Increasing the power factor is an effective means to reduce the loss of line reactive power, thereby reducing the loss of the power supply and distribution system and achieving energy saving. In the specific engineering design, corresponding measures need to be taken according to different situations: if the conditions permit, the designer should increase the power factor of the electrical equipment as much as possible. Appropriate capacitors can also be used for reactive power compensation. Through the capacitors, the circuit can improve the power factor and at the same time reduce the overall reactive current; for specific circuits, decentralized on-site compensation and centralized compensation of high and low voltage cabinets can also be used in the way [4].

3.3. Energy-saving design of lighting system
The lighting system must first consider the choice of lighting source, and the lighting source is divided into the following elements: light effect, colour temperature, colour rendering index, light source life and price. Due to the implementation of China's energy-saving policies, some new light sources have gradually been widely used, such as LED lighting. Some new light sources have partially replaced the position of incandescent lamps, such as compact fluorescent lamps. Although the initial investment is
slightly higher, from the analysis of lamp life and energy consumption, the comprehensive benefit is much better than incandescent lamps. In the practical application of the project, the light source should be determined according to the place of use, the quantity and quality of lighting, and the nature of the project. Reasonable selection of lighting control methods also plays an important role in energy saving of lighting systems. The existing traditional lighting control system mainly includes single lamp control, sound control, multiple lamp control and dual control switch control; intelligent lighting control methods mainly include building bus control, automatic control system control and detector control. How to choose the lighting control method needs to be analysed according to the actual situation, to meet the convenience and energy saving effect. Figure 3 shows the energy-saving design of the lighting system.

Figure 3. Energy-saving design of lighting system

4. Example analysis

4.1. Overview
The building area of the sports competition hall is 16 158 m², with 6000 seats, which is a medium-sized building of Class B. The sports competition hall has 4 floors: on the first floor, there are spectator rooms, athlete rooms, competition management rooms, news media rooms, etc.; on the second and third floors, ticket offices, air-conditioning rooms, toilets, etc. are set; , Broadcast machine room, lighting control room, air-conditioning machine room [5].

4.2. Load class
According to the provisions of JGJ 31-2003 "Code for Design of Sports Buildings" (see Table 1 and Table 2), the project belongs to the Class B medium-sized gymnasium building and is a Class II building. The power for fire-fighting equipment, emergency lighting, substation power supply, data room, timing and scoring device, broadcasting room, TV relay and news camera should be designed according to the second load, and the rest of the equipment should be designed according to the third load.

Table 1. Classification of stadium sizes

| Classification | Auditorium capacity / seat |
|----------------|---------------------------|
| Extra large    | 10000 or more             |
| Large          | 6000-10000                |
| Medium         | 3000-6000                 |
| Small          | Below 3000                |
Table 2. Sports building levels

| Grade   | Main requirements                                                      |
|---------|----------------------------------------------------------------------|
| Premium | Host the Asian Games, Olympic Games and world-class home games       |
| Class A | Host national and individual international competitions               |
| Class B | Hold regional and national individual competitions                   |
| Grade C | Organize local and mass games                                       |

The project introduces two 10 kV power sources to supply power simultaneously. When either circuit fails or the transformer is overhauled, the other power source can bear 100% of the secondary load. For safety precautions, fire control, and competition power, such as timing and scoring, data processing, and television broadcasting, UPS or EPS should not be used as the third power source except for dual-power automatic power supply at the end. The emergency lamps and evacuation instructions are equipped with secondary batteries as the third power source except for dual power supply [6].

4.3. Energy saving
(1) The substation is located on the ground floor of the sports centre, adjacent to the main power load freezer room, and only 30m away from the sports arena, effectively reducing voltage loss and improving the reliability of power supply. (2) The transformer is an energy-saving dry-type transformer. After reactive power compensation, the power factor is 0.95. (3) The transformer winding wiring adopts D, yn11 mode, which makes the 3pth harmonic current close to flow on the high voltage side, which can effectively reduce the higher harmonic current. (4) There are multiple 22kW inverter units in the air conditioning system, which will generate a lot of harmonics. In order to effectively suppress the harm of harmonics to the power grid, the distribution lines of inverter air conditioners are laid through metal pipes, and the distribution cabinets use reactive power compensation capacitors with harmonic elimination functions. (5) Considering the impact of the starting of a large-capacity motor on the transformer, the power sources of the two large heat pumps are taken from different transformers. (6) The design illuminance value and power density value of each functional room should be set strictly in accordance with the relevant provisions of "Architectural Lighting Design Standard". (7) All kinds of fluorescent lamps are equipped with electronic ballasts, single lamp power factor ≥ 0.9.

5. Conclusion
Green environmental protection and energy saving is the development direction of society. With the improvement of people’s material and cultural level, people’s awareness of environmental protection and energy saving is increasing, and the state’s requirements for green energy conservation in the construction industry are becoming more and more strict. The application of new green energy-saving technologies in building construction has enabled the industry to develop rapidly and with high quality.

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