A new type of self-powered external cooling shell of air conditioner

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Abstract: In recent years, with the rising demands on indoor comfort, the use of air conditioners is becoming more and more widespread. The energy consumption of air conditioners is rising, accounting for about 40% -60% of the total building energy consumption[1]. During the use of air conditioner in summer, the disordered discharge of condensate water and the excessive temperature of external machine are two major problems that need to be improved. In view of these above problems, we have designed a new type of self-powered external cooling shell of air conditioner. It includes condensate water collection subsystem, solar panel cover subsystem, energy storage subsystem, intelligent control and ultrasonic atomization subsystem. The purpose of this device is to collect the useless air conditioner condensate water and cool down the air conditioner external machine. This device can not only save water, but also enhance the effect of air conditioner refrigeration, save electric energy and enhance the service life of air conditioner.

1. Instruction
At present, the outer shell of household air conditioner only plays a role in sheltering. The traditional treatment of condensate water leads to seriously waste of water resources. According to the above background analysis, we come up with a new air conditioner heat sink enclosure. The system consists of five parts: intelligent control subsystem, condensate collection subsystem, solar panel covering subsystem, energy storage subsystem and ultrasonic atomization subsystem.

It collects the useless condensate of air conditioner, and uses ultrasonic atomization device to dissipate heat for the external air conditioner. It can also enhance the efficiency of air conditioner and refrigeration and save energy by saving water.

2. Research content
Condensate collection subsystem collects and stores the condensed water into the sink to solve the waste of water resources. At the same time, it can solve and the environment problem caused by the discharge of condensed water. The solar panel covering subsystem will collect solar energy and transform it into electrical energy for feeding the entire system. It can also alleviate the high temperature burden caused by the direct sunlight. The energy storage subsystem stores the electrical energy converted by the solar panels in order to provide a lasting power supply to the entire system. The control subsystem controls the water level sensor on the surface of the sink so that it detects whether the water level has reached a reasonable threshold. When it reaches the threshold, the atomizer start working. Ultrasonic atomization subsystem starts to atomize when the water tank to reach a reasonable water level. It was sprayed on the
air conditioner in the form of water mist for achieving external heat sink cleaning work to achieve energy-saving effect.

3. Conceptual design

3.1 Overall design scheme

It is found that the condensate collecting module can collect and dispose the air conditioner condensate water to reduce waste of condensate water through group experiments. We use the ultrasonic atomization module to atomize the condensed water atomized and spray on heat sink. This method cost low energy consumption and makes condensed water vaporize and absorb heat, has the maximum possibility to take away the heat on the heat sink. Solar panels have the characteristics of strong corrosion resistance. The use of solar panels to replace the original baffle can not only make the whole system in the state of self-supply, but also make the use of baffle longer. The energy storage subsystem stores the energy collected by the solar panels and ensures that the entire system is stable. According to the research, the installation distance between the outdoor unit and the side wall of the outdoor unit is 30cm, which is not less than 20cm. Thus the distance between the air conditioner and the wall is enough to install the whole set. The system schematic is shown in Figure 1.

3.2 Design of intelligent control subsystem

In order to actualize the automatic control, this device adopts low power consumption single chip microcomputer STM32 as the control chip. It includes temperature sensor, water level sensor, switch module to build the control system. The system block diagram is shown as in Figure 2.

Through communication with the liquid surface sensor, it can detect the level of the water level in the atomizing tank. By controlling the switch module to control the atomizer to stop working at low water level and start atomization at high water level, the best atomization effect can be achieved. At the same time, the working mode of the atomizer can be adjusted by measuring the temperature of the outer machine with the temperature sensor. The intelligent processing is realized, and the data of water level and temperature can be fed back to the end of the user to realize real-time monitoring. The system workflow diagram is shown in Figure 3.
3.3 Design of energy storage and utilization subsystem
This system uses 12V/12AH series of optical silicon energy storage battery. The output voltage of solar panel can be used to charge the battery directly. The energy stored in the battery is used to supply various modules, but the atomizer power supply voltage is 24V. Therefore, the boost module is needed for voltage conversion. The boost module is built by TI's current mode PWM controller UC3843A as the core, and the schematic diagram of the circuit is shown in Figure 4. According to the features of the UC3843 control chip and the Boost topology, a current controlled Boost converter is designed. By external feedback, the resistor is configured to determine the boost voltage and the maximum current. The battery voltage of 12V is raised to the working voltage of 24V nebulizer. The module has current limiting protection, undervoltage protection and anti reverse connection, which can be used safely for the nebulizer. The material object is shown in Figure 5.

3.4 Design of ultrasonic atomizing subsystem
The ultrasonic nebulizer module is placed in the condensate tank, mainly including the power transformer and the vibration circuit. The power module mainly realizes the boost of the battery voltage, and increases the output voltage of the 12V battery to the 24V voltage of the atomizer working normally. The oscillating circuit starts to work when the water level of the sink reaches the working water level of the atomizer. Oscillatory transmission to the surface of the piezoelectric ceramic oscillator, piezoelectric ceramic oscillator will produce axial mechanical resonance changes and transmitted to its contact with the liquid. Thus the surface of the liquid produce a bulge in its surface to produce a finite amplitude of surface tension waves. The wavefront of tension wave fly scattered, the liquid atomized into 1 ~ 5μm ultrafine particles, while producing large amounts of negative ions, purify the surrounding air. The amount of atomization of the ultrasonic nebulizer designed in this design matches the condensing amount of water produced by the air conditioner.

