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Investigation and Performance Analysis of Humidification and Dehumidification System with Single Stage Flash Evaporation System

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ABSTRACT: In this paper we have received experimental result of a potable water with different variation of setup, environmental condition and time of reading. The saline water prepared by adding 300 grams of salt per litre of water as a raw water for experimental purpose. The dates of the experimental readings were 1st march to 6th March 2021. Here the readings of the all the days were remain the similar types so the readings of 1st March 2021 has been used in the result. The cumulative output of setup is 15.38 Kg for a reading hours.

KEYWORDS: Distillation, Humidification and dehumidification, Flash evaporation, potable water.

I. INTRODUCTION

Today's world is plagued by a lack of potable water. Only about 1% of the earth's water is potable, with the rest ending up in the ocean as saline water. In addition, saline water is not used for drinking. Desalination refers to the process of converting saline water into potable water. Vapour compression, reverse osmosis, multi effect distillation, and other desalination techniques are among them. However, all desalination techniques are extremely expensive, with a longer payback period. Humidification and dehumidification are environmentally friendly techniques that are used in a variety of applications such as cooling towers, air conditioning systems, and more. Many researchers have worked on solar-powered humidification and dehumidification systems, but the energy payback time and water outputs are still low. Some researchers worked on the flash evaporation system, which is commonly used in thermal power plants. However, no one in the world has used the idea of combining a humidification and dehumidification system with flash evaporation to produce potable water from saline or prepared water.

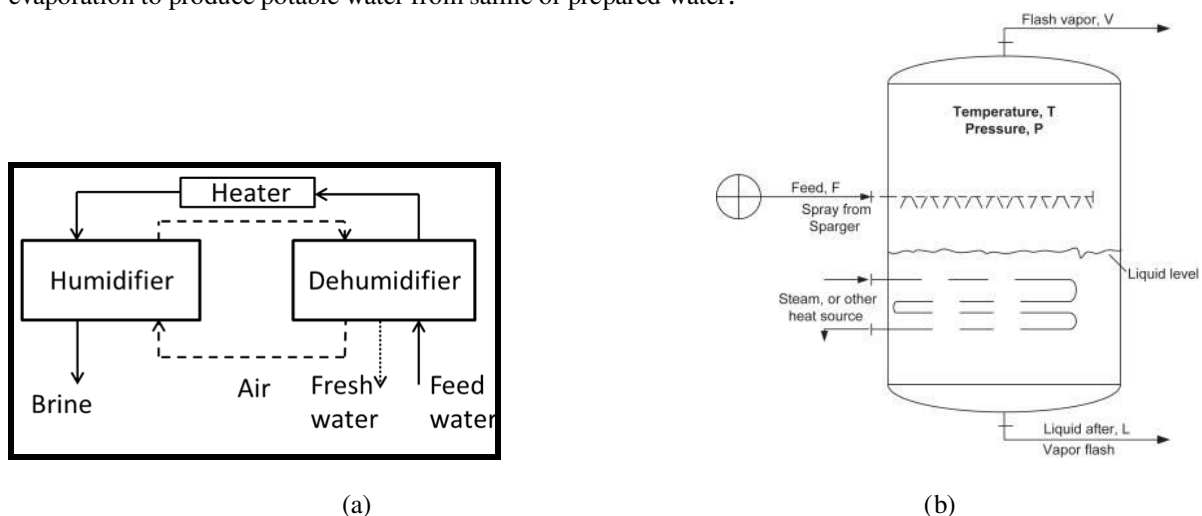


Fig. 1. Basic diagram of (a) Humidification dehumidification principle (b) Flash Evaporation principle

The Humidification-Dehumidification system (HDH) works on the principle of humidifying the air with water vapour and then dehumidifying it to obtain pure water back. The humidification is done with spraying of brine or impure water in a humidification chamber to obtain saturated air. This air is then dehumidified in a fin-and-tube heat exchanger at

low temperature to condense the water out from humidified air. The fin and tube exchanger works as an evaporator for a VCR system to obtain low temperature.

The flash system works on the principle of flashing a saturated liquid at low pressure. Flash system consists of a flash chamber maintained at vacuum pressure. Water is heated in the chamber and pumped at high pressure through a nozzle. The sudden drop in pressure and increase in volume causes the water to flash into water vapour. This water vapour is passed through a shell and tube heat exchanger to condense the vapour into pure water. Cold water is used to exchange heat in the shell and tube heat exchanger.

