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Measuring the Efficiency of a Solar-Powered Dew Point Evaporative Cooling System: An Experimental Analysis

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Abstract

Dew-Point Evaporative Cooling (DPEC) is an efficient method for energy conservation, relevant to both energy supply and demand systems by enabling rapid heat and mass transfer. This research examines the intrinsic capacity of evaporative cooling to lower air temperatures without elevating humidity, a concept well-documented in prior investigations. The results demonstrate that the velocity in the wet channel substantially influences the efficiency of the cooling process. Data indicates that an increase in velocity within the wet channel correlates with a decrease in the temperature of the outgoing air, with a reduction of 2.4ºC to 3.2ºC noted when the velocity is elevated from 2.2 meters per second to 8.5 meters per second. Moreover, both wet bulb and dew point efficiencies enhance with increased wet channel velocities, a pattern consistently observed in both electrically driven systems and those utilising solar energy. It was observed that as relative humidity rises while the Dry Bulb Temperature (DBT) remains constant, the efficacy of both wet bulb and dew point cooling diminishes. The results demonstrate the efficacy of evaporative cooling in lowering air temperature without increasing moisture, while also emphasising the significance of wet channel velocity and inlet air conditions in optimising the process. The results obtained in the experimental analysis also demonstrate that the DPEC system shows a promising solution in the wet and dry regions due to its ability to operate without using energy-intensive compressors and harmful refrigerants.

Major Findings: *During the experimental analysis, it has been found that: 1. The DPEC system shows higher wet bulbs and dew points. 2. Effectiveness due to higher airflow velocity in the wet channel. 3. In the same way, the system is showing higher wet bulb and dew point effectiveness when there is lower relative humidity of incoming air.*

Keywords: *Dew Point Effectiveness, Dew Point Evaporative Cooling, Wet Bulb Effectiveness, Wet Channel Velocity Relative Humidity*

1.0 Introduction

Not with standing the extensively recorded environmental repercussions and substantial energy usage associated with vapour compression Air Conditioning (AC) systems, these systems remain prevalent in numerous buildings for cooling applications. Solid Desiccant Air Conditioning (DAC) is one of the most sophisticated, economical, environmentally sustainable and energy-efficient options accessible[1]. Direct Air Capture (DAC) systems predominantly utilise low-grade thermal energy, including solar energy or waste heat, in contrast to the high-grade electrical energy demanded by traditional Vapor-compression Air Conditioning (VAC) systems[2]. The transition to thermal energy as the primary power source enhances the sustainability of DAC systems.

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Significant energy is required to uphold clean indoor air quality in buildings and to provide a pleasant temperature for people. As a result, air conditioning systems constitute a substantial share of overall energy usage[3]. The demand for air conditioning is anticipated to rise by around 35% from 2010 to 2035, with this trend forecast to intensify globally. Buildings account for around 30-40 % of global power use, with space heating and cooling constituting over half of this energy usage. Although vapour-compression air conditioning systems are extensively utilised for indoor comfort, their dependence on high-quality energy exacerbates problems such as passive air pollution[5]. Although these systems efficiently provide the appropriate indoor climate, they include environmental disadvantages. DPEC provides an energy-efficient option applicable to both the supply and demand facets of energy systems. This technique facilitates exceptionally efficient heat and mass transport, rendering it especially appropriate for air conditioning applications. DPEC has created several opportunities in the design and implementation of cooling systems[6].

DPECS is a promising solution to many applications like cold storage of agricultural products in wet and dry regions since it can lower the temperature of product air up to its dew point temperature without any addition of moisture.

Recent progress has been achieved in creating both experimental and computational models to investigate the integrated heat and mass transport mechanisms in Liquid Desiccant Solution (LDS) dehumidification systems. These models concentrate on examining the concurrent processes of heat and mass transfer involved in LDS dehumidification and regeneration. These mechanisms result in the extraction of moisture from the atmosphere. Integrating this form of dehumidification with evaporative cooling can substantially decrease overall electricity use. The procedure facilitates a systematic reduction of moisture load, culminating in the final phase that targets the sensible load. This sequential method is notably efficient and solar energy is progressively utilise to satisfy heating requirements. After dehumidification, evaporative cooling devices can enhance the cooling process. Despite DAC systems often attaining a wet bulb efficiency of approximately 70-95%, they are less appropriate for hot and humid environments because of the added humidity potentially causing discomfort for occupants. Conversely, indirect evaporative cooling systems can efficiently lower air temperature without elevating humidity levels, while their wet bulb efficiency ranges from approximately 40% to 60% of their maximum capacity. Dew-Point Indirect Evaporative Cooling (DPIEC) is an advanced form of indirect evaporative cooling. It can lower incoming air temperatures below the Wet Bulb Temperature (WBT). In principle, it can lower the air temperature sufficiently to induce condensation. This feature enables the system to reduce the intake of air temperature much below its wet bulb temperature, hence its designation.

