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A design manual of an intelligent high-pressure sterilizing water equipment dedicated to the safety of animal drinking water

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Abstract

In modern society, the living environment of stray animals is constantly compressed, and the healthy water source is constantly reduced, which seriously endangers the health of small animals. At present, most of the water feeders on the market are household equipment, which have large energy loss and cannot meet the requirements of long-term work. Intelligent high-pressure water disinfection equipment aims to provide a safe and clean outdoor mobile water source for small animals. The equipment ensures water quality through dry and wet condensation water and high-pressure sterilization; photovoltaic power generation and energy storage technology achieve self-sufficiency in energy; and mobile phone APP can remotely monitor the indicators of intelligent high-pressure sterilizing water production equipment. Through photovoltaic power generation, intelligent water production, HVEF disinfection and remote monitoring technology, to ensure the safety of outdoor drinking water for small animals, and make a contribution to the public welfare cause of animal protection in China.

Keywords

High voltage electric field disinfection, drinking water safety, dry and wet combined with condensing water, photovoltaic energy storage, public welfare.

1. Introduction

The intelligent high-pressure disinfection water production equipment applies HVEF disinfection technology to animal drinking water safety. The equipment integrates HVEF disinfection, dry and wet combined water production, MPPT maximum power point tracking, cloud remote monitoring and other functions, realizing the four-in-one intelligent unsupervised water production of "energy supply, water production, disinfection and monitoring". The whole system adopts the integration of water production and elimination, the water vapor adsorption through the surface pressure difference of the new desiccant, the solar heating desiccant releases the water vapor, and then the secondary condensation filtration of the evaporated condensate water in the reheater. Then, the microcontroller controls the reverse excitation circuit to output pulsating DC, and then the high voltage boost and high voltage electrostatic field is used to eliminate the condensate water, so as to realize the integration of water production and elimination, and solve the problem of drinking water safety for small animals. The microcontrol processor of the system processes the data information collected by the sensor of the device, transmits it to the cloud data terminal using the communication module, and then visualized the information collected through the cloud computer to realize cloud monitoring and intelligent display.

2. Development background and significance

With the acceleration of the urbanization process, the living environment suitable for stray animals in the city is constantly compressed. In addition to rain, "wet food" in the trash can and

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domestic sewage, it is difficult for small animals to find other water, which seriously endangers the health of small animals. Therefore, the problem of drinking water for small and medium-sized animals in cities needs to be solved urgently. At present, most of the market users to solve the drinking water problem for animals are household pet water feeders, which often need long-term work and cause a lot of energy loss. The emergence of this equipment not only solves the problem of small wild animals living in human society, but also can meet the water demand of family pets when it is used in public places such as parks and communities. In addition, the equipment adopts the self-sufficient energy supply of photovoltaic power generation to realize the utilization of renewable solar energy, and the recycling of water resources reduces the demand for natural water resources and greatly saves energy and manpower consumption. To sum up, in order to provide a high quality water for small animals, intelligent high pressure disinfection equipment came into being.

3. Current situation at home and abroad

In some developed countries; there are also animal shelters established by private or welfare organizations. These organizations or institutions play a vital role in the protection and shelter of animals. However, in China, the abandonment of animals leads to stray animals and fewer animal protection organizations shows that the current situation of stray animal protection in China is not optimistic at present. In other words, the concept of animal protection in China has not yet formed a certain scale, and we still need to make corresponding efforts in this regard. Intelligent high-pressure water disinfection equipment uses renewable energy, and can achieve self-sufficiency, with less funds and energy investment in the later stage.

4. Feasibility analysis

4.1. Energy supply

The cooling fans, various sensors and high-voltage static field generation equipment used in this equipment are powered by low-voltage power supply. Photovoltaic power generation and energy storage technology is the ideal choice. At the same time, set the battery to store too much energy. Select energy from the nature to meet the power supply conditions of the system, clean and low-carbon, safe, efficient and pollution-free.

