

A double-use device based on bubble pump and solar energy

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Abstract. In order to solve the problem of high power consumption of traditional household air conditioning and meet the requirements of energy saving and economic operation cost, how to make full use of renewable energy and bubble pump technology has been widely concerned in the world. This device creatively combines the solar energy, the bubble pump and the air conditioning system. This device reduces the consumption of electric energy, and has obvious significance of energy saving and emission reduction.

1. Introduction

At present, most of the household air conditioners in China are made of steam compression units. Because the unit needs to consume a lot of electric energy, it will increase power consumption and noise at the same time in summer and winter [1].

In order to solve this series of problems, we designed a dual-use device for home air conditioning and hot water based on solar energy and bubble pump. The device uses solar energy and natural gas together as a driving energy source to realize the utilization of renewable energy and reduce the consumption of electrical energy. On the other hand, the device uses an optimized bubble pump instead of the compressor to reduce noise and further reduce power consumption.

2. Device design

2.1. Operation Plan

In the summer cooling season, the operating principle of the device is as follows: When the solar energy is sufficient, the natural gas heater is turned off, and the heated water of the solar collector enters the heat storage tank and continues to provide heat to the bubble pump generator, which is the bubble pump's Operation provides power. The following operation is performed in accordance with the bubble pump and lithium bromide refrigeration process described below. The condenser water and the evaporator are used to obtain the refrigerant water, and the refrigerant water enters the fan coil to provide cold air for the room. When the solar energy is insufficient, the gas heater is started and the hot water in the heat storage tank is further heated so that the temperature of the hot water reaches the use requirement. At the same time, the hot water in the heat storage tank can be used as domestic hot water for daily life.

In the winter heating season, the operating principle of the device is as follows: Close a series of devices such as a bubble pump. When the solar energy is sufficient, the gas heater is turned off, and the hot water heated by the solar collector enters the heat storage tank. After passing through the gas heater, part of it enters the fan coil to provide hot air for the room, and the other part is used as



domestic hot water. When the solar energy is insufficient, the gas heater is started and the hot water in the heat storage tank is further heated so that the temperature of the hot water reaches the use requirement.

2.2. Working principle

2.2.1. Principle and optimization of bubble pump. When the bubble pump starts to work, the heating device at the bottom of the tube starts to work, so that some of the liquid in the tube boils and evaporates. The bubble generated is mixed with the liquid to form a gas-liquid mixture with a lower density, so the buoyancy that can be generated is greater than the resistance of the liquid in the tube. The gas-liquid mixture in the pipe is raised to a certain height, and finally the liquid and gas are separated.

For the home air conditioning system, the bubble pump is optimized in this paper. On the one hand, in order to increase the liquid circulation capacity and cooling capacity and shorten the entire cycle time, the bubble pump adopts a multi-conduit structure; on the other hand, in order to reduce the flow resistance of the liquid in the tube and improve the efficiency of the bubble pump, the bubble pump tube is used. Variable section design [2].

2.2.2. The cooling process based on the bubble pump. The lithium bromide solution is used in this refrigeration process, which has no pollution to the environment and has no damage to the atmospheric ozone layer. Lithium bromide has a boiling point of 1265°C. Therefore, when a lithium bromide aqueous solution is heated at a high temperature, it is considered that only water vapor is generated. The density of the mixture of concentrated solution and steam decreases, causing pressure imbalance, so that the absorption of the mixture increases, and finally reaches the gas-liquid separator. Lithium bromide concentrate solution and water vapor are separated in the gas-liquid separator. The lithium bromide concentrate solution passes through the heat exchanger and enters the absorber. The water vapor enters the condenser to condense, and the condensed condensate enters the evaporator for cooling. Water vapor enters the absorber and is absorbed by a concentrated solution of lithium bromide from the gas-liquid separator. It becomes a dilute solution of lithium bromide, and the dilute solution flows back into the bubble pump and the refrigeration cycle is resumed [3].