II. LITERATURE REVIEW

H. Xu, Y. Zhao and Y.J. Dai., [1] calculated the fresh water cost of the two-stage HDH desalination system is reduced by 17.36 percent, and system productivity and gained-output-ratio (GOR) are increased by 15.51 percent and 55.64 percent, respectively, when compared to the single-stage system, according to the experimental results.

Yin Zhanga,1, and Chunguang Zhua,1, [2] On the productivity of the system, the effects of seawater temperature, air temperature, and air flow rate are investigated. The temperature of the seawater has a positive effect on productivity, while the effect of the air temperature is negligible. As the air flow rate rises, productivity rises to a maximum value at a certain air flow rate, then falls as the air flow rate continues to rise. The proposed fresh water system's maximum productivity is 22.26 kg/h.

Ali I. Shehataa and A.E. Kabeelb [3] An experimental investigation on the solar system for water desalination was conducted according to the methodology of humidification-dehumidification. The heated air is humidified through two sequent stages; the primary stage is achieved through employing a heated water spatter from the evacuated solar collector. The Further stage is employing an ultrasonic technique for its highly efficient humidification rate. The findings of fresh water output rate is affected by two main parameters; firstly the mass flow rates of both air and water spray, secondly solar radiation. . The maximum amount of daily productivity reaches to 44.8 kg/day with mass flow rate of 0.46 kg/s for air, The ultrasonic humidifier improves the daily productivity by 9.3% at 0.24 kg/s and 14.6% at the maximum value of the air mass flow rate 0.46 kg/s.

Qian Chena, and Muhammad Wakil Shahzada,b, [4] Under various outdoor conditions and parameters, the integrated indirect cooling evaporative unit can cool the supply air to below 25 °C, and the purge air temperature can be reduced by 5–10 °C compared to the intake air temperature. Fresh water productivity and gain-output ratio (GOR) are respectively 25–125 L/hr and 1.6–2.5. The overall coefficient of performance (COP) was discovered to be between 2.1 and 2.5. The information in this paper explains how to make cooled fresh water.

Taranjeet Sachdev and Vivek Kumar Gaba, [5] In this paper, the cooling effect and fresh water production of a wind tower in combination with a solar air heater assisted humidification-dehumidification desalination system working with a closed and open air water cycle are numerically analyzed.

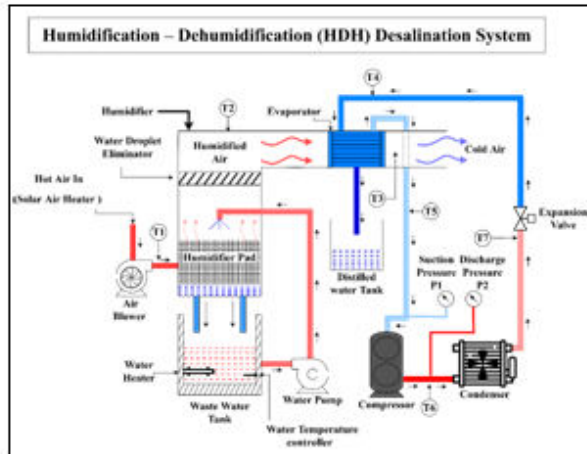
Yingchen Yang, [6] A new desalination process based on humidification-dehumidification (HDH) has been proposed. Throughout the HDH process, a vacuum pump is used to keep the air moving. It is the only piece of equipment that uses electricity. The HDH process is investigated under a variety of conditions, including humidification at low pressures (as low as 0.2 atm) and dehumidification at ambient pressure. Depending on pipe size and weather conditions, freshwater production rates range from 4 to 11 l/h per HDH line. The vacuum pump's associated minimum electric energy consumption ranges from 0.9 to 1.6 kWh/m³-water. The vacuum pump's associated minimum electric energy consumption ranges from 0.9 to 1.6 kWh/m³-water.