4.2. Water production conditions

The atmosphere is rich in water resources, about 98% of which water remains vapor. Even in the Sahara desert area, where the average annual air temperature is 30℃ and the average humidity is 25%, there is 8 grams of water per cubic meter of air. Therefore, it seems that the air has the water vapor conditions to extract water and realize the utilization of renewable energy, which is in line with the original intention of water conservation.

4.3. Safe drinking water

Dry and wet combined with condensation water technology is a new type of pollution-free and low energy consumption water production. It greatly reduces the content of impurities and harmful substances in the initial water source from the source through the method of capturing water molecules in the air from the source. The water produced is filtered and stored in the water tank and regularly uses the high pressure static electricity field for sterilization. Finally, the water supplied to small animals fully meets the physical and chemical indicators of the national drinking water standards stipulated by livestock and poultry, ensuring the safety of drinking water for small animals.

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5. Block diagram of the system structure

The system combines photovoltaic power generation and energy storage technology, the system uses dry and wet condensing water, and the high voltage electrostatic field elimination, to provide drinking water service for small animals. This equipment only needs the initial equipment input, and no follow-up management.

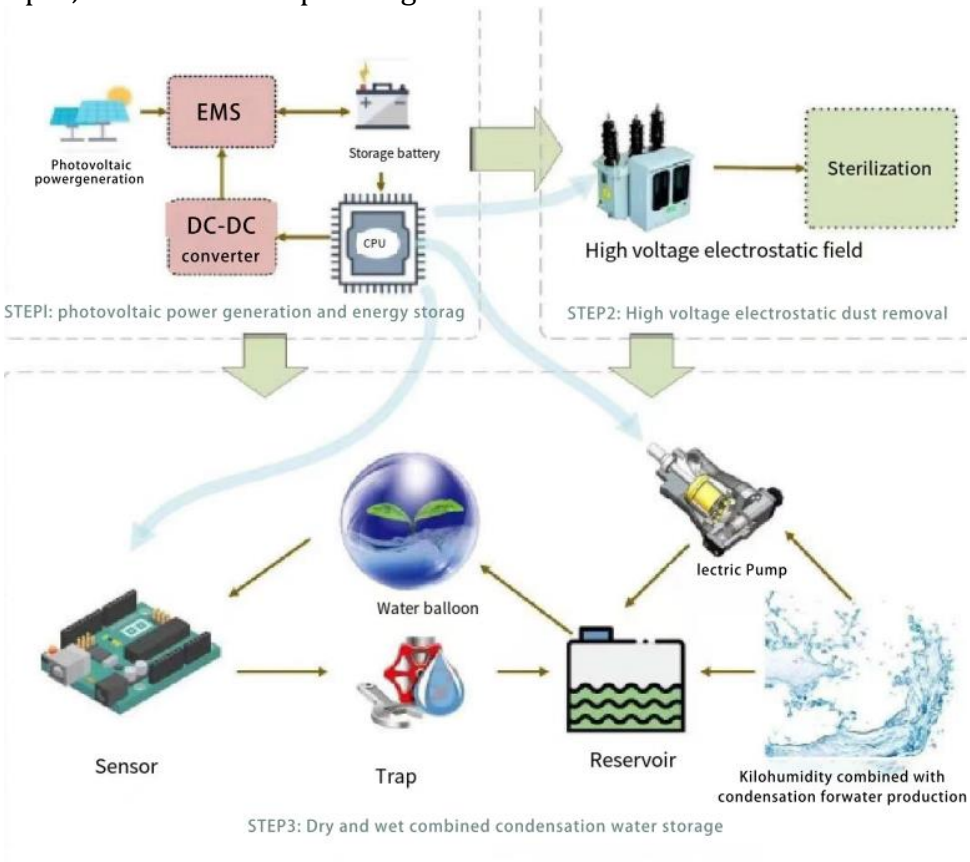

Fig. 1 System structure block diagram

6. Model design and principle

The equipment combines photovoltaic power generation and energy storage technology, dry and wet combined with condensation water technology, high voltage static field disinfection technology, and provides a safe, efficient and convenient water source for small animals.

