Study on an air humidification-dehumidification system with subatmospheric pressure for desalination

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Introduction

In recent years, seawater desalination using air humdification and dehumidification process has gradually attracted people's attention, especially solar humdification and dehumidification seawater desalination technology is favored. It has the advantages of simple process, can be driven by low-temperature heat source and insensitive to temperature change[1]. Traditional humdification and dehumidification techniques work under atmospheric pressure. In recent years, scentists have changed the pressure of system to improve it's water yield and system performance[2]. Narayan et al established humdification and dehumidification systems under different pressures and studied the influence of temperature under different pressures on moisture content[3]. In this paper, the relation of fresh water yield under different pressure is studied.

Experimental system

The structure of subatmospheric pressure air humidification and dehumidification seawater desalination system in Figure.1. The humidification system includes a water distributor, a humidifer bed and a humidifer chamber. The dehumidification system includes condenser and condensing chamber.

The device is divided into three cyclic processes and one subatmospheric pressure state. Brine circulation: the cold brine is pumped into the compound parabolic concentrator by the circulating pump for heating, and then sprayed evenly on the wet curtain by the water distributor. The water flows into the bottom of the humidifying chamber through the wet curtain and is recycled to the cold salt water tank. Cold water circulation:the cooling water at the temperature of 20℃ in the condenser heat transfer mode for the up and down. Air circulation: dry cold air and wet curtain heat exchange to form humid hot air, water ring vacuum pump will be inhaled humid hot air and it's internal water to the steam seperator, humid hot air in the condensor surface of the dehumidification chamber condensation to form fresh water; The heat transfer of humid air forms a dry cold air, which is then transmitted to the bottom of the humidifying chamber through the air duct to form a cycle. Subatmspheric pressure condition: the water ring vacuum pump rapidly inhales the air in the humidifying chamber to keep the humidifying chamber to keep the humidifying chamber in a low pressure condition.

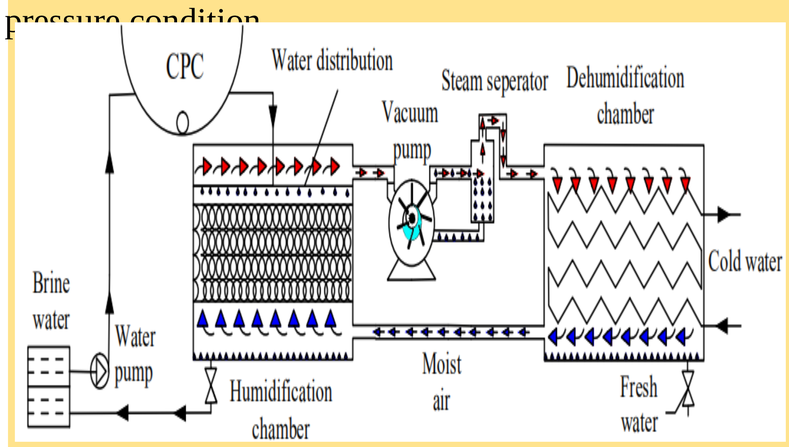

Fig.1. The sub-pressure of humidification and dehumidification seawater desalination system

Test results

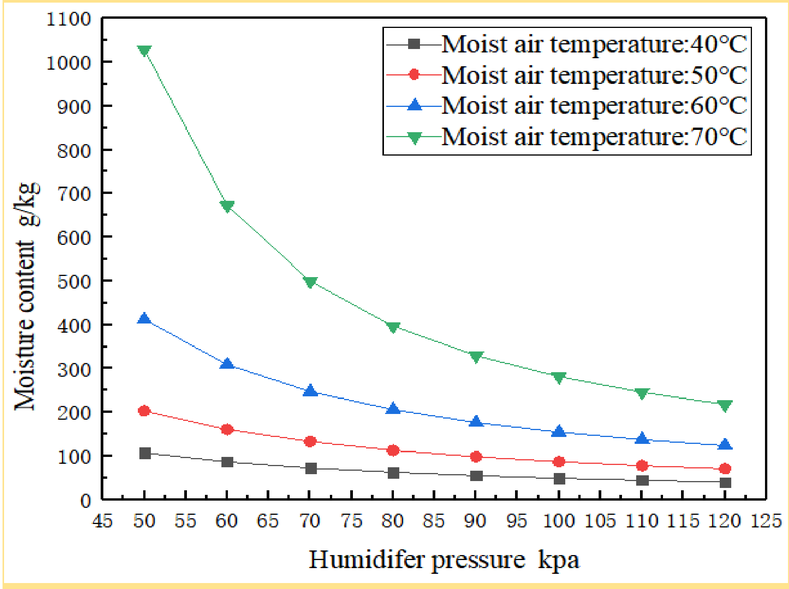

Fig.2.The relationship between pressure and moisture content

Figure.2 shows the influence of pressure on moisture content of wet air at different temperature. With the increase of humidity air temperature,the moisture absorption capacity is enhanced,and the moisture content of humidity air increases. Pressure also affects the change of moisture content. On the other hand, when the temperature of humid air is fixed, the pressure of saturated water vapor is determined accordingly, which reduces the pressure inside the chamber and increases the moisture content. On the other hand, the decrease in pressure leads to an increase in the volume of the internal gas, which changes the concentration of water vapor in the moist air and thus speeds up the mass transfer rate. When the pressure is 70Kpa, the temperature rises from 50℃ to 60℃, and the moisture content rises from 133.1g/kg to 247.5g/kg. When the temperature of wet air 70℃, the pressure decreases from 80Kpa to 70Kpa, and the moisture content increases from 397g/kg to 499.2g/kg.