2.0 Literature Review

Evaporative cooling has its origins in ancient cultures[7]. Archaeological evidence indicates that primitive evaporative cooling techniques were employed in edifices in areas including Ancient China, Egypt and the Persian Empire[8]. Subsequently, these approaches disseminated to other regions characterised by comparable hot and arid conditions. In recent years, various studies have investigated novel research avenues in this domain, particularly emphasising dew-point evaporative coolers, which have attracted considerable interest. Researchers have utilised many methodologies including numerical simulations, experimental investigations, performance analysis and system characteristic optimisation to enhance this technology. Antonellis[9] examined the design of Indirect Evaporative Coolers (IEC), emphasising geometry and flow combinations, such as counter and parallel water flows. Their research examined the impact of plate design and pitch on wet bulb effectiveness and pressure decreases. It was determined that parallel water flow improved wet bulb efficiency and diminished pressure drops relative to counterflow configurations. Jia *et al.*[10] proposed a novel design that integrates counterflow and crossflow, merging the high efficiency of counterflow with the compactness of crossflow systems. This hybrid method provides an equilibrium between performance and spatial efficiency, presenting a novel solution in the design of evaporative cooling systems. Meng *et al.*[11] performed an exploratory investigation on a cross-flow indirect evaporative cooler with airborne water vapour condensation. They evaluated the cooler's performance under different input airflow conditions, evaluating parameters including output air temperature, wet bulb

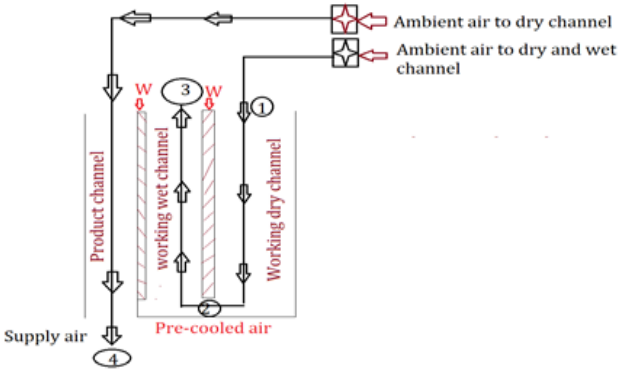
effectiveness, water consumption rate, heat transfer and condensation rate. Their studies identified three categories of condensation: absence of condensation, moderate condensation and complete condensation. Subsequent research by Sun *et al.*[12] examined the influence of nozzle type and spray methods on the efficacy of indirect evaporative cooling systems. Their findings demonstrated that spiral-type nozzles and intermittent spraying yielded the most effective cooling results. Furthermore, Al-zubaydi *et al.*[13] investigated several water spray configurations for indirect evaporative coolers and developed an optimised water spraying technique that enhanced the efficacy of IEC systems. Dizaji *et al.*[14] performed studies to investigate the influence of critical design and operational parameters on the efficacy of multi-stage dew-point evaporative coolers. They assessed exit temperatures, humidity ratios, dew-point efficacy and wet bulb efficacy under various situations. They determined the ideal design and operational parameters for the cooler based on their findings. Furthermore, they devised a distinctive model for a multi-stage dew-point evaporative cooler, employing their wet-surface theory to tackle the system's problems.

Moshari *et al.*[15] developed an analytical solution to minimise pressure drop in IEC. Their research highlighted the significance of accounting for pressure drops in the pre-design phase of IEC systems. Numerous researchers, such as Anisimov *et al.*[16], Pandelidis *et al.*[17], Heidarinejad *et al.*[18] and Kabeel *et al.*[19], examined heat and mass transfer mechanisms employing the effectiveness- Number of Transfer Units (NTU) approach or its modified variants. The original NTU-based model was initially simplistic but has now developed to incorporate longitudinal heat conduction, resulting in a more sophisticated description of the system.