6.1. Equipment appearance

The height of the intelligent high-pressure water sterilizing equipment is set to 40cm, and the height of the water feeder is set to 20cm and 30cm to ensure the normal drinking water of small animals. Flexible solar panels are laid on the cutting surface of the stump to improve the power generation and ensure the normal work of the system. In order to attract small animals and integrate with nature, the equipment, after certain bionic consideration, the overall structure and color matching adopts the stump style.

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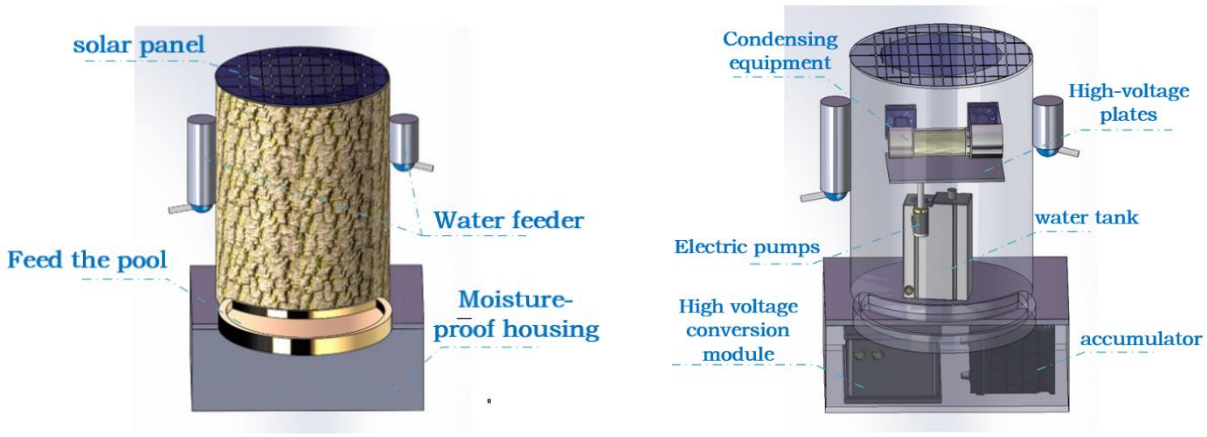

Fig. 2 Internal and external structure diagram of the equipment

6.2. Internal module composition

Considering the use environment of the equipment, the team buried the battery, high voltage generating equipment, high voltage conversion module and all circuit modules at the bottom of the equipment and conducts moisture-proof treatment. The high pressure control module can sterilize and provide safety guarantee for drinking water for small animals. The middle and upper layers include the dry and wet combined condensing water system, with air introduction, refrigeration, condensation, desiccant module and water collecting chamber. By optimizing the structure, the water intake is effectively increased; use the water pump into the water collecting chamber, make it slowly drop into the water connector below, make full use of the water source and reduce the waste of water resources.

7. System principle

7.1. Solar power generation and maximum power output

Under light, the solar panels produce a potential difference that is converted into electricity, called the photovoltaic effect. The equipment will be used outdoors, and the light conditions will change, affecting the power of the solar panels. To maintain the maximum power output, the maximum power point tracking technology (MPPT) is used. The system uses the Boost DC converter to adjust the circuit, match the impedance, track the best power point, and optimize the output power of the solar cell.

