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Analysis of the Current Status of Research on Air Extraction Device Technology in Desert Areas

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Abstract

At present, there are numerous means of air water extraction, and the application of this means is very promising for the unique climatic characteristics of desert areas. This paper summarizes the advantages and disadvantages of the three air intake methods, analyzes their application areas, and analyzes the cooling condensation water extraction device which has more room for optimization, summarizes the advantages and disadvantages of the cooling condensation water extraction optimization device in recent years and future improvement measures, and finally makes suggestions for the future development of the cooling condensation water extraction device.

Keywords

Water Extraction; Comparative Analysis; Cooling Dew Extraction Device; Optimization Device; Development Proposal.

1. Introduction

At present, the lack of water has become a serious constraint on China's social and economic development, one of the "bottlenecks", the State Council has been advocating urban water supply, water conservation and water pollution prevention work conference spirit, to encourage the development, production and use of water-saving products, appliances. Air water extraction is one of the methods with great potential to solve the problem of lack of fresh water resources in arid areas and has attracted much attention. Air water harvesting refers to the use or storage of as much water as possible in the form of water vapor in the natural air through various techniques to turn it into liquid form. In addition to natural means such as rainfall, artificial air water extraction technology mainly cooling dew for water, hygroscopic agent moisture absorption - heating desorption, poly-mist water extraction method three types: ① Cooling wet air, so that it reaches below the dew point temperature, condensing water; ② The use of hygroscopic solid or liquid desiccant absorption of water in the air, and then heated desorption, condensing water vapor to get fresh water; ③ Will be separated from the small droplets of water in the fog for water. Each of the three methods has its own advantages and disadvantages, and the scope of application and scenarios are very different.

With the continuous updating of refrigeration technology, dew condensation method of water extraction method of optimization device has also been greatly developed, cooling dew water extraction method of the actual mass exchange of the driving force is the wet air and the surface temperature of the cooler contact process, when the temperature is lower than the air dew point temperature, water vapor condensation in the air on the surface of the cooler produces a layer of water film and the water vapor partial pressure difference between the nearby saturated wet air. In the enthalpy and humidity diagram is expressed as a cooling and dehumidification process, this process is constantly condensing water vapor, unit mass of air condensation water can be used (i.e., the difference between the moisture content of the air before and after the process). In recent years,

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especially in arid regions combined with different methods of power generation and cooling, forming different ways of water extraction. For example, the combination of solar power, semiconductor surface cooling and dew condensation methods for water extraction.

Table 1. Three types of air extraction

Air extraction method	Cooling dew extraction method	Absorbent hygroscopy-heat desorption method	Mist extraction method
Realization path	It consists of refrigeration unit, power unit, and cooling unit.	Moisture-absorbing agent more solid moisture-absorbing agent, liquid moisture-absorbing agent application is less, more composite porous media moisture absorption.	A giant nylon barrier is generally used to adsorb small droplets of fog and flow into the water storage device after polymerization.
Application Scenarios and Benefits	Priority is given to scenarios where the natural air dew point is high and a cold source can be easily made.	Optimization techniques are relatively well developed and applicable to most scenarios.	Low cost, high efficiency, only suitable for arid but foggy areas to carry out.
Optimization direction	There is a large potential for optimization, such as energy-saving, efficient and scientific water storage devices.	Development of adsorbents with greater water output.	There are very few arid and foggy areas in China, while the mountainous areas of western South America are suitable for the application of this method. The difficulty lies in how to ensure the continuity of the fog gathering process.

In this paper, we summarize the water extraction methods proposed in recent years for cooling dewy air, analyze their advantages and disadvantages and propose further optimization possibilities for desert areas in the future on this basis.

2. Conventional Method of Water Extraction by Cooling Dewy Air Section Headings

In 1993, JANNOT Y first proposed a cooling air water extraction device [4], which uses the evaporative end of the solar adsorption heat pump to cool the condensate surface of the cooler so that the wet air falls below the dew point temperature and condenses and drops into the collector. However, the device has more energy conversion steps and high energy losses resulting in low efficiency, and does not meet normal demand.