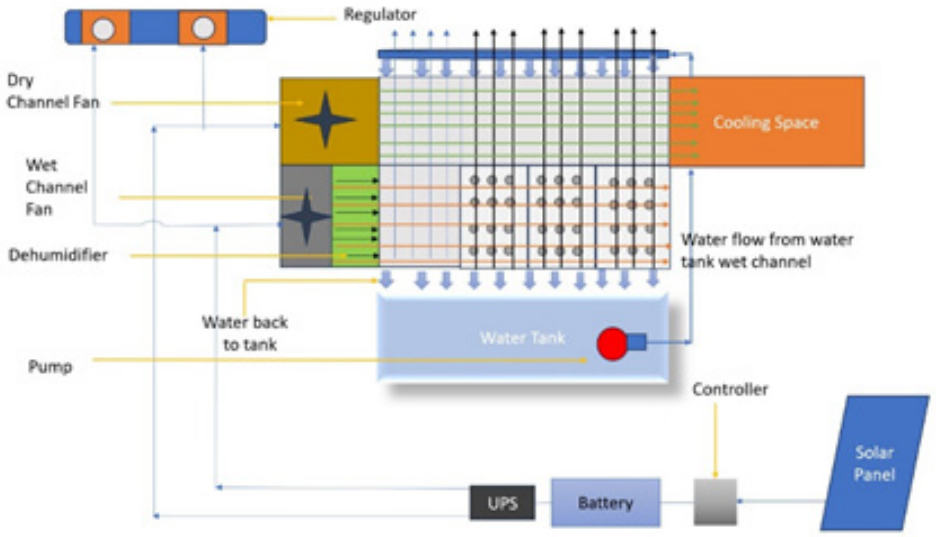
Cui *et al.*[20] created numerical models for DPEC utilising ANSYS FLUENT and COMSOL software and compared them with analytical models. Cui and colleagues presented an analytical framework utilising a modified Logarithmic Mean Temperature Difference (LMTD) methodology. This method facilitates the resolution of several algebraic problems rather than performing comprehensive numerical simulations. The simplified model exhibited precise performance predictions when juxtaposed with experimental findings, with a maximum variance of under 8%. Recently, Lin *et al.*[21] established the foundation for a physics-based model. The suggested framework, when integrated with data-driven prediction, facilitates swift optimisation and is considered an efficient approach for constructing DPEC systems. Simulations indicated that data-driven optimization might enhance performance by 30-60 %. Prior research has investigated theoretical and mathematical models of dehumidifiers, including numerical models for dehumidification and evaporative cooling systems, and their respective experimental validations. This study seeks to investigate techniques that capitalize on the benefits of evaporative cooling, including its capacity to reduce air temperatures without increasing humidity—a well-established advantage. The procedure entails the evaporation of water, which then cools the air, utilizing a heat exchange medium commonly employed between these stages. The temperature differential produced by water evaporation enables air cooling through a heat exchanger, promoting heat transfer from the cooled air stream to moist surfaces without direct contact. Consequently, no further moisture is added, and the conditioned air is efficiently cooled.

3.0 Experimental Set-Up and Methodology

To create an eco-friendly evaporative cooling system, essential components are a heat exchanger, fan, chilled compartment and pump. The set-up has a very important unit called a heat exchanger that consists of several wet channels and dry channels. The air is guided in the wet and dry channels with the help of an acrylic sheet. Wet



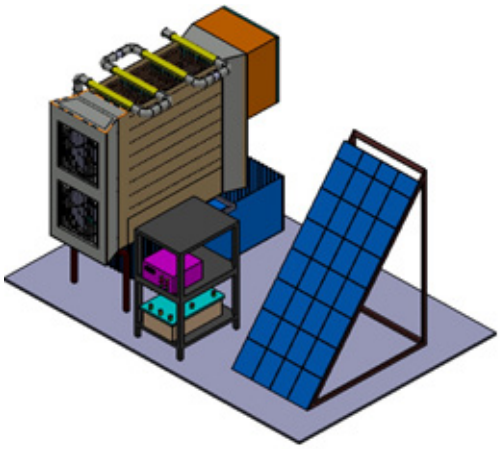
(A) Working principle of dew point evaporative cooling system.



(B) Schematic of the experimental test set-up.



(C) Actual photograph of the experimental test set-up.



(D) CAD set up.

Figure 1. Experimental test set-up used for the research work.

channels are made with wet pads of cotton cloth on which water is sprayed uniformly. The mechanism in the wet channel is direct evaporative cooling whose cooling effect is transferred to product air that passes through the dry channel.

The heat exchanger, which enables the transfer of heat from external air to the water utilised in the cooling process, is generally situated on the roof or in proximity to the cooling area. The blower, electrically operated, is fastened to the heat exchanger and facilitates the circulation of air via the heat exchanger into the cooled area. The refrigerated space denotes the area necessitating chilling, including a room, structure or outdoor sector. At the foundation of the system's reservoir lies the pump, which utilises electrical energy to transfer water from the reservoir to the heat exchanger, so guaranteeing a continual flow of cooling water.

The configuration of the green evaporative cooling system comprises several essential components, including a single-stage heat and mass exchanger, a blower assembly,

a casing to channel airflow into the heat exchanger, water supply pipes to the wet channels and an enclosure to collect and assess the temperature and other characteristics of the output air. The air blower functions at 230 volts, 30 watts, with a speed of 1300 RPM and a sweep of 20 millimetres, whilst the pump is rated at 220-240 volts and 20 watts. The system incorporates thermocouples and a temperature controller to assess the dry and wet bulb temperatures of the entering and departing air, facilitating the monitoring of air quality. The blower's speed is established at 2 meters per second.

The device is activated and permitted to operate for a minimum of one hour to achieve a steady state. Following stabilisation, six temperature measurements are recorded at ten-minute intervals while maintaining a constant blower velocity. This experiment aims to assess the efficacy of the eco-friendly evaporative cooling system by examining the DBT of the output air. The experiment's results will elucidate the system's efficiency and identify prospective enhancements to optimise its overall performance.

At its maximum speed of 1300 revolutions per minute, the blower introduces supply air axially into the evaporative cooling system at a temperature of 30°C. Upon traversing both the dry and moist channels, the supply air exits the casing in the axial direction. Aluminium sheets are employed in the dry channel to cool the supply air prior to its distribution to the designated location. Simultaneously, in the moist channel, the operational air extracts heat from the incoming air as water evaporates from the hessian fabric. The evaporation of water, facilitated by a pump that recirculates water in the wet channel, transfers latent heat to the surrounding material. At peak blower velocity, the temperature of both the supply and operational air is recorded at 28°C. The indirect evaporative cooling technique can only attain temperature reductions up to the ambient air's wet bulb temperature; however, the latent heat transfer of the evaporative heat exchanger and the vaporisation process are essential for attaining the necessary cooling effect. The equipment is facilitated with solar panels and the role of fluctuations of solar power is important. Since solar power is unpredictable and intermittent it can cause voltage and frequency changes and this leads to variation in output results when compared with the results obtained without solar power.