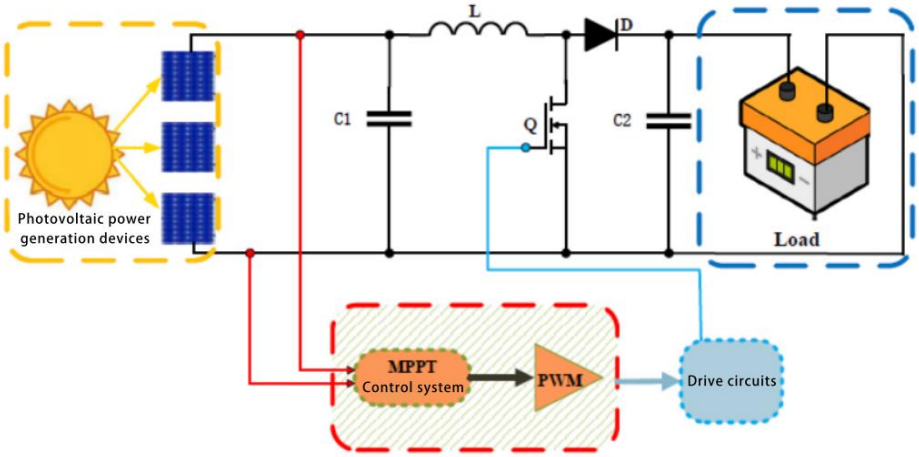

Fig. 3 Solar energy equivalent circuit

7.2. Battery charging mode

There are two common methods of battery charging: "two stage" and "three stage". The second stage charging first constant current charging, and then the current gradually decreases into

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the constant voltage charging. However, this method cannot solve the problem of polarization loss and affect the charging effect. After the third-stage charging, trickle charging and pulse current are used to compensate the self-discharge loss. Compared with the second stage, the three-stage charging effectively eliminates the battery polarization, with fast charging speed, little temperature change, and less impact on the battery life. In order to extend the service life of the equipment and reduce the maintenance cost, the equipment adopts the three-stage charging charging method.

7.3. Dry and wet water are combined with condensed water

Dry and wet combined with condensation water is air condensation water and hygroscopic desorption water organic combination to achieve the effect of "one plus one is greater than two": hygroscopic desorption water is the use of desiccant surface and ambient air evaporation pressure difference as hygroscopic power, using photovoltaic power generation energy will desiccant heating, make the water vapor diffusion, at the same time the water vapor cooling into liquid water. Using the fan to accelerate the air circulation to improve the moisture absorption and desorption efficiency; air condensation water is wet air into the reheater, after cooling through the evaporation end and produce the condensed water, the condensed air into the reheater to pre-cool the filtered wet air. This part of the air is mixed with the air of the air inlet, and the cooler and the condenser are cooled. The condensed water generated in the reheater is collected together with the condensate generated on the heat pipe after passing through the heat pipe, and filtered into the high-pressure sterilizing equipment. The desiccant uses new metal-organic frame porous adsorption materials (MOFs). MOFs can capture more water in low relative humidity and require lower temperatures than conventional moisture, which also means that less heat can be consumed but there is faster recycling efficiency.