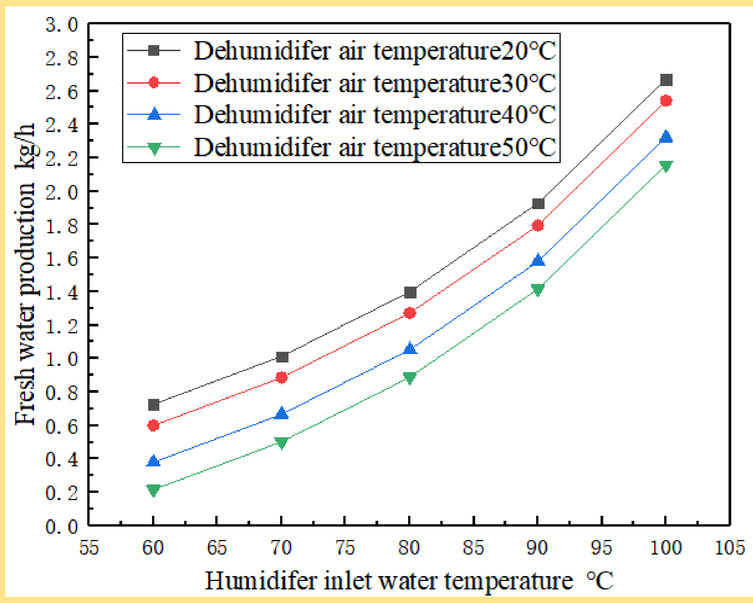

Fig.3.The relationship between inlet water temperature and fresh water yield (100KpA)

Figure.3 shows the relationship between humidifier inlet water temperature and fresh water yield at a pressure of 100kpa.As can be seen from the figure, the fresh water yield increases with the increase of water temperature under the same pressure. When the air temperature at the outlet of the dehumidifer air temperature is 20℃, and the water inlet of the humidifer inlet water is 60℃, the fresh water yield is 0.73kg/h.When the inlet temperature of the humidification chamber is 90℃, the fresh water output is 2.7kg/h. This is because when the inlet temperature of the humidification chamber is increased, the temperature of the wet air at the outlet increases, and the moisture absorption capacity of the wet air increases, so does the moisture content.When the inlet water temperature of humidifer water is 70℃ and the temperature of dehumidifer air temperature is 20℃, the fresh water yield is 1.01kg/h.When the air temperature at the outlet of the dehumidication chamber is 30℃, the fresh water output is 0.89kg/h.It can be found that the temperature of the humidification chamber remains unchanged, and the fresh water output decreases with the increase of the temperature of the dehumidification chamber. This is because the temperature of the dehumidication chamber increases, and the condensing effect of the condenser becomes worse. The hot and humid air from the humidification chamber into the dehumidification chamber does not condense well, and the fresh water output decreases.

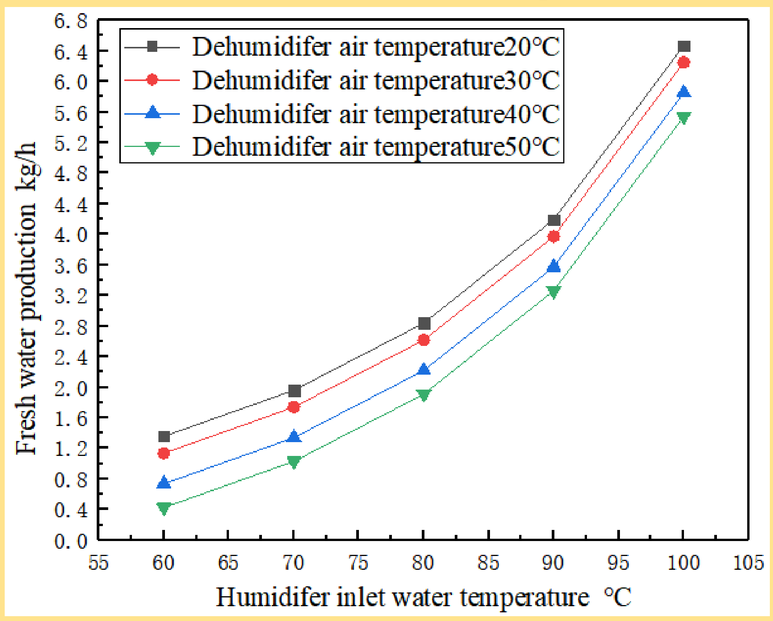

Fig.4.The relationship between inlet water temperature and fresh water yield (60Kpa)

Figure.3 shows the relationship between humidifier inlet water temperature and fresh water yield at a pressure of 60kpa. dehumidifer chamber outlet air temperature 20 ℃, the humidifer inlet temperature was 60 ℃, water yield of 1.36 kg/h, humidification chamber inlet temperature is 90 ℃, and water yield is 6.5 kg/h, can be found under different pressure, temperature, the same water entry pressure is lower, the more the water yield,This is because the decrease of pressure in the humidification chamber leads to the increase of gas volume inside, which speeds up the mass transfer rate of the wet air and increases the moisture content accordingly, and the pressure has a greater impact on the fresh water production.

Conclusions

The main conclusions drawn from all these work are:

- Reduce the pressure of humidifying chamber and increase the moisture content of outlet moist air;
- Reduce the pressure of humidifying chamber and increase the fresh water production;
- Increase the temperature of humidifying chamber and increase the fresh water output;

References

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[3] Narayan G P, McGovern R K, Lienhard J H, et al. Variable pressure humidification dehumidification desalination system[C]//ASME/JSME 2011 8th Thermal Engineering Joint Conference. American Society of Mechanical Engineers Digital Collection, 2011.