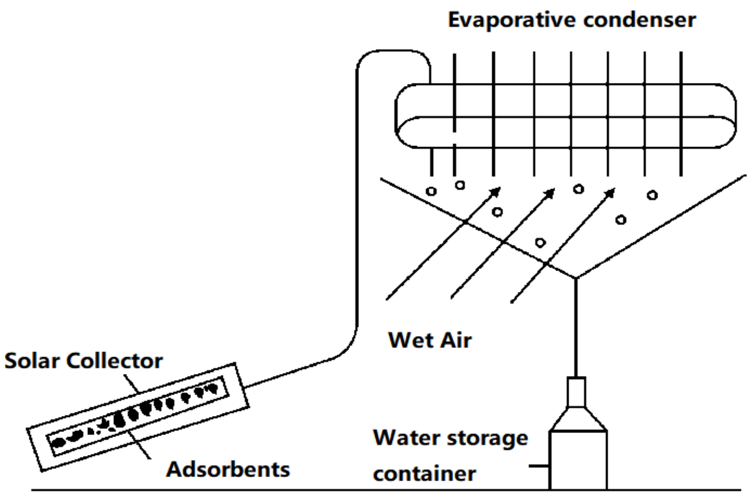

Fig. 1 Conventional Method of Water Extraction

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3. Solar Semiconductor Cooling Condensation Extraction Device

In 2003, Jitao Ye et al. [4] proposed a solar-powered semiconductor cooling dew extraction device, using the climate characteristics of strong daytime sunlight and large temperature differences between day and night in desert areas, using solar energy to charge the panels during the day, and low temperatures and high humidity at night, which is very conducive to using the panels to power the semiconductor cooling. The use of fans so that the natural wind constantly through the semiconductor cooling plate cooling to below the dew point there is condensate precipitation, by the natural wind through the out to the water storage equipment.

3.1 Benefits and Performance Analysis

The device does not use chemical substances. The use of the characteristics of the semiconductor refrigeration will not produce environmental pollution, reduce carbon dioxide, sulfur dioxide and dust emissions, condensate water quality is excellent, and take into account the economic factors, in order to avoid wasting the cold in the system to add back the heaters, so that the lower temperature air from the condensate chamber out of the air into the cold plate before the pre-cooling, recovery of the cold at the same time to improve the water extractor The water extraction rate per unit of energy is very suitable for water condensation in desert areas. The water extraction rate is 0.14 g/kJ when the ambient temperature is 293 K and the relative humidity of the air is 50%, and under the same conditions, the extraction efficiency is proportional to the heat transfer efficiency of the recuperator, the temperature of the air at the outlet of the recuperator, the relative humidity of the air, and inversely proportional to the ambient air temperature. The best water extraction dew temperature is between 0°C and ambient atmospheric temperature. Based on this research, Deyi Li et al. designed and constructed a solar cooling dew extraction system, using solar cells, controllers, batteries and other components to build a simple model of solar photovoltaic system; using semiconductor cooling tablets, cooling blocks, heat sinks, thermal insulation pads, cooling fans, power controllers, thermometers and other components to form a semiconductor cooling system, and installing cooling fans at the hot end to enhance natural air convection heat dissipation.

After measuring the cold end temperature, relative humidity, dew point temperature, moisture content of the air, initial enthalpy, the device uses the equation of the solar semiconductor cooling air to extract water $m_n = m_s(d_1 - d_2)$ and the equation of energy conservation of the steady state cooling sheet dew to extract water to $\mathrm{Q} = \mathrm{m}_s \Delta \mathrm{h} / \mathrm{t} + \Delta \mathrm{Q}$ calculate the theoretical cooling capacity of the device can generate 27.68 g of water in 1 h.

The amount of water that can be generated during the operation of the experimental setup is measured as shown in the figure.