3.1 Data Analysis

Figure 2 illustrates the mechanism of the dew point evaporative cooling system. As ambient air (Point 1) enters the dry channel, sensible heat is conveyed from the dry channel to the wet channel, as illustrated by the psychrometric route 1-2. This causes the outlet air (Point 2) to be expelled at a temperature considerably lower than the ambient air. A segment of this cooled air may be sent to the wet channel to substitute the operational air, so improving system efficiency. Path 2-3 demonstrates that the working air becomes humidified and acts as a heat sink, absorbing heat from the dry channel. Ultimately, this operational air is discharged into the atmosphere. As a result, the exit air temperature is lowered down below the ambient wet bulb temperature, while maintaining the relative humidity same. In an optimal cycle, the exhaust air temperature can be lowered to the dew point temperature of the incoming ambient air[22,23].

Figure 2 depicts the enthalpy equilibrium of the fluids entering and exiting the system. Utilising this enthalpy balance, the correlation between the outlet air temperature and other variables can be established through the subsequent equation:

$$\dot{m}_i = (h_1 - h_2) = \dot{m}_w(h_3 - h_2) \qquad (1)$$

The difference in enthalpy within the dry channel is exclusively attributable to the sensible cooling of the process air. The change in enthalpy between position 1

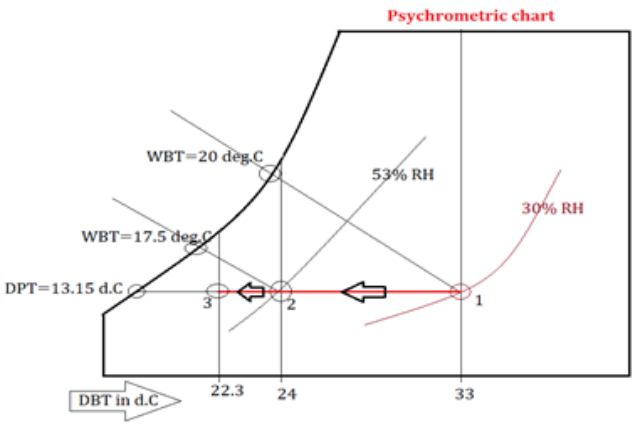


Figure 2. Psychometric process.

and position 2 on the psychrometric chart, illustrated in Figure 2(b), can be expressed by the subsequent equation:

$$(h_1 - h_2) = C_p(t_1 - t_2) \quad (2)$$

The wet bulb efficacy (ε_w) and the dew point effectiveness (ε_D) are essential performance criteria for evaluating a dew point indirect evaporative cooler. The effectiveness indicators can be computed using the subsequent equations:

$$\varepsilon_w = \frac{t_{db1} - t_{db2}}{t_{db1} - t_{wb}} \quad (3)$$

$$\varepsilon_D = \frac{t_{db1} - t_{db2}}{t_{db1} - t_{dp}} \quad (4)$$

3.2 Uncertainty Analysis

The experimental setup utilised the following measuring devices, with their respective accuracies detailed in Table 2:

- A Testo 610 relative humidity meter was employed to ascertain the wet bulb temperature, DBT, Dew Point Temperature (DPT) and Relative Humidity (RH) of the environment.
- The DTM-21 digital thermometer was employed to ascertain the water temperature.
- An anemometer was employed to measure the velocity of the airflow.
- A rotameter was mounted at the intake of the IEC system to accurately measure the mass flow rate of water and monitor fluid flow rates.

4.0 Results and Discussion

This study aims to evaluate the performance of a heat exchanger system under different DBTs of incoming

Table 1. Accuracy and resolution of measuring instruments

Instrument	Resolution	Accuracy
Anemometer	0.1m/s	2%
Testo 610 RH meter	0.1%	
Rotameter	LPM	±2.5%
"DTM-21 Digital Thermometer	0.1°C	± 0.1°C"

Table 2. Experimental trial at DBT = 31°C, RH = 54%, WBT = 23.59°C and DPT = 20.62°C

Mode of Operation	"Dry Channel Velocity (m/s)	Wet Channel Velocity	Product Air Outlet Temperature	Wet Bulb Effectiveness (ε_w)	Dew Point Effectiveness (ε_D)"
Electric Operated	2.7	2.2	28	0.4	0.29
		4.1	27.1	0.53	0.38
		5.4	25.6	0.73	0.52
		6.6	25.1	0.8	0.57
		8.5	24.9	0.82	0.59
Solar Operated	2.7	2.2	27.5	0.47	0.34
		4.1	27.1	0.53	0.38
		5.4	26.1	0.66	0.47
		6.6	25.2	0.78	0.56
		8.5	24.6	0.86	0.62

