

Combined Operation of Solar Energy Source Heat Pump, Low-vale Electricity and Floor Radiant System

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Abstract: Today energy sources are decreasing and saving energy conservation becomes more important. Therefore, it becomes an important investigative direction how to use reproducible energy sources in the HVAC field. The feasibility and necessity of using solar energy, low-vale electricity as heat sources in a floor radiant system are analyzed. This paper presents a new heat pump system and discusses its operational modes in winter.

Key words: solar energy source heat pump(SESHP), low-vale electricity(LVE), floor radiant system, combined operation

1. INTRODUCTION

With development of our economy, energy lacks more and more badly and has lasted for several years. In order to save energy, a valid method is to find new energy. In all new energies, solar energy is one of best reproducible and green sources.

Solar energy is tremendous, reproducible and no pollution. At present energy crisis and environment pollution are considered as two social problems, it is paid more attention to use solar energy. It not only saves high-grade energy but also protects environment to use heat pump to link with solar energy device and heat storage device. At the present time, it is on experimental and investigative phase to use solar energy and provide hot water heating system^[1]. Solar energy has many advantages, but it also has many disadvantages because solar energy has quite uncertainty owing to seasons, day and night, weather influence. It

usually needs accessorial heating source to use SESHP to heat in north of our country. Feasibility and necessity of using solar energy, LVE as heat source in a floor radiant system are analysed. Presents a new heat pump system and discusses its operation modes in winter.

2.FEASIBILITY AND NECESSITY OF COMBINED OPERATION OF SESHP AND LVE

2.1 Solar Energy and LVE

Solar energy is huge and the energy which reaches earth is 50×10^{18} kJ, and the regions which receive annual sunlight's time more than 2000h are more than 2/3 areas in our country. So using solar energy in our country is favorable^[2]. The total energy that solar energy reaches earth is large, but its energy density is very low. Its most radiant intensity in tropic of cancer is about 1.1-1.2kw/m², in winter about half and in cloudy day about 1/5^[3]. The solar energy is influenced by random factors such as seasons, latitude, altitude and weather, so it has instability and uncertainty. It needs not only large area of collection of heat but also heat storage device, thus initiatory investment of device is increased and restricts solar energy to be extended and applied.

LVE is low vale load in city, its price is about half of normal price. Nowadays, the electric load in city increases quickly, the difference between peak value and low vale is large, thus it influence safe circulation of electric net, increases the cost of generate electricity and power supply, r

reduce power supply's reliability and increases the cost of using electricity. On the other hand, in spring, autumn and night, the electric device about 40% is on vacancy, thus it influences seriously safety of electric net and economic benefit of company.

Now in all heating modes, heating with electricity is one of the cleanest modes. It has many advantages in protecting environment, safe operation, convenient operation and social benefit. Its cost isn't more than that of central heating to use

LVE for heating, so in many cities such as Beijing and Tientsin it is advocated to use LVE for heating.

The cheap price of LVE usually is in 0:00-8:00, while using solar energy is little. It accords with our country energy policy and is in favor of economic and safe operation of electricity net to use LVE. It associates with solar energy to reduce heat storage device of solar energy and initiatory device cost. Thus it is propitious to be extended and applied for SESHP.

So combined operation of SESHP and LVE can make up the disadvantages to only use SESHP, avoids its intermission and uncertainty. Combined operation is a favorable mode and makes full use of each advantage, and it has good effect for building energy conservation.

2.2 Terminal System User with Floor Radiant Heating for Combined System

Hot water temperature supplied by combined system can fit floor radiant heating system and it has a few characteristics thereafter.

1) The floor radiant heating system needs low temperature water about 30-50°C and its heating ability is in 50-120w/m² [4].

2) The hot water temperature supplied by solar energy heat pump satisfies floor radiant heating.

3) The coefficient of heat pump for heating,

$$\varepsilon_k = \frac{\text{valid quantity of heat}}{\text{net input energy}}, \text{ in reverse Carnot cycle, } \varepsilon_h = \frac{T_h}{T_h - T_a}, T_h, \text{ high heat source temperature, } T_a, \text{ low heat source temperature. The coefficient of heat pump increases when temperature difference between high heat source and low heat source decreases. So in winter, Low water temperature will improve efficiency of heat pump and get good economic effect.}$$

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4) Floor radiant heating system directly makes use of SESHP for heating in early and later winter and reduces to use LVE, thus decreases energy consumption and cost.