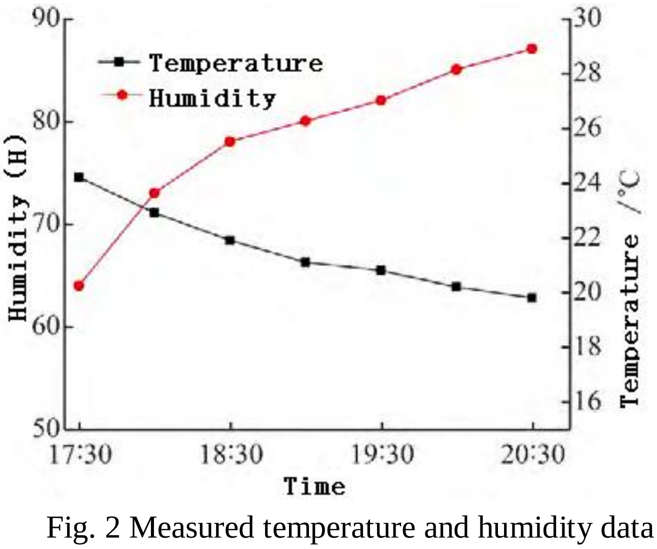

Fig. 2 Measured temperature and humidity data

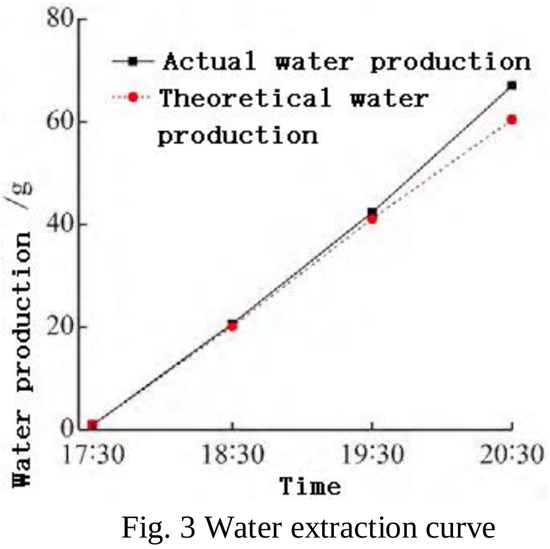

Fig. 3 Water extraction curve

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3.2 Problems and improvement analysis

(1) Improving the photoelectric conversion efficiency of solar panels and the reheat efficiency of heat return is an effective way to increase the water extraction rate and reduce energy consumption.

(2) The energy consumption of the wind turbine also occupies part of the electrical energy of the panel, which can be replaced by wind energy in desert areas or the Gobi Desert using the characteristics of natural wind power to achieve energy-saving effects.

(3) In windy areas, a combination of wind and solar energy storage systems cansingle solar panel to provide electricity.

4. Air water extraction device using temperature difference between soil and atmosphere in the desert

Xingtian Wang et al. explored an air-water extraction device that uses a more constant temperature soil as a cold source instead of semiconductor cooling, allowing the whole system to use very low energy consumption. This device places a soil heat exchanger in the soil and uses the horizontal nozzle of a fan on the ground to pressurize the air so that the air enters the underground heat exchanger to exchange heat with the lower temperature soil. When the temperature drops to the dew point and below, the air is saturated with water vapor precipitation, and small liquid droplets flow down the wall of the heat exchanger into the lowest water storage, and then the water is extracted through the water pump's delivery pipe, and the air is discharged through the air outlet pipe.

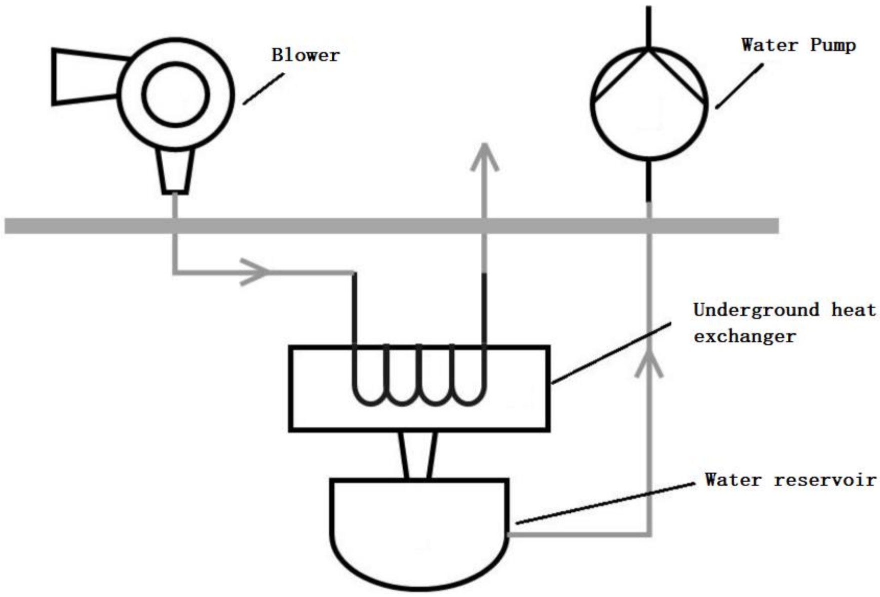

Fig. 4 Process diagram to facilitate soil cold source water extraction

4.1 Benefits and Performance Analysis

The device uses the temperature difference between soil and air due to the difference in heat capacity to cool the air to below the dew point after having the effect of water extraction. The advantage of using soil instead of solar photovoltaic panels for power generation semiconductor cooling device, compared to solar semiconductor cooling dew water extraction device is to reduce the energy conversion process, theoretically able to reduce energy consumption, and does not cause irreversible damage to the soil, the soil will return to its original state after 24h after the water extraction cycle. For desert areas this device has the advantages of localization, low energy consumption and high cleanliness. After experimental analysis, the optimal air volume for the water extraction system is 11.37 m/s. After laboratory verification experiments at 11.5 m/s, 20 m^3 of air is collected through the water extractor and 102.5 g of condensate is collected through heat exchange.