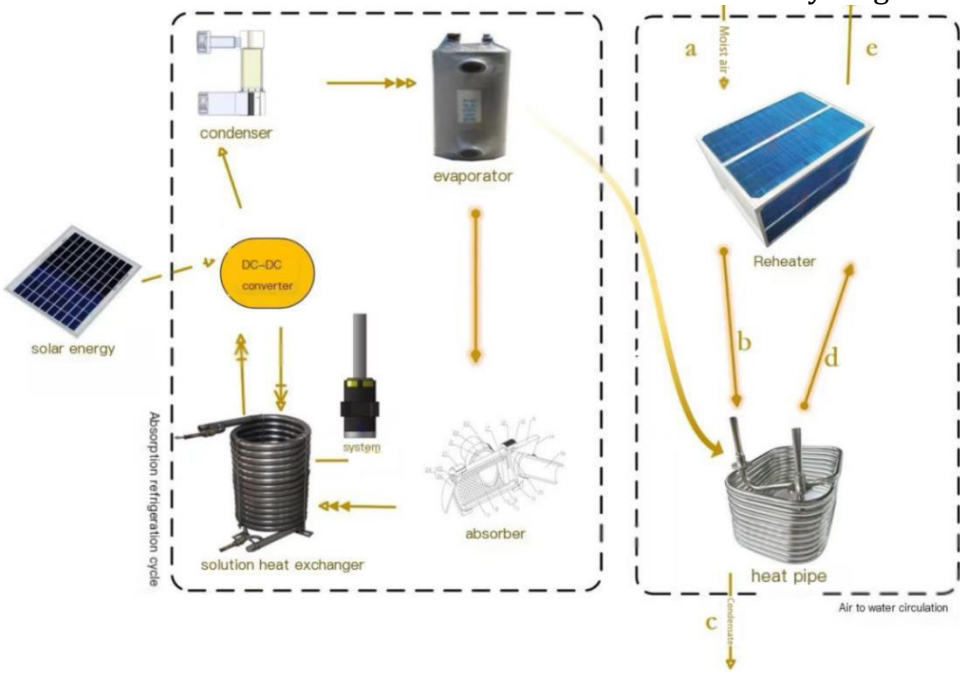

Fig. 4 Brief diagram of water system

7.4. Three-port DC-DC converter

Using the single-chip computer STM32F407, as the three-port DC-DC converter system, select the Boost circuit, adjust the duty ratio through the disturbance observation method to complete the maximum power point tracking, improve the output power of the analog PV cell to improve the PWM microcontroller, control the excitation circuit MOSFET switch, generate the pulsating direct current on one side, and boost the voltage. After sampling through the sampling circuit, the signal is fed back to the STM32F407 control chip regulation output.

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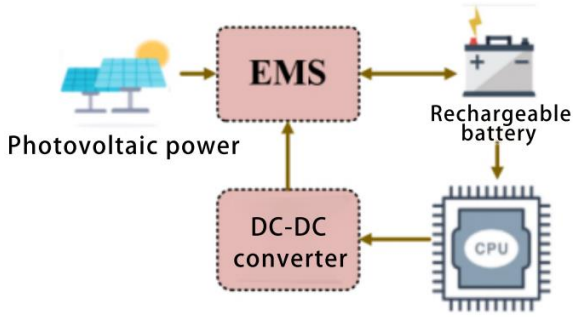

Fig. 5 Three-port transformation diagram

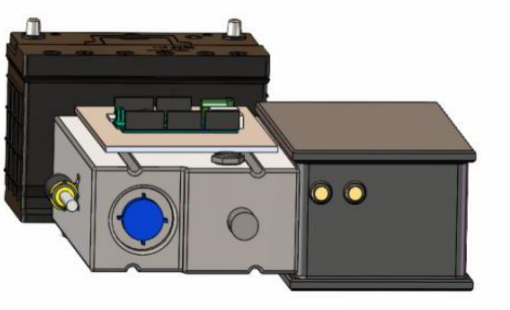

Fig. 6 High-voltage generation equipment

7.5. High-voltage electrostatic field

The base of the equipment is provided with the high pressure generating mechanism, which provides high pressure for the whole equipment, and the water body can be sterilized by the water tank to effectively ensure the water quality. The high voltage generating mechanism includes a set high voltage control module and a high voltage conversion module. The input of the high voltage conversion module is connected to the output end of the battery, the battery provides electricity for the high voltage generating mechanism, and the high voltage control module is equipped with an anti-static processing unit and a high voltage electrostatic field generator.

Fig. 7 Physical application scenario diagram

8. Theoretical design and calculation

8.1. High-pressure sterilization

This equipment adopts non-heat treatment bacteria elimination —— HVEF sterilization technology to sterilize the water production, and Hulsheger model is introduced to analyze the relationship between microbial survival rate and field strength.

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$$lgS = Kp(|P - P_c|) \quad (1)$$

Where $S=N_0/N_1$,N_0 and N_1 are the number of microorganisms in the water before and after PEF treatment,cfu/mL; Kp is the regression coefficient， which characterizes the sensitivity parameters of microorganisms to PEF; P is the treatment condition, the equipment is the electric field strength E (kV/ cm); P_c is the critical value for the various treatment conditions.

Under the same sterile conditions, the condensed water was divided into uniform groups, and each group was treated with different field strengths, and the bacterial survival rate data was recorded as shown in Fig. According to the bar chart, the sterilization rate increased significantly with the voltage intensity.