III. METHODOLOGY

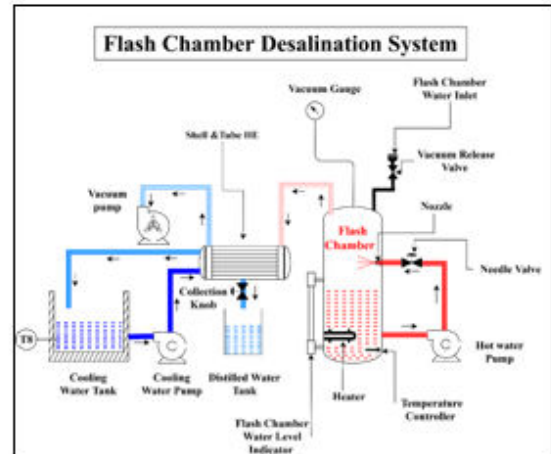
Procedure To Start Up The System

- (1) Ensure that all switches of the panel box should be off.
- (2) Connect the system to the main power supply.
- (3) Switch on the main switch of the panel box.
- (4) Switch on the water heater if required. The temperature of the waste water can be set by the temperature controller given in the panel box. Water temperature should not be above 50 °C.
- (5) Switch on the air blower. The speed of the blower can be regulated by the air flow controller.
- (6) Switch on the water pump. The speed of the pump can be regulated by the water flow controller.
- (7) Run the system up to this for 2 minutes and then switch on the compressor.

- (8) Pressure can be check by suction and discharge pressure.
(9) Temperature scanner shows the different temperatures of the system.



(a)



(b)

Fig . 2. Schematic diagram of (a) Humidification and dehumidification (b) flash chamber desalination system

T1	Humidifier Air Inlet
T2	Humidifier Air Outlet
T3	Cold Air Outlet
T4	Evaporator Refrigerant Inlet
T5	Evaporator Refrigerant Outlet
T6	Condenser Refrigerant Inlet
T7	Condenser Refrigerant Outlet
T8	Flash Chamber Cold Water