5) Floor radiant heating system has better effect of saving energy and comfort compared with ordinary heating. It gives people to feel feet warm and head cool, thus it accords with people's physiology characteristic and improves comfort of indoor environment [5]. On the other hand, floor radiant heating system has longer life and its life is up to fifty years.

6) Divided calculation heat is easily carried out in floor radiant heating system. It is helpful to solve charge question. According to statistic, it can save energy about 20~30% that charge according to heat quantity compared charge according to area.

2.3 Government Encouraging Use of New and Reproducible Energy

In order to save energy in architecture field, government and MINISTRY OF CONSTRUCTION P.R. CHINA issue a series of laws and rules to advocate to use new and reproducible energy. In 《Energy Conservation Law of the People's Republic of China》, “government encourages to explore and use new and reproducible energy.” In 《Administration and Provisions of Energy Conservation for civil buildings》, “Applied technology and equipments of reproducible energy such as solar energy and saving energy technology and manufactures in HVAC are considered as saving energy manufactures encouraged by country.” In order to encourage industrialization's development, 《STATE ECONOMIC&TRADE COMMISSION, PRC》 issued 《The tenth five-year-layout of new and reproducible energy industrialization's development》, put forward developmental emphases on s

olar energy, and indicated “researching and empol dering combined technology about using solar en ergy、heating、air-conditioning and incorporate ar chitecture^[6]”.

So it has not only government’s promotion b ut also its advantages of saving energy effect to use solar energy. It must become an important in vestigative aspect of saving energy to use combin ed operation of SESHP, LVE and floor radiant sy stem.

3. COMBINED OPERATION OF SESHP, LVE AND FLOOR RADIANT SYSETM

3.1 System Structure

Combined operation of SESHP, LVE and flo or radiant system is made up of heat storage dev ice of solar energy、water tank of accumulation o f heat、electric heater、heat pump unit and other equipments and terminal equipment uses floor rad iant heating system. Heat storage device links wit h heat pump unit in series. The heat storage dev ice of solar energy and evaporator of heat pump form circulation in series and the heat of evapo rator comes from heat storage device of solar en ergy or water tank of accumulation of heat. This linked mode has many advantages^[7].

1)The temperature of heat storage device of solar energy is low(20-30°C),so it can make up of cheap equipment of accumulation of heat, thus not only reduces cost but also has high efficient. At the same time, it consumes smaller electricity when LVE heats up water tank.

2) Heat pump works at high vapping temperature a nd has high COP of heating.

3) Heat pump consumes a small quantity of electricity energy and upgrades the heat of heat storage device of solar energy heat to input the rooms which need heating. In same load, the area of heat storage device of solar energy and initiatory cost reduces.

4) Water tank of accumulation of heat is installed. It can store partly solar energy in day and the energy can be used in night. Thus it can provide continuously heating for heat pump unit.

Principle figure of combined system is shown as

fig1.

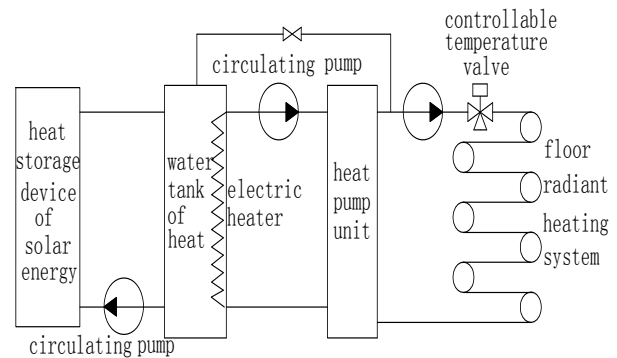


Fig.1 Principle of combined system of heating

3.2 System Circulation Flow

3.2.1 System circulation flow in early late winter

In early and late winter, it needn’t operate accessorial heater of LVE to heat up, it can satisfy the need of heating and the system directly uses solar energy for heating. Hot water of water tank directly supplies floor radiant heating system by circulating pump. Principle figure of heating in early and late winter is shown as figure2.