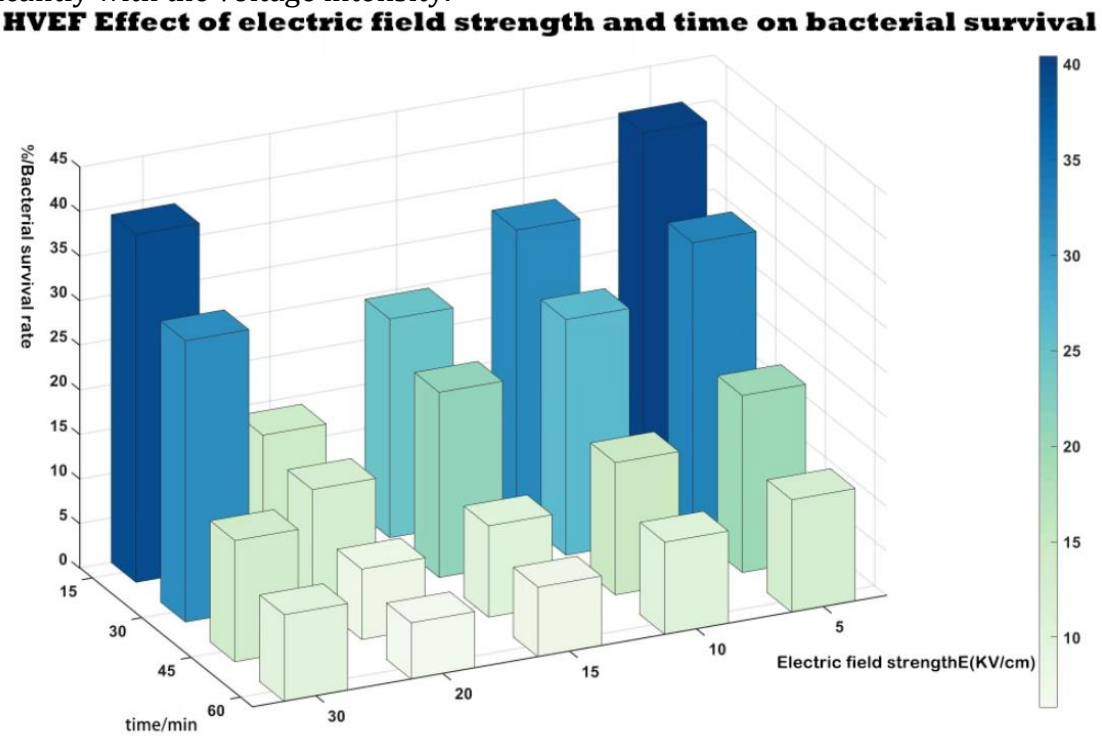

Fig. 8 Effect of HVEF and time on bacterial survival rate

Taking Kp=100, P_{EC} =20kV/cm, the microbial survival rate and electric field intensity curves are as follows, and the bacterial survival rate is the lowest at 20kV/cm. In addition, considering the actual situation, the high pressure field intensity in the range of 15kV-20kV to meet the normal drinking water of small animals.

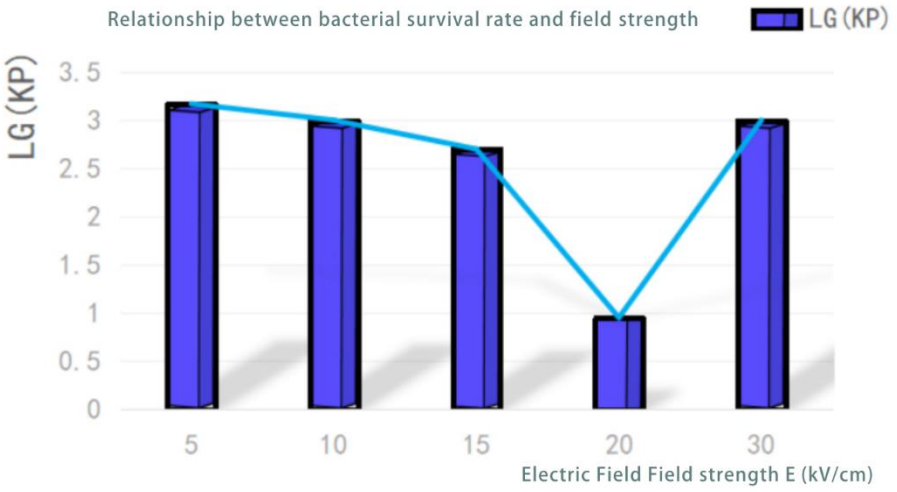

Fig. 9 Plot of bacterial survival rate and field strength

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8.2. Photovoltaic production capacity

The monocrystalline silicon photovoltaic panel used in this system has an Ac area of 0.65 m2,The national average total irradiation amount of the horizontal level is 1815.8kWh/m2,η1 is the photoelectric conversion efficiency, take 20%; η2 is the comprehensive power generation efficiency, take 80%.