P1	Suction Pressure
P2	Discharge Pressure

Pressure Point List of system

Temperature Point List of system

Activ

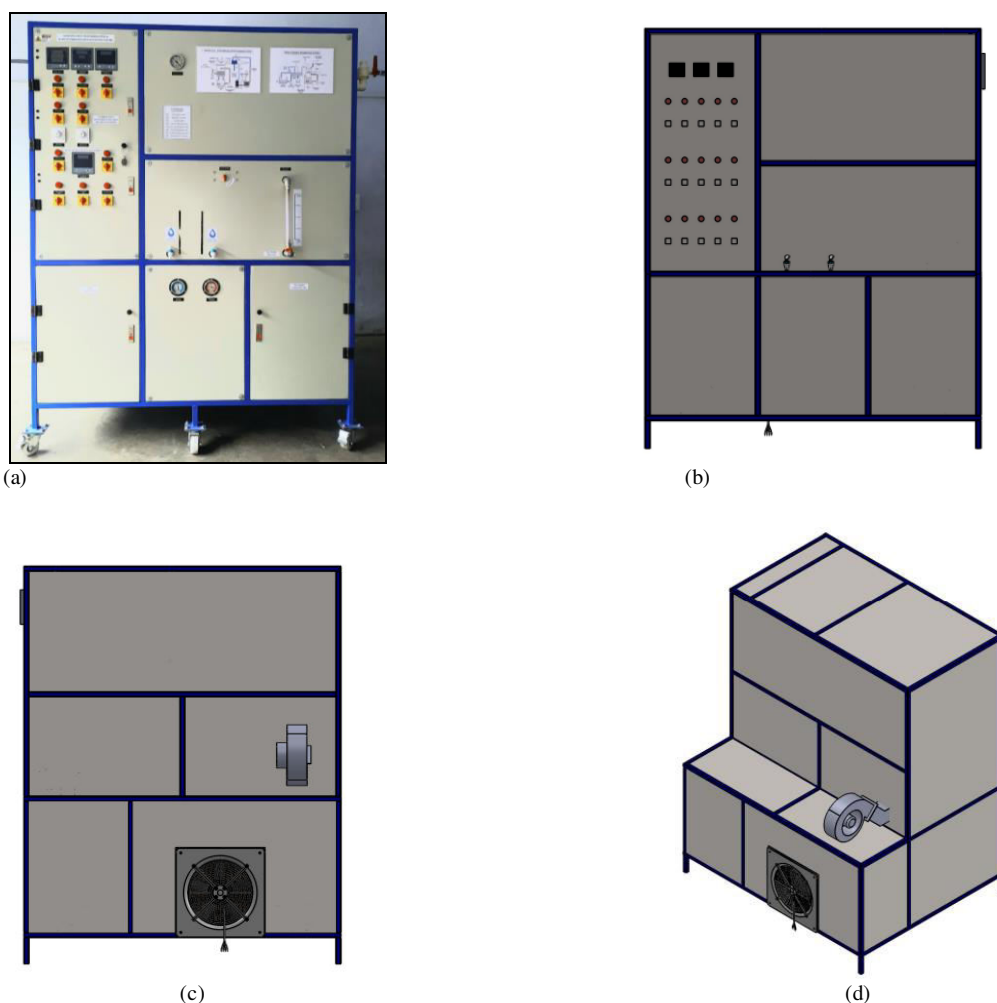


Fig. 3. Experimental setup of Humidification and dehumidification system with Flash chamber (a) Experimental setup panel and control board (b) Front view (c) Back view (d) Isometric view (back left view)

IV. EXPERIMENTAL RESULTS

Humidification and dehumidification system with the flash evaporation systems result and discussion is presented. Calculations of distilled output is presented here. Humidification and dehumidification and Flash chamber. The main purpose of the present system is to obtain the distillate output. Therefore the distillate output received from the both system have been collected and measured. Then the summation will be carried out to receive the total distillate output obtained from the system. The experimental readings were recorded from 1st March to 6th March 2021. Here the readings of the all the days were remain the similar types so the readings of 1st March 2021 has been used for the discussion.

(1) Air Side

Time	Ambient Air Temp. (°C)	Humidifier air In Temp. (°C)	Humidifier air Out Temp. (°C)	Evaporator air Out Temp. (°C)	Cooling Load (Watt)
2:00 PM	39.3	39.3	27.9	17.8	2.12
3:00 PM	37.8	37.5	26.7	17.3	2.00
4:00 PM	36.2	36.4	26.5	16.9	1.99
5:00 PM	36.9	36.7	26.6	15.2	1.89

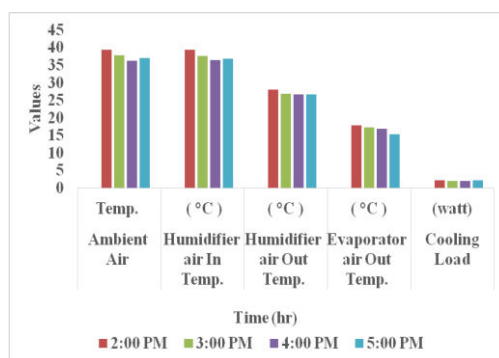


Fig. 4. Variation at Air Side of Humidifier

(2) Water Side

Time	Waste Water Temp. (°C)	Water Output (Kg/hr.)	TDS	
			Waste water	Distilled water
2:00 PM	45	1.83	715	21
3:00 PM	45	1.75	715	26
4:00 PM	40	1.70	715	32
5:00 PM	40	1.68	715	18

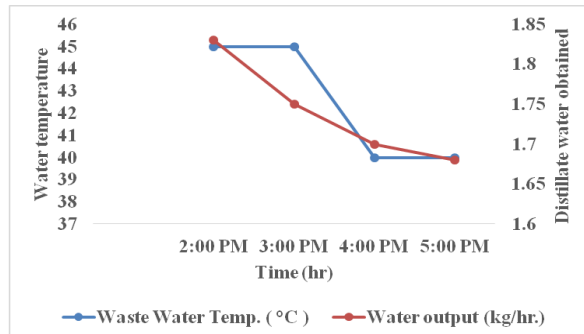


Fig. 5. Variation at Water Side of Humidifier

(3) Refrigeration Side

Time	Suction Pressure (psi)	Discharge Pressure (psi)	Evaporator outlet Temp. (°C)	Evaporator Inlet Temp. (°C)	Compressor Outlet Temp. (°C)	Condenser Outlet Temp. (°C)
2:00 PM	46	298	6.3	13.8	72.8	55.7
3:00 PM	52	318	7.1	14.2	71.7	53.6
4:00 PM	50	312	7.0	13.6	75.3	59.6
5:00 PM	45	290	6.5	12.1	74.4	58.2