Table 3. Experimental trial at DBT = 32°C, RH = 42%, WBT = 22.03°C and DPT = 17.5°C

Mode of Operation	Dry Channel Velocity (m/s)	Wet Channel Velocity	Product Air Outlet Temperature	Wet Bulb Effectiveness (ε_w)	Dew Point Effectiveness (ε_D)"
Electric Operated	2.7	2.2	26.1	0.55	0.36
		4.1	24.6	0.71	0.47
		5.4	24	0.78	0.52
		6.6	23.5	0.84	0.56
		8.5	22.9	0.9	0.6
Solar Operated	2.7	2.2	26.3	0.52	0.35
		4.1	25.1	0.66	0.44
		5.4	24.6	0.71	0.47
		6.6	23.6	0.82	0.55
		8.5	23.1	0.88	0.59

Table 4. Experimental trial at DBT = 33°C, RH = 40%, WBT = 22.38°C and DPT = 17.62°C

Mode of Operation	Dry Channel Velocity (m/s)	Wet Channel Velocity	Product Air Outlet Temperature	Wet Bulb Effectiveness (ε_w)	Dew Point Effectiveness (ε_D)"
Electric Operated	2.7	2.2	24.4	0.77	0.49
		4.1	23.3	0.89	0.58
		5.4	22.7	0.96	0.62
		6.6	22.2	1.02	0.66
		8.5	22	1.04	0.67
Solar Operated	2.7	2.2	24.3	0.78	0.5
		4.1	24	0.81	0.52
		5.4	23.6	0.86	0.55
		6.6	23.4	0.88	0.57
		8.5	22.6	0.97	0.63

air. The air velocity in the dry channel is consistently maintained at 2.7 m/s, while varying speeds in the wet channel are examined, ranging from 2.2 m/s to 8.5 m/s. Critical parameters, including the temperature of the produced water, the temperature of the air at the output and the relative humidity of the expelled air, are assessed through experimental measurement. The measurements are conducted throughout a spectrum of DBT ranging from 31°C to 34°C. The system comprises vital components such as an electrically operated air blower and a water pump. The primary objective of the research is to evaluate the system's efficiency when utilising solar energy in contrast to conventional electrical power. This comparison underscores the prospective advantages of incorporating renewable energy into the grid. The experimental findings, derived from both power

Table 5. Experimental trial at DBT = 34°C, RH = 32.5%, WBT = 21.39°C and DPT = 15.19°C

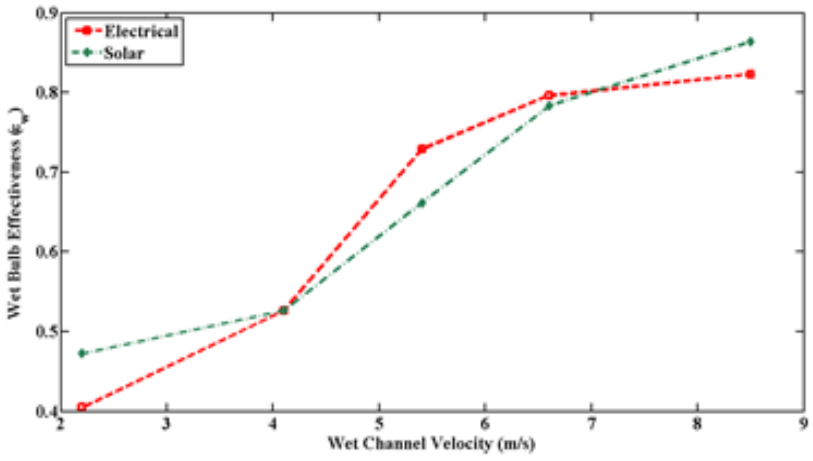
Mode of Operation	"Dry Channel Velocity (m/s)	Wet Channel Velocity	Product Air Outlet Temperature	Wet Bulb Effectiveness (ε_w)	Dew Point Effectiveness (ε_D)"
Electric Operated	2.7	2.2	25.2	0.6	0.37
		4.1	23.9	0.74	0.45
		5.4	23.1	0.82	0.5
		6.6	22.8	0.85	0.52
		8.5	22.5	0.88	0.54
Solar Operated	2.7	2.2	25	0.62	0.38
		4.1	23.7	0.76	0.46
		5.4	23	0.83	0.51
		6.6	22.6	0.87	0.53
		8.5	22.4	0.89	0.54

arrangements, are shown in Tables 2 to 5, providing an in-depth investigation of the system's performance at various DBTs.

4.1 Wet Bulb Effectiveness (Ɛw)

Figures 3(a), 3(b), 3(c) and 3(d) illustrate the fluctuation in wet bulb efficacy when the wet channel velocity varies at distinct air- DBT (31°C, 32°C, 33°C and 34°C) in both solar-integrated and non-solar systems. The wet channel velocity in the investigation was systematically varied from 2.2 m/s to 8.5 m/s. Figure 3 illustrates a constant correlation: when the wet channel velocity escalates, the wet bulb's effectiveness is enhanced, regardless of the initial air-DBT. This phenomenon is chiefly attributable to the augmented heat transfer capacity of the wet channel at elevated velocities, leading to reduced water temperatures at the system's exit.