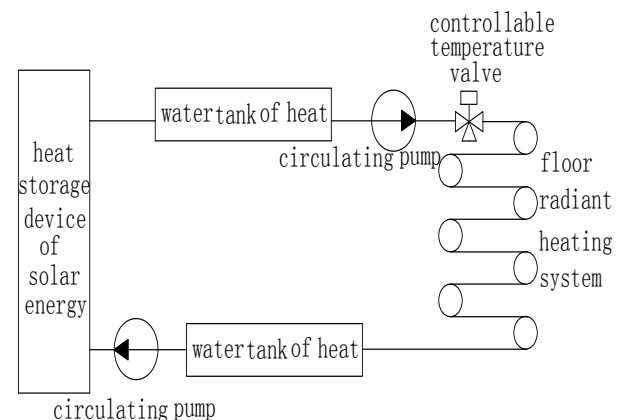


Fig.2 Principle of heating of in early and late winter

3.2.2 System circulation flow in winter

In winter heating load is large, contrarily solar radiant density is low, the heat and efficiency of heat storage device of solar energy is low, thus the heat supplied by SESHP doesn’t satisfy the heating load. So the system circulation must combine SESHP with LVE to satisfy the load of buildings. Principle figure of heating in winter is shown as figure3.

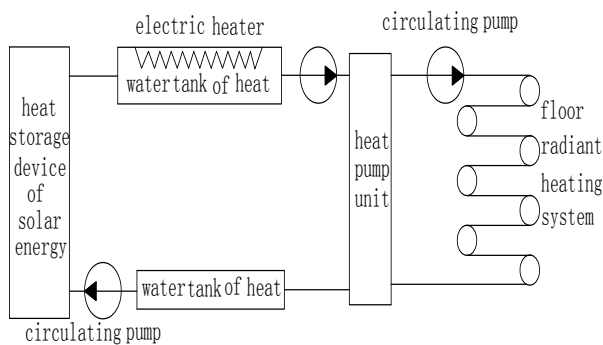


Fig.3 Principle of heating in winter

In winter, when sunlight is fine, the water absorbs solar radiant energy in heat storage device and goes into water tank of heat. Then water exchanges heat with refrigerant in evaporator of heat pump and makes heat through pump heat cycle in order to guarantee comfortable indexes kept reasonable fluctuant range such indoor temperature and average temperature of floor surface. The water which has decreases its temperature returns heat storage device of solar energy..

When heat pump unit runs in night and bad weather, heat of water tank is insufficient, the system use LVE to heat water tank and fulfill heat pump cycle. Combined system was used in buildings of Oujingyuan in Hami, solar energy and low vale electricity each has 50% load respectively, and the cost drops 43.5% compared with current fee standard^[8].

4. ADVICES AND EXPECTATIONS

1) The combined system uses new and reproducible energy and low vale electricity encouraged by government as heat source and terminal system uses floor radiant system, so it exhibits advantages of combined system completely. Thus it should be used in building of energy conservations.

2) Terminal system of floor radiant system has a good characteristic of heat storage and heat stability, indoor temperature field changes uniformly and gently. When floor radiant average temperature is guaranteed in night, it should sufficiently use heat of accumulation of floor and reduces time to use LVE.

3) It should calculate status to use solar energy and reasonably allot each load of solar energy and

LVE in combined system.

4) It should think over incorporate building of solar energy and reasonably dispose areas of heat storage device of solar energy heat in combined system. In addition, it should consider angle between heat storage device of solar energy heat and sun's radiation.

5) Initiatory investment of combined system is large and twice of traditional heating mode, but run-time cost is low, the cost drops 40% compared with central heating, and initiatory investment can take back in a few years. The combined system accords with our energy policy and has environmental benefit, so it will become an important heating mode in north.

6) In order to make combined system work well, an automatic controller should be researched. The controller can setup the water level and temperature in the water tank according to requirement. The water level, temperature and the temperature of backwater are measured and displayed in real time. The controller also has functions of below water limit warning and electricity leaking monitoring^[9].

5. CONCLUSIONS

Combined system is discussed based as our energy status and north climatic characteristic, its feasibility and necessity are analysed in north. Furthermore a new circulation mode of heat pump is given and it is proved that the combined system has energy conservations effect. It can lighten environmental and energy problems. So combined system must be extended and applied in future, moreover, this technology also needs academic reasoning and experimental research to be utilized widely.

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