New solar heating system based on graded heat conduction

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Abstract: Building a low-carbon society and developing a low-carbon economy have become the new goals of current development. In China, the energy consumption of buildings, industrial energy consumption, and transportation energy consumption constitutes three major energy consumptions. This project proposes a new type of solar heating device, which uses high-efficiency, fast heat-dissipating, and thermally stable heat-conducting oil instead of water in a traditional heating device as the heat-conducting medium, and designs a new type of solar-heating system based on oil-water grading heat conduction.

1. Introduction

At present, the total energy consumption of buildings in China accounts for about 20.7% of the end energy consumption of society, of which heating energy consumption in northern towns accounts for 36% of the total energy consumption of buildings in the country, which is the largest component of building energy consumption. In the towns of the Three North Regions, the current proportion of heating to household stoves is about 75%, and their thermal efficiency is generally only 15% -25%. In large and medium cities, decentralized boiler rooms account for a large proportion. It accounts for about 84%, which indicates that China's current heating efficiency is very low, coal consumption is large, and the environmental impact and damage are large. At the same time, the conditions of solar energy resources in the north of China are very rich, which is suitable for the promotion of solar heating and heating systems, and can obtain better economic and social benefits [1].

Figure 1. The current application of solar energy in residential heating systems

Among the three main ways of using solar energy, solar thermal utilization is the most widely used and the most diverse. The research content of this project is a new type of solar heating system based on oil-water staged heat collection mode applied in buildings [2].
2. Design of a new type of solar heating system with oil-water classification and heat conduction

2.1. Disadvantages of solar-heated hot water heating systems
As an important clean energy, solar energy plays an increasingly prominent role in controlling pollution, reducing haze, changing the energy structure, and promoting ecological civilization, especially in northern China. The use of solar heating and heating can not only optimize the industrial structure, but also greatly reduce the emission of harmful substances. It is of great significance to reduce smog pollution and achieve energy conservation and emission reduction. However, the hot water heating system using solar heating in northern cities and towns of China mainly has the following problems:

① The traditional solar heat collection system using water as the heat collection medium has a low utilization rate of solar energy;
② Water in the heat-conducting medium is easy to evaporate, it is easy to freeze and block, and it is easy to scale to block the vacuum tube;
③ Prone to leakage and pipeline corrosion;
④ The circulation pipeline is complicated and the system stability is poor.

2.2. Advantages of new solar heating devices
This project proposes a new type of solar heating device, which uses high-efficiency, fast heat-dissipating, and thermally stable heat-conducting oil instead of water in the traditional heating device as the heat-conducting medium. Compared with the existing solar heating equipment, the advantages of this new structure device are as follows:

① The heat transfer medium is innovatively selected from silicone oil type heat transfer oil with high heat transfer efficiency, fast heat dissipation and strong thermal stability. The solar heat collection system using heat transfer oil as the heat transfer medium has greatly improved the utilization efficiency of solar energy and reduced dependence on fossil energy, and reduce environmental pollution.
② design heat storage system, water as heat storage medium, the storage system of the heat collecting heat under conditions of good light environment; and installation of auxiliary heat temperature control system based on intelligent modern control theory, rainy weather and at night to ensure the user Heating.
③ The program based on the original equipment on the further improved embodiment of the solar collector through the new fractionated oil - energy conversion efficiency, and, since water collector hierarchy, the existing indoor water as the heat transfer medium substantially constant heating facilities, transformation of low cost, can promote the use of large area.
④ HTF high boiling point, low freezing point and excellent stability characteristics, to ensure the stable operation of the system. At the same time, its high flash point and lower the pressure on the line and so has provided a guarantee for the security of the system.

Based on the above, the present research project thermally conductive grade water new solar heating system may facilitate a variety of low-carbon-based heat source or a heat source in combination with zero carbon upgrade, used in the field is expected to replace the existing north heating carbon source. Compared with conventional heating methods, energy saving effect of the present apparatus is more apparent [3].

3. Structural design and performance analysis
This project is mainly composed of three subsystems, namely the solar heat collection system, the oil-water heat exchange temperature control system, and the closed pipeline circulation system. The application of solar energy in the heating system was realized through the design of the above systems.

1) Solar heat collection system: This system uses solar energy as the heat source, and through the use of parabolic trough design, solar tracking technology, new heat collection tubes and the
application of heat transfer oil self-circulation technology, the maximum utilization of solar energy in the existing technology is realized.

2) Oil-water heat exchange temperature control system: This system takes oil-water heat exchanger as the main body, and adds auxiliary heating devices and energy storage boxes to ensure the stability of heating. The oil-water heat exchanger uses the tube-and-tube heat exchange method to maximize the heat exchange efficiency, and the auxiliary heating device is combined with the energy storage box to ensure the temperature controllability.