Nonetheless, while the velocities in the wet channel remain constant, the wet bulb efficacy often diminishes



(A)

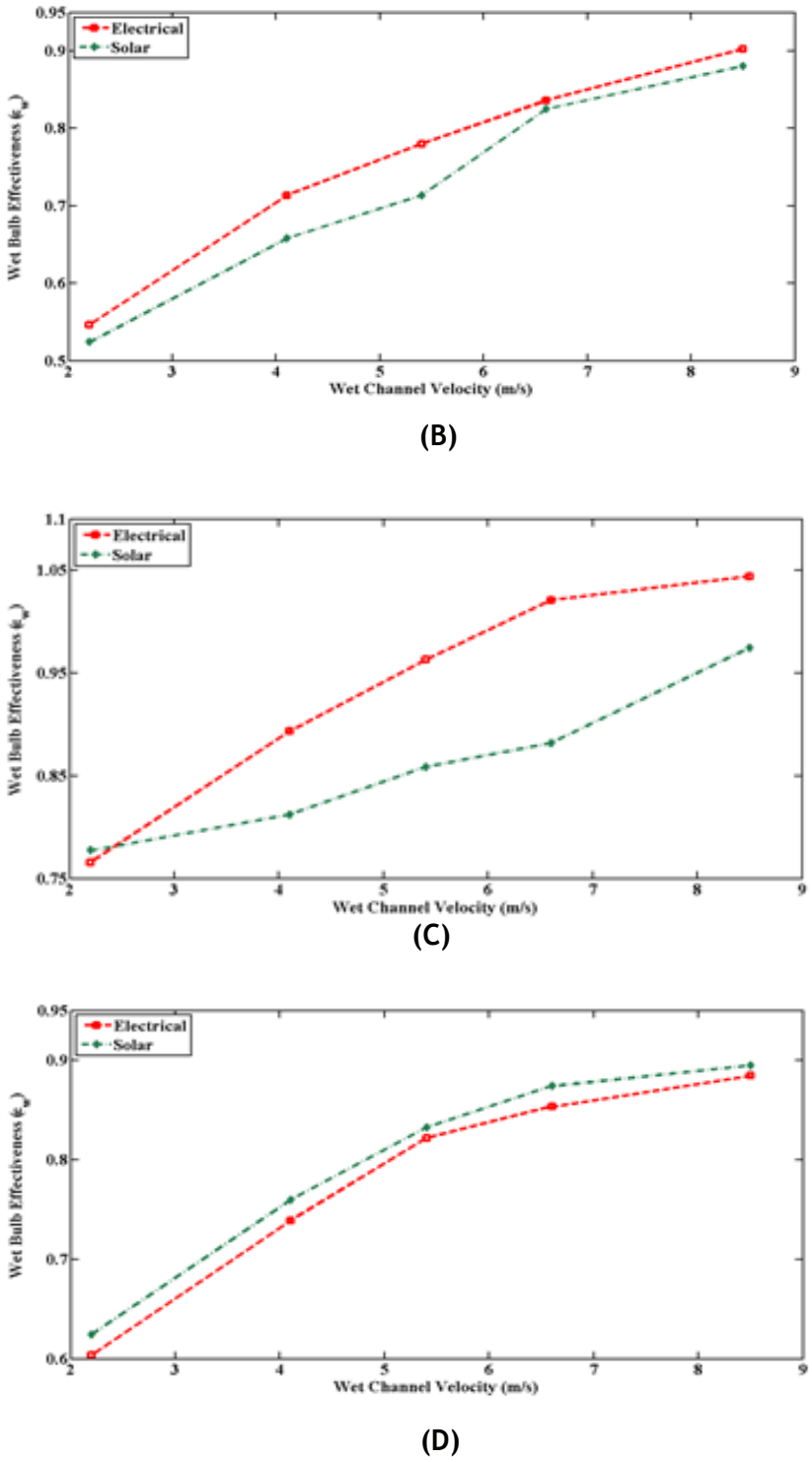


Figure 3. Variation of wet bulb effectiveness with wet channel velocity at **(A)** DBT 31°C, **(B)** DBT 32°C **(C)** DBT 33°C and **(D)** DBT 34°C.