According to the photovoltaic power generation formula：

$$En = Q \cdot A_c \cdot \eta_1 \cdot \eta_2 \tag{2}$$

The daily generating capacity is:

$$En = 1815.8/365 \times 0.65 \times 20\% \times 80\% = 0.5174kWh$$

According to the calculation, it can fully meet the power supply demand of high voltage elimination, water production system, circuit and other power consumption modules, and achieve self-sufficiency.

Table 1. Power consumption of each power consumption module

Power consumption module	power consumption (W)	Time per day(h)	Mean daily consumption of electricity(KW*h)
High pressure plate	20	2	0.04
Condensing water production equipment	75	6	0.45
suction pump	15	1	0.015
Total power consumption	—	—	0.505

8.3. Analyze the water quantity

When the air enters the condensation equipment through the air supply system and the temperature drops below the dew point, the condensation becomes water. Theoretically, the water production amount of the air water making equipment can be obtained by the following formula:

$$W = G\rho(d1 - d2) \tag{2}$$

G is the air volume, measured in unit m^3/h; ρ is air density, per unit kg / m^3; d_1 is moisture content of inlet air, per unit g/kg; d_2 is moisture content of outlet air, per unit g/kg.

After entering the condensing equipment, the desiccant is used to make water. The selected desiccant is the new metal organic frame (MOFs), which can consume less heat and faster dehumidification and hygroscopic cycle efficiency.

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QUITE HUMIDITY(%)	TEMPERATURE: ℃ 15℃	20℃	25℃	30℃	35℃
30%	967	1198	1221	1534	1756
40%	1002	1279	1512	1759	2041
50%	1359	1756	2056	2219	2413
60%	1756	2013	2341	2502	2767
70%	2159	2314	2724	3012	3212
80%	2215	2647	3078	3426	3601

Fig. 10 Water production drawing at different temperature and humidity

8.4. high-pressure sterilization

Under room temperature conditions, the water was treated for 2h, and the operating voltage was adjusted, and the survival rate of bacteria in the water under different high voltage electrostatic field strengths was detected. The high voltage electrostatic field generating equipment of the system can achieve a stable output voltage up to 2kV, with 10cm interval between the two plates, forming a high voltage electrostatic field strength of about 20kV / m, and the sterilization rate can reach more than 90% after 2h treatment of water.

8.5. Photovoltaic power generation

Considering that all parts of the system are powered by low-voltage power supply, photovoltaic power generation and energy storage technology is the ideal choice. The energy comes from solar energy, which can fully meet the power supply demand of power consumption modules such as high voltage elimination, condensation and drying system, noise dust removal, and circuits. It makes full use of solar energy, a renewable energy, realizes self-sufficiency and effectively reduces the consumption of power resources.

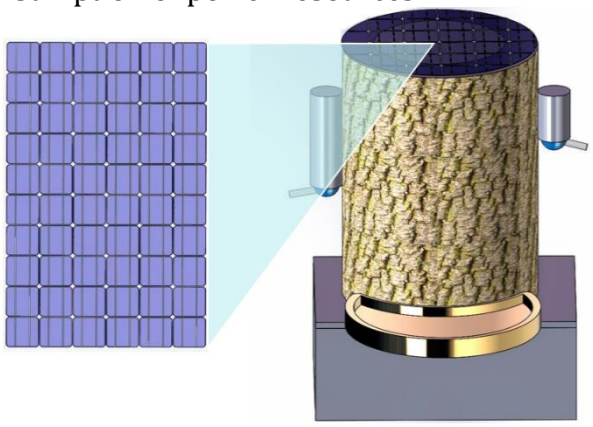

Fig. 11 Schematic diagram of equipment photovoltaic power generation

9. Conclusion

The development of photovoltaic technology power supply, condensing water, plus the public welfare nature of small animal drinking water equipment, completed the multi-link, multi-field, multi-level use. The whole system will further improve the utilization rate of renewable energy to achieve clean, low-carbon, safe and efficient. Create a new development model with low