3) Closed pipeline circulation system: This system controls the circulation of heat transfer oil and water respectively to reduce the heat loss during the transmission process and achieve the effect of improving energy utilization. The working fluid pump provides power for the circulation and optimizes the piping structure to achieve the adaptive circulation of the heat conducting medium, thereby ensuring the stable operation of the system [4].

4. Design of each subsystem

(1) Collecting tube design

Completed the design of heat collecting tube structure and material. Analyze the effect of different types of collector tubes on the light-to-heat conversion efficiency and the advantages and disadvantages under different working conditions. With reference to the structure of related collector tubes at home and abroad, determine the type of collector tubes. After the three-dimensional model is established, the thermal conversion performance of the model is analyzed using Matlab software, and the structure is optimized. The design of the structure of the heat collecting tube in this device needs to adapt to the special working environment in the north and improve the light-to-heat conversion efficiency. Therefore, we have designed this all-glass vacuum heat collecting tube correspondingly, and fully consider the frost resistance and the time of exposure during the design. Factors of thermal deviation [5].

The all-glass vacuum heat collecting tube consists of a stainless steel heat-absorbing tube, a glass sleeve, a degassing ring and a corrugated tube. The outer surface of the metal tube is plated with a selective metal-ceramic coating with high absorption and low emissivity for the solar spectrum. The glass sleeve is made of heat-resistant glass, and a vacuum is drawn between the inner and outer tubes, so that the vacuum between the two tubes is 0.05Pa, which ensures the working life in the northern environment and effectively reduces the heat loss caused by convection [6].

(2) Design of parabolic trough reflector

First, a preliminary scheme design of the parabolic trough reflector is carried out according to the needs of conversion efficiency, including a parabolic reflector, a vacuum absorption tube, a supporting structure, a connecting tube, and a fuel tank. On this basis, parabolic reflectors and related equipment with similar parameters are purchased for modification and experimental verification, mainly including the geometric characteristics of paraboloids, deflection angles, and reflection materials. Among them, the transformation of the geometric features of paraboloids is the research content of the next substructure.

Figure 2. Schematic diagram of parabolic trough reflector
A parabolic trough reflector is used. The focal line of the parabola and the axis of the heat collecting tube are on the same straight line. When the parallel beams emitted by the sun are affected by the reflector, they are concentrated on the heat collecting tube to achieve the maximum utilization efficiency of solar energy.

(3) Design of collector circulation system

The design of the circulation system of this project includes the following two aspects:

① The natural circulation system works by the density difference caused by the temperature difference of the heat transfer medium. Use oil temperature monitoring, including superheated plus cold oil and supercooled plus auxiliary heat to ensure stable hot oil temperature;

② The mechanical circulation system relies on the mechanical power of the circulating oil pump to force the oil to circulate in the collector. During specific operation, the two meet different working conditions.

5. Expected economic benefits and promotional value

The heating system designed by this project is a new type of heating system with solar energy as the heating source and heat transfer oil and water as the heat transfer medium. The heating system in northern cities and towns is the main research object. The expected economic benefits and promotion value are summarized as follows:

① The water circulation part of the new heating system can directly use the original pipes. When installing this system, the residents do not need to remove or change the indoor heating system that has been installed. They only need to install this system on the basis of the original structure. Low installation cost and high feasibility.

② The heat transfer oil does not corrode the original equipment, it is not easy to be oxidized in contact with air at normal temperature, and the service life can be up to several decades under the sealed condition, which greatly improves the utilization rate of system equipment and reduces the economic pressure caused by frequent replacement of equipment.

③ The heat transfer oil is suitable for different temperature ranges, and has the characteristics of low cost, low pollution, low toxicity, high heat transfer coefficient, and low operating pressure, which is convenient for market development of the heating system.

④ The heat transfer oil system does not require a lot of water treatment equipment, low maintenance costs, simple system and convenient transportation. Compared with most water heating systems using steam in the north, it is more economical and convenient, and is easy to be accepted by residents.

6. Conclusion

This project designed a new type of heating system with solar energy as the heating source and heat-conducting oil and water as the heat-conducting medium. The heating system in northern cities and towns is the main research object. The heat-conducting medium uses a silicone oil-type heat-conducting oil with high heat transfer efficiency, fast heat dissipation, and strong thermal stability. The solar heat-collection system using heat-conducting oil as the heat-conducting medium has greatly improved the utilization efficiency of solar energy and reduced the dependence on fossil energy.

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