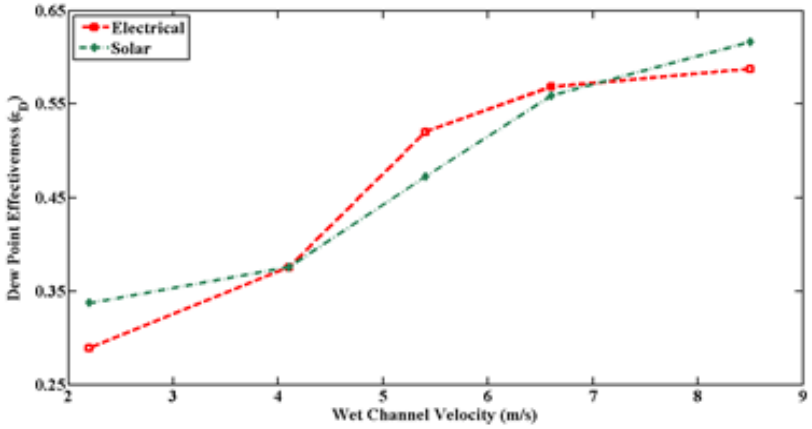
as the air-DBT increases. The wet bulb efficacy for both solar-integrated and non-solar systems varies from 0.40 to 0.86 at 31°C, 0.52 to 0.90 at 32°C, 0.76 to 1.04 at 33°C and 0.60 to 0.89 at 34°C. Significantly, when contrasting systems with and without solar power under analogous conditions, the wet bulb effectiveness may vary by as

much as 9%. The influence of solar power integration on wet bulb effectiveness exhibits uneven trends, revealing both positive and negative variations. At a DBT of 32°C and a wet channel velocity of 6.6 m/s, the solar-powered system exhibits a 2.35% superior wet bulb effectiveness relative to the non-solar system. Conversely, at a DBT of 31°C, the non-solar system has a 1.28% superior wet bulb effectiveness compared to the solar-powered system. The variation in result occurs when the system is working on a solar system due to voltage and frequency changes since solar power is unpredictable and intermittent.

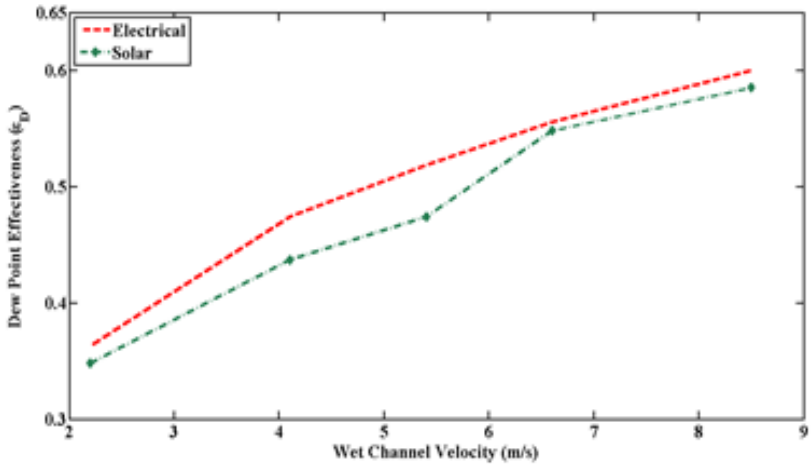
4.2 Dew Bulb Effectiveness (ε_D)

Figures 4(a), 4(b), 4(c) and 4(d) depict the correlation between dew point effectiveness and wet channel velocities in solar-powered and non-solar systems at DBT of 31°C, 32°C, 33°C and 34°C. Analogous to the tendency noted with wet bulb effectiveness, the dew point effectiveness constantly enhances as the velocities in the wet channel increase. This phenomenon can be attributed to the improved heat transfer efficiency within the wet channel of the heat exchanger, which is directly affected by the increased air velocity, facilitating more effective cooling.

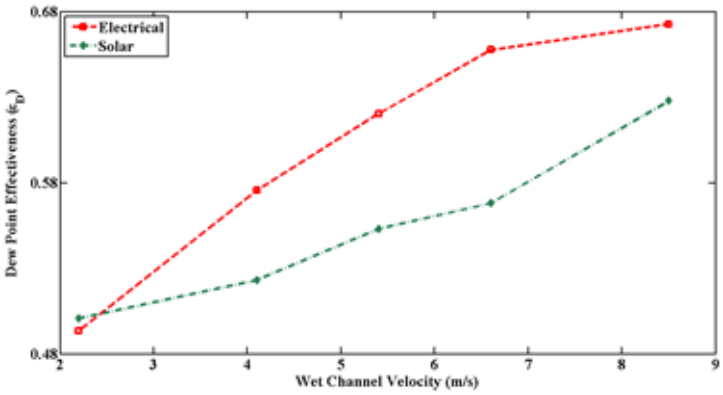
The dew point efficacy ranges from 0.29 to 0.62, 0.35 to 0.60, 0.49 to 0.67 and 0.37 to 0.54 for DBT of 31°C, 32°C, 33°C and 34°C, respectively. Values were documented for both solar-integrated and non-solar systems at wet channel velocities between 2.2 m/s and



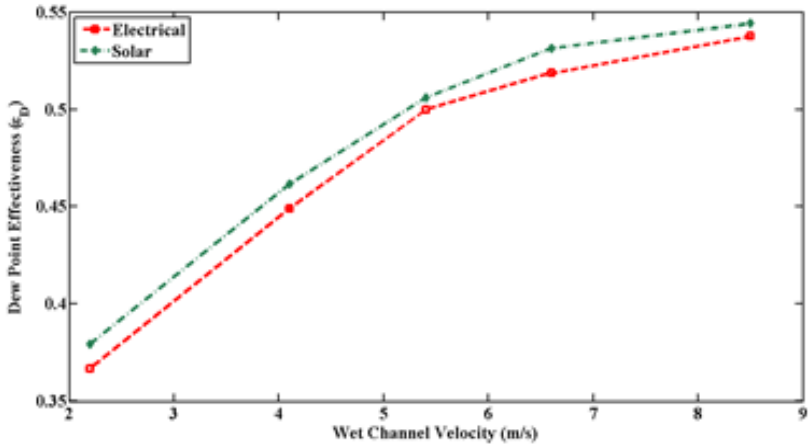
(A)



(B)



(C)



(D)

Figure 4. Variation of dew bulb effectiveness with wet channel velocity at **(A)** DBT 31°C, **(B)** DBT 32°C **(C)** DBT 33°C and **(D)** DBT 34°C.