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energy consumption, low emission, low pollution, high efficiency and high yield, and achieve a win-win situation of social, economic and ecological benefits. At the same time, the equipment has advanced self-sufficient operation mode without maintenance, and the application scenarios without geographical restrictions have significant application space in the future, in order to establish a resource-saving and environment-friendly society and promote the sustainable development of economy and society. In addition, as the country has always attached great importance to the development of public welfare undertakings, its development prospects are very broad.

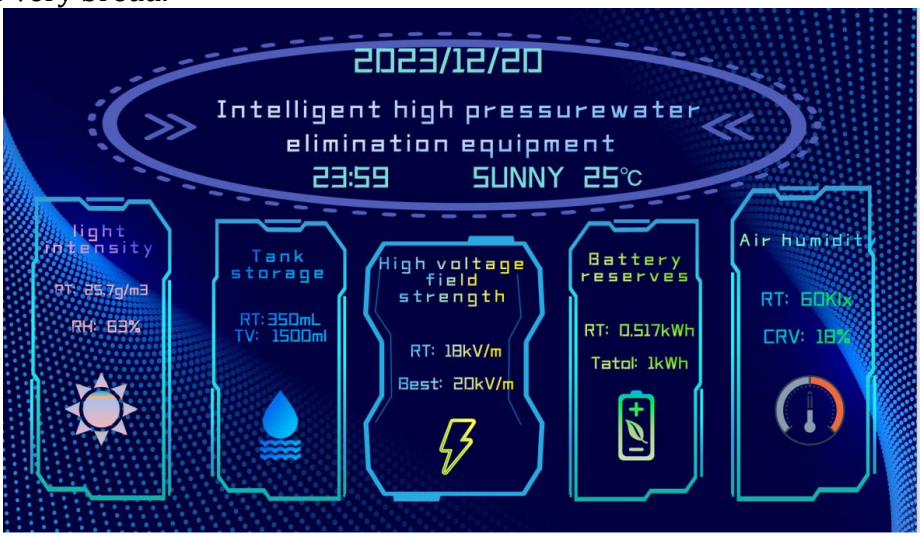

Fig. 12 Monitoring screen of the upper computer

References

[1] Zhu Runqi, Cai Dehua, Song Hai, etc. Design and performance analysis of small solar air water generator [J]. Refrigeration and air Conditioning, 2022,22 (09): 5-9 + 20.(In Chinese)
[2] Peng Yangxing, Liu Chengmei, Liu Wei, etc. Transient high-pressure sterilization technique [J]. Grain processing, 2005, (03): 45-48.(In Chinese)
[3] Zheng Yanru, Li Chenliang, Wang Yanfeng, etc. Development and application of automatic water IVC in experimental animal room [J]. Chinese modern educational equipment, 2021,(07):59-61.(In Chinese)
[4] Luo Ying, Zhang Baiqing, Wei Baodong. Study on static Hsterilization [J]. Packaging and Food Machinery, 2005, (05): 12-14.(In Chinese)
[5] Zhang Haiyan, Wang Li, Zhang Hui. Progress in in autopressure pressure technology [J]. Food and Food Industry, 2010,17 (03): 23-25 + 29.(In Chinese)
[6] Qi Mengyuan, Liu Qingyan, Shi Su Su and so on. Progress in the application of high-voltage electric field technology in food sterilization [J]. Food Science, 2022,43 (11): 284-292.(In Chinese)
[7] Chen Shufen. Experimental study on sewage [D]. Chongqing University, 2009.(In Chinese)
[8] Zeng Xin'an, Gao Dawei, Li Guoji. Study on the effect of high-voltage electric field sterilization [J]. Microbiology Bulletin, 1998, (05): 268-271. (In Chinese)