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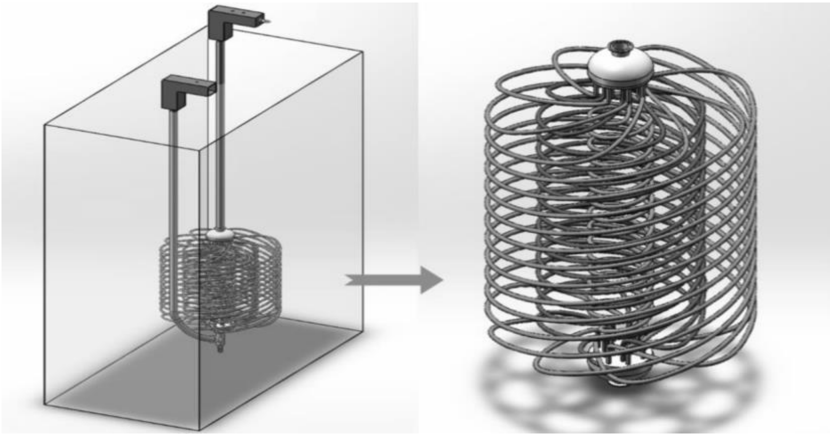

Fig. 5 Underground heat exchanger model

4.2 Problems and improvement analysis

(1) The amount of water condensed by the device is affected by natural conditions, such as wind speed and temperature difference between soil temperature and dew point temperature, wind speed at 11.37m/s, the temperature difference is better when the water extraction effect, so how to ensure continuous water extraction should be the focus of attention in the next step.

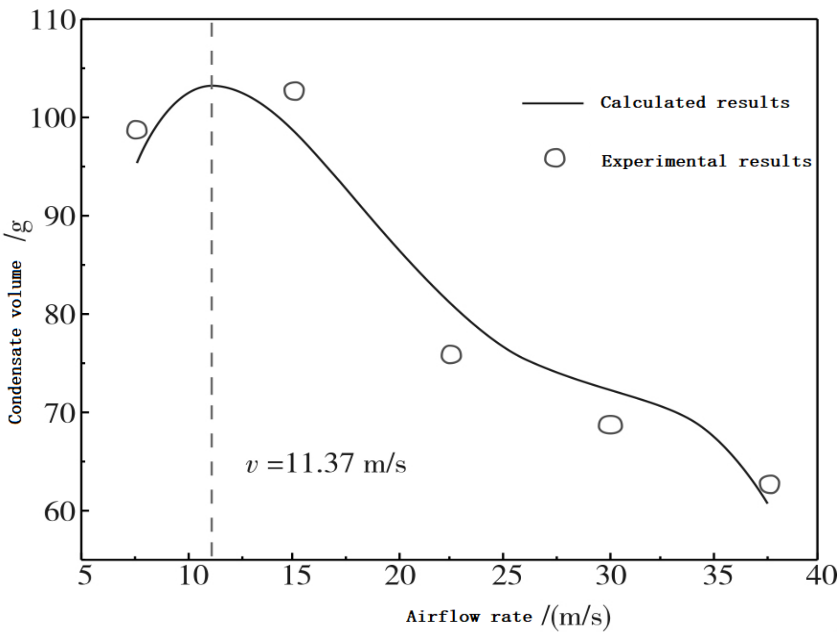

Fig. 6 Condensate volume versus air flow rate

(2) Water recovery devices have a greater impact on the amount of water taken, so in-situ irrigation is a more desirable use.

(3) This device can be used as a pre-cooling device for ordinary air-cooled water extraction devices.

5. Conclusion

This paper summarizes and analyzes the principle and advantages and disadvantages of the existing air cooling water extraction devices applicable to desert areas, and puts forward some improvement suggestions for future air extraction devices in desert areas, with the following main conclusions.

(1) Improvement of device performance: It can be combined with the unique climatic characteristics of desert areas, for example, stronger wind can set the fan inlet as a horizontal wind outlet on the

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ground that can be rotated according to the wind detection device. In addition, the combination of multiple devices can effectively ensure the effectiveness of water extraction, and the portability of future air extraction devices is also an issue that needs to be considered.

(2) Use of going: Chinese desert areas are mostly sandy shrubs and other annual plants, can consider setting up water extraction devices in situ irrigation in the irrigation area.

(3) Modern technology combined with large database analysis, the establishment of the division of the desert area irrigation area for the air water intake device unified management system, the desert area water shortage problem can have a certain degree of solution.

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