4. Feasibility Analysis
4.1 Power analysis
The rated working voltage of STM32 is 3.3V. This project adopts normal working mode (all peripherals in working state), and current 36mA. It can control main MCU to peripheral valves such as solenoid valves, and its power consumption is 118.8mW. The power of each ceramic vibrator is 19W at rated operating voltage. The system uses 4 ceramic vibrators to work together, and the maximum power is no more than 76W. The rated working voltage of the LCD display screen is 3.3V. The full screen display
current is about 20mA. The power consumption is about 60mW when the normal full screen display is displayed. The system adopts ultra low power temperature sensor, water level sensor and WiFi module with total power of no more than 0.5W. Combined with the above analysis, the maximum energy consumption of the system is no more than 77W, which is analyzed by the above energy module and power module. The output power of solar panels and solar cells that are absorbed by solar panels is enough for the power supply of the system.

4.2 Calculation and analysis of condensate water

From the air conditioner principle, if the temperature is lower than the dew point temperature of the air, the water vapor in the air will be condensed into condensate. The surface temperature of all normal working air conditioner evaporators is lower than the dew point temperature of the air. When the air flows through the surface of the air conditioner evaporator or fan coil, because the surface temperature of the air is lower than the dew point temperature of the air, the vapor condenses into distilled water[3]. Figure 6 is the enthalpy humidity diagram of air treatment process. The fresh air W is mixed with indoor air N. After mixing, the state is C, the air conditioner evaporator or fan coil pipe is cooled to the dew point L of the machine. The water vapor in the air is condensed into water, and the dew point air comes out from the air outlet to enter the indoor area.

\[ W = \rho G (d_C - d_L) \]

Calculation: \( W = 1.788 \text{kg/h} \)

If you press the climate in Wuhan, air conditioners run at least 180 days a year, calculated according to 8 hours a day, one year can produce 2574.72kg of condensate. This shows that the amount of air conditioner condensate is very impressive.

4.3 Calculation and analysis of energy

The average temperature of the exportation of the condensate of air conditioner is 23.6097 degrees Celsius by actual measurement, and the average temperature of the effluent of the atomized condensate after the radiator is 21.354 degrees Celsius. Heat dissipation by condensation water is calculated according to the calculation of lower heat: \( Q = MC_w(t_w2-t_w1) \)
The amount of condensed water per hour of air conditioner is 1.788kg/h

Specific heat capacity of water is 4186.8J/(kg.℃)

Outlet temperature of condensate after heat dissipation is 23.61℃

The temperature of Condensate water flowing down the water pipe is 21.35℃

1 air-conditioners theoretically condensed water takes 4.70W of the heat per hour

\[
Q = \frac{1.788 \times 4186.8 \times 2.26}{3600} = 4.70W
\]

From the actual measurement data we can obtain the experimental data as shown in the following table 1

| The air conditioner unit of starting atomizer | The air conditioner unit of not starting atomizer |
|---------------------------------------------|-----------------------------------------------|
| **Weather conditions**                      | **Weather conditions**                        |
| Sunny and cloudy                            | Sunny and cloudy                              |
| **Outdoor temperature**                     | **Outdoor temperature**                       |
| 33℃~35℃                                    | 33℃~35℃                                      |
| **Temperature of Corresponding maching room** | **Temperature of Corresponding maching room** |
| 25.4℃                                       | 25.4℃                                         |
| **Working time of 4kW air blower**          | **Working time of 4 kW air blower**           |
| 10h                                          | 10h                                           |
| **Working time of 19.2kW compressor**       | **Working time of 19.2kW compressor**         |
| 6h14min                                      | 7h48min                                       |

The results show that under the same climate and physical environment, the atomization water cooling can increase the maximum energy efficiency of refrigeration by nearly 20% compared with that without atomizing water. After the cooling of condensate is used to reduce indoor temperature, the running time of air conditioner decreases, and the input power of air conditioner with ultrasonic nebulizer is lower than that of air conditioner prototype. Through the relevant information query\(^4\), we can calculate the saved energy according to the working hours saved by the compressor. This shows that the cooling condenser can reduce the power consumption of the air conditioner after the atomization of condensate water, and it is a feasible measure for energy saving.

At present, the efficiency of air conditioner in our country is very high. The quantity of air conditioner is increased. The effect of energy saving is obvious, and its application prospect is very wide.

5. Conclusion

The new type of self-powered external cooling shell of air conditioner is aimed at the disorderly emission of the condensed water and the poor heat dissipation effect of the external air conditioner. Taking recovery of condensate water and protection of external machine as targets, we designed this new type of external cooling shell of air-conditioner for most of the air conditioner. Adopting theoretical calculation and test methods for analyzing its energy saving effect. In terms of the environment, the air conditioner shell collects the condensate water to avoid the waste of water resources. In terms of family, condensate water is used to assist heat dissipation to save household electricity. The recycling and utilization of air conditioner condensate is the response to Chinese policy of energy conservation, emission reduction, low carbon and environmental protection\(^5\).

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