

Experiment of Active Solar Heating System and Running Analysis

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Abstract: The active solar heating system is composed of solar energy collector system and supplementary electricity heater. The system is used to satisfy the heating and domestic hot water demands. Basing to design, construction, test and economic analysis of a demonstration project with the solar heating system, this paper discusses how to connect the solar energy collector with the electricity heater and heating system, so that affirms the best state of comfort and energy saving. The real cost of running is calculated and compared with that of other heating methods. The traits and the scope of application of the solar heating system and the problems in designing, installing and operating are indicated in this paper, at last.

Keywords: regenerative energy, solar heating system, energy-saving

1. INTRODUCTION

Solar energy is an important renewable energy and abundant in China. Fully utilizing solar energy could reduce emission of greenhouse gas and protect environment. The solar utilization would not only benefit us now, but also be meritorious for the future. Therefore, developing solar energy application is strategically important. With the improvement of accommodation conditions and sanitary habit, the portion of the energy consumed on bath water in total energy consumption has increased significantly, so the wide application of solar water heater could play a critical role for environmental protection.

2. METHODS

This project applies solar energy in heating system. The demo project, which has about 30 m² construction areas, is located at Beijing. The general situations of the demonstration project are below.

- (1) Solar energy collector system and heating system are devised independently. The heat medium in solar energy collector system is antifreeze. The heat medium in heating system is water. Both two systems have a heat-exchanger unit made of copper pipe to exchange quantity of heat with the thermal storage material. Pump is necessary to provide driving force in two systems.
- (2) The obliquity of the solar energy collector is 35°.
- (3) The thermal storage tank is used in exchanging heat and saving up the extra quantity of heat. The cubage of the tank is 200 liters.
- (4) Heating mode is floor-radiate heating system.
- (5) The supplementary heat source is electricity heater.
- (6) The area of demonstration project is about 30 m² construction areas; the cost of demo project is RMB15000.

This system heats circulating water by solar

energy collector and use it for heating. Supplementary electric heater is equipped to guarantee the operation in all kinds of weather conditions. The scheme of system is showed in Fig. 1. The systems are showed in Fig. 2 and Fig.3

When the sunshine is sufficient, solar energy collector as the main energy source undertakes the whole heat load of the building. During the time of night and less sunshine, electric heater starts, as supplementary heat source, to provide heating. By heating up water in the tank with low price electricity at midnight and using it in low sunshine conditions, the operating cost could be reduced greatly.

3. RUNNING ANALYSIS

The operating method of the system is separated into two situations. When temperature of heat medium in solar energy collector system exit is between 45°C and 60°C, pump begins to work and the system begins to collect quantity of heat. In other situations, solar energy collector system does not work. According to if the temperature of medium in thermal storage tank is between 35°C and 40°C, supplementary electricity heater is commanded to work or not. The room-temperature is kept between 14°C and 16°C. All manipulations mentioned above are controlled automatically.

The system was installed (the system is showed in Fig. 2 and Fig.3) and put in commissioning on Jan. 2005. Test result (from Mar. 3rd to Mar. 6th, 2005) is showed in Fig.4. Power consumption and operating cost is showed in Tab.1. According to the situation in Beijing, power rate is 0.44 ¥/kWh, but from 23:00 to 7:00 between Nov. 1st and Mar. 31st, the power rate is 0.20 ¥/kWh. In the period of operating, mean room-temperature is 15.2°C, mean outdoor temperature is -1.3°C. The designed room-temperature is 16°C; the designed outdoor temperature is -4.5°C.

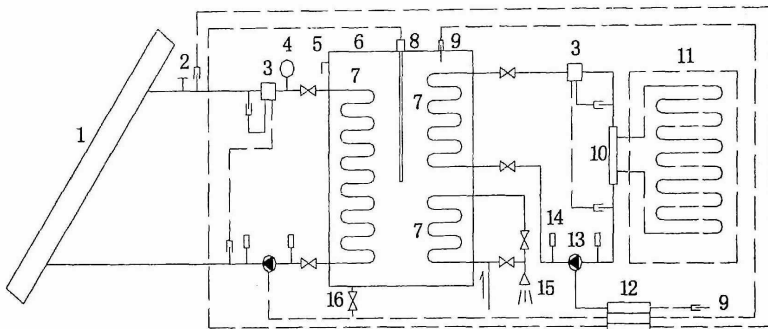


Figure 1: The sketch map of solar energy integration utilization system

1—solar energy collector; 2—entrance of antifreeze; 3—thermal meter; 4—expansion tank; 5—vent-pipe; 6—thermal storage tank; 7—heat exchanger; 8—electric heater; 9—temperature sense; 10—distributor of medium; 11—low-temperature hot water floor radiant heating systems; 12—control center; 13—circulating pump; 14—pressure gauge; 15—hot water; 16—discharge-valve