3. Various parameters of the device

3.1. Design requirement

In order to better meet the general requirements of the family, the design standard of the device are as follows: in the standard cooling conditions, the outdoor side into the dry / wet bulb temperature is 37/26°C, the refrigeration capacity reached 15.7kW, inlet / outlet temperature reaches 11/7°C; in the case of standard heating, the outdoor side into the dry / wet bulb temperature is 8/6°C when the capacity is up to 17.8kW, inlet / outlet temperature is 41/45°C, and it can provide 50 degrees year-round living hot water.

3.2. Design parameters

According to the requirements of the actual situation and design, we determined the following parameters: the cold water inlet and outlet temperature is 12/7°C, inlet and outlet temperature of hot water is 100/96°C, the condensing temperature is 45°C, the condensing pressure is 9.59kPa, the 32°C is the air inlet temperature, outlet temperature of the condenser is 42°C, 35°C is the wind temperature of absorber.

Evaporator and generator adopts copper tube, the effective length of the tubes is 0.5m; the absorber and the condenser use copper pipes, it outside finned, effective length is 0.65m, the ribbed coefficient

is 20, the effective length of the tubes is 0.4m; condenser and absorber use air-cooled, the selected wind speed is 2 ~ 3m/s, the air temperature is 32 °C, the outlet temperature is 35~45°C.

The use time of solar collector is calculated according to every 7 hours, and it is used for 200 days in a total year, and the annual average sunshine intensity is 4620 MWJ/m². The efficiency of the solar collector system is about 70%, and the heat output of the collector is 23 MJ per square meter. Because the volume of custom cooling is 16.5kW. So the calculation is available, and the required collector area is 20 m². In addition, according to the literature, the effective volume of the heat storage tank is about 0.6 m³.

4. Performance analysis

The usual household hanging air-conditioner is used for heating in winter and cool in summer. It takes 60 days per winter and summer operation, averaging 8 hours per day, and saves electricity for three families to use electricity for half a month at the same time. If the promotion is carried out, the overall power saving is considerable.

The device is compared with the household wall mounted air conditioner with the same refrigerating capacity [4]. The total annual operating cost T is calculated by the next type.

$$T = A + R \quad (1)$$

R is the annual operating cost of the device. The annual cost of payment A can be expressed as:

$$A = \frac{P(1+i)^n i}{(1+i)^n - 1} \quad (2)$$

P is the initial investment of the system; n is the service life of the equipment for 10 years; i is the annual interest rate.

After analysis and comparison, it is concluded that the initial investment of bubble pump driven air conditioning is larger than that of household air conditioner, but the annual average cost is lower than that of household air conditioner, and its environmental pollution is much smaller than the other two kinds of air conditioners. Therefore, this device has a great development prospect.

5. Innovation and application prospect

This device creatively combines the solar energy, the bubble pump and the air conditioning system. From the point of view of energy saving and environmental protection, it has created an effective way for household air conditioning.

5.1. The utilization of solar energy

The energy consumption of traditional household air conditioning is great, especially in summer and winter, people need to use air conditioning to adjust the temperature. The system mainly uses solar energy as energy supply, providing power for the whole system, realizing the utilization of renewable energy and effectively reducing the consumption of electric energy.

5.2. Improvement of bubble pump

As the driving core of the whole device, the bubble pump is driven by the density difference produced by the local heating, and then it provides steam for the subsequent refrigeration process. Compared with the traditional household wall air conditioner compressor, it does not consume electrical energy and reduces the noise. In this paper, the bubble pump is optimized and its use value is improved.

5.3. *The use of auxiliary heat source*

Considering the fact that solar energy can not work normally on rainy days, the device adds auxiliary heat sources, and uses electric heating or natural gas heating to achieve environmental requirements.

5.4. *Convenience of life*

Considering the daily life, this device can provide hot water throughout the year while providing the function of refrigeration and heat making, which provides convenience for life.

6. Conclusion

We designed a dual-use device for home air conditioning and hot water based on solar energy and bubble pump. The working principle of the device is as follows: when the cooling is needed in summer, the device uses the auxiliary heat sources of solar energy or natural gas to heat the hot water in the regenerative tank, and uses this part of heat to drive the improved bubble pump. The improved bubble pump continuously conveyed steam into the gas-liquid separator, in which the steam was involved in the refrigeration cycle. When heat is needed in winter, hot air is provided by hot water in the storage tank directly. And the device can provide domestic water for one year.

References

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