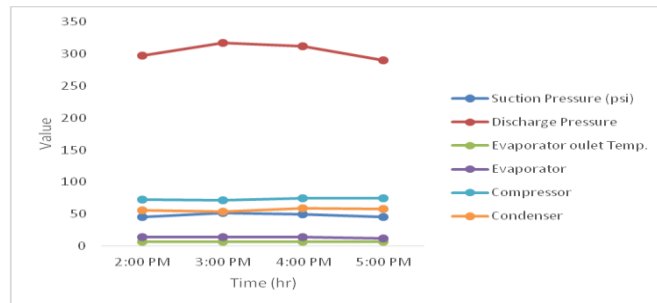


Fig. 6. Variation at Refrigerator Side

(4) Flash Chamber

Time	Flashchamber Vacuum Pressure (mm Hg)	Flash chamber Temperature (°C)	Flash chamber Inlet water TDS	Distilled water TDS	Water received (Kg/hr)
2.00 PM	560	81	715	24	2.45
3.00 PM	515	78	715	29	2.12
4.00 PM	490	72	715	32	1.98
5.00 PM	460	67	715	21	1.87

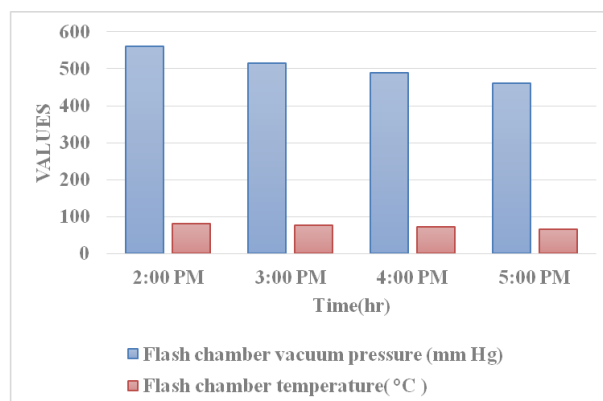


Fig.7. Variation of Pressure and Temperature at Flash Chamber

(5) Distilled Output

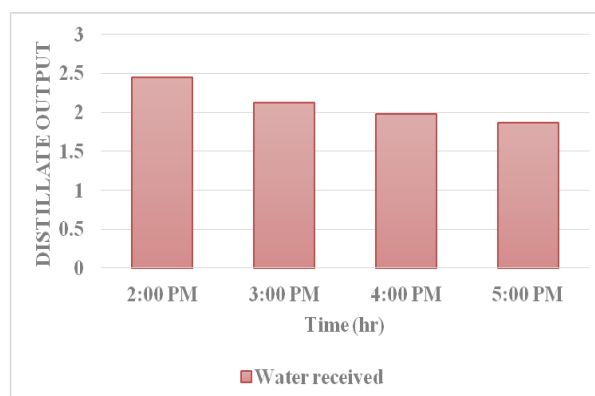


Fig. 8. Distilled Output

V. CONCLUSION

The experimental analysis of the humidification and dehumidification system with the flashing evaporation system has been presented. The performance of the system has been evaluated by the readings obtained during 1: 00 pm to 5: 00 pm during the experimental days.

- The distillate output received by the humidification and dehumidification system was around 6.96 kg during the experimental hours.
- Flash evaporation system the distillate output is not remains constant during the experimental hours and it was around 8.42 Kg.
- The cumulative distillate output from the Humidification and dehumidification system was $6.96 + 8.42 = 15.38$ kg.
- Humidification and dehumidification system with flash evaporation system is sustainable for providing the potable water because the distillate output obtained from both the system.
- Humidification and dehumidification system with the flashing evaporation is a sustainable system to provide the potable water.
- Flash evaporation system requires the maintained vacuum in the system and the distillate output remains higher as compared with the Humidification and dehumidification system.

VI. FUTURE SCOPE

- The whole system was run by the normal electricity so the system can also operate by the solar panels to make it for sustainable development.
- Only four hours of testing has been carried out. But the present system can be started for eight to nine hours so the distillate output can be enhanced. Also the comparison is also possible with other researchers work.
- Humidification and Dehumidification system with flash evaporation can be modeled with the energy balance equation and theoretical results can be determined and also compared with the experimental analysis results.
- Output enhanced through thermal equation and ANSYS CFD analysis and simulation.

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