Figure 2: Indoor system



Figure 3: Solar energy collector system

Table 1: Power consumption and operating cost of the system of Mar.3~6

time	Max./min. room temperature/°C	Max./min. outdoor temperature/°C	Amount of normal electricity/ kWh	Amount of lower price electricity/kWh	Operating cost/ ¥/(m ² ·d) ⁻¹
Mar. 3 rd 9:00 to Mar. 4 th 8:30	15.18/13.35	4.8/-3.5	12.5	10.1	0.24
Mar. 4 th 9:00 to Mar. 5 th 8:30	16.93/14.06	3/-3.5	14.1	9.8	0.26
Mar. 5 th 9:00 to Mar. 6 th 8:30	17.64/14.93	10.5/-0.8	13.0	10.3	0.24

Explain: Power consumption is composed of three parts. They are the amount which is consumed by supplementary electricity heater, circulating pump, computer and lamp and so on.

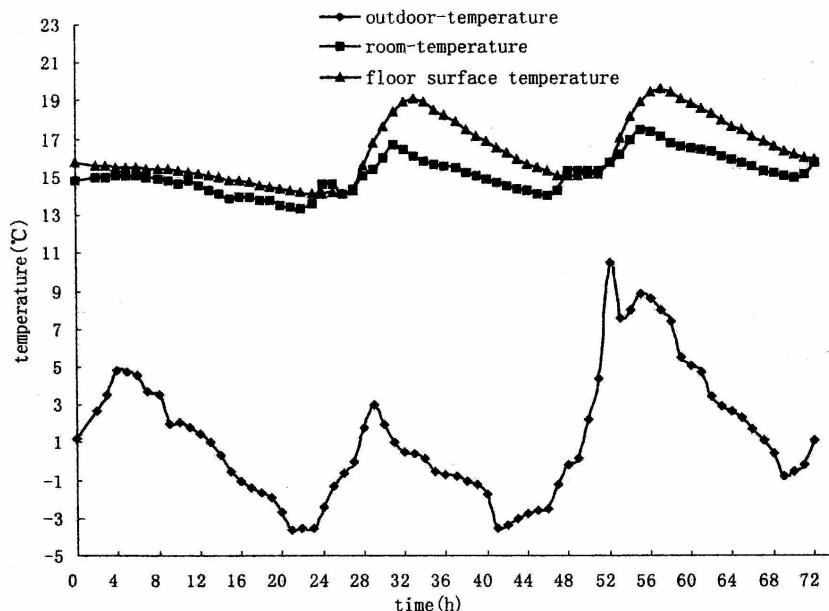


Figure 4: Experimental result of March.3~6

The heating period in Beijing is from Nov. 15th to Mar. 15th. It is well known that outdoor temperature is not very low and the heating load is less in the prophase and anaphase of heating period. So the solar energy collector system can collect enough quantity of heat for heating. Because of thermal inert, room can be kept warm without supplementary electricity heater in the night. The operating cost can be decreased greatly. This characteristic has been validated in the experiment.

The average operating cost is 0.25 ¥/(m² d) as the active solar heating system working normally. If

supplementary electricity heater does not work, the corresponding cost is 0.05 ¥/(m² d) (just pump consumes electricity). On the assumption that two above methods of operation work 61 days respectively a year, the operating cost of heating system is about 18.30 ¥/(m² a).

Table 2 shows the cost of building and running of several different heating methods, including district heating, household gas-fired boiler heating system, household electricity radiator and solar energy heating system.

Table 2: Cost comparison of several different heating methods

Heating method	District heating	Household gas-fired boiler	Household electric radiator	Solar Energy Heating System
Cost of building (¥/m ²)	50	110	40	400
Cost of running (¥/a)	735	1941.76	1753.6	585.6
Cost of every entire and year (¥/m ² ·a)	23	60.68	54.8	18.3

Explain: 1. Operating cost includes the cost of electricity for pump. 2. The price of gas is 1.4 ¥/W³. 3. The power rate is 0.45 ¥/(kWh).

We can draw a conclusion basing on the above analysis. Although the cost of running is more than that of district heating, the cost is less than the other two. The cost of building of solar energy heating system is the most expensive, but it uses solar energy mainly, so it can save a lot of fossil fuels, at the same time it can reduce emission of greenhouse gas. Not only the solar energy heating system works well, but also it can protect environment. The other excellence of the system is economic.

4. CONCLUSION

We can draw a conclusion that the active solar energy heating system in our experiment can be used all right. The performance is good, and the cost is less. At the same time, it can save a lot of fossil fuels and reduce emission of greenhouse gas. Automatic control system in the heating system can decrease the operating cost greatly, saving a lot of money.

So the solar energy heating system is fit for heating in areas where there is no district heating, especially in the mountainous areas and beauty spots where the other heating methods which can pollute environment are forbidden.

5. ACKNOWLEDGEMENT

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