8.5 m/s. No substantial link was identified between the utilisation of solar power and fluctuations. For example, at a DBT of 32°C and a constant wet channel velocity of 8.5 m/s, the non-solar system exhibited a value of 0.60, whereas the solar-powered system recorded a value of 0.59. At a DBT of 34°C and a wet channel velocity of 8.5 m/s, both systems demonstrated a value of 0.54. The average percentage difference between solar and non-solar systems is from 3% to 5%. These data underscore the intricate link between solar energy use and dew point efficacy, indicating the influence of solar power.

4.3 Effect of Relative Humidity (RH)

To assess the impact of relative humidity on system performance, a series of experimental tests were conducted utilising a non-solar powered system. The experiments were performed at a DBT of 31°C, with RH levels of 43%, 47% and 54%. Figures 5 and 6 illustrate the outcomes derived from these experimental tests. Raising the relative humidity of the air unequivocally leads to a reduction in both wet bulb effectiveness and dew point effectiveness across all wet channel velocities.

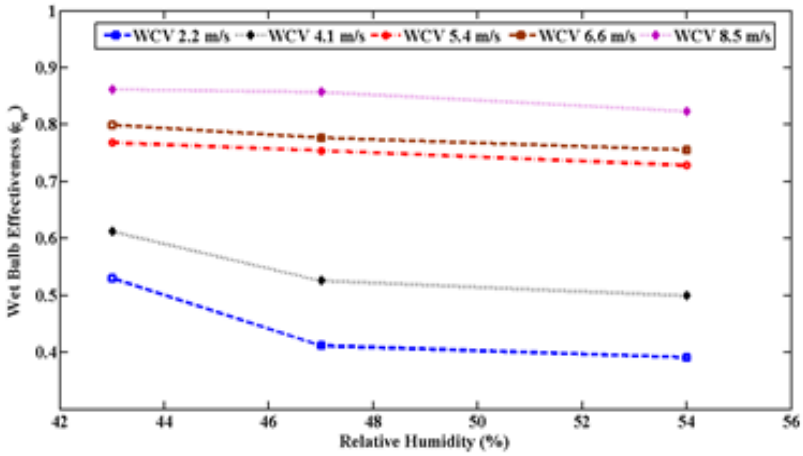


Figure 5. Effect of relative velocity on wet bulb effectiveness at DBT 31°C.

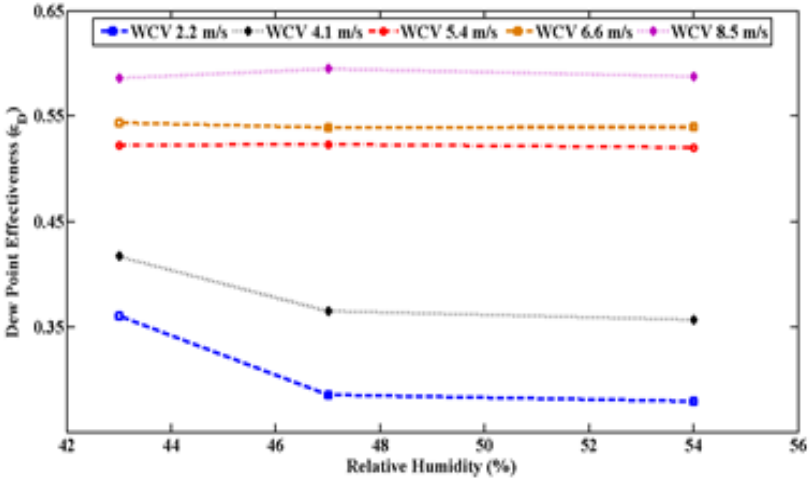


Figure 6. Effect of relative humidity on dew point effectiveness at DBT 31°C.

The decline in performance is attributed to the elevated relative RH adversely affecting the efficiency of heat movement within the system. The dew point effectiveness and wet bulb effectiveness exhibited significant reductions at lower wet channel velocities, particularly at 2.2 m/s and 4.1 m/s. As the RH rose from 43% to 54%, the wet bulb efficiency diminished by 26.41% and the dew point effectiveness decreased by 22.22% at a wet channel velocity of 2.2 m/s. Conversely, when the velocities in the wet channel were elevated to 5.4 m/s, 6.6 m/s and 8.5 m/s, a marginal reduction in the efficacy of the wet bulb and dew point was observed. At a wet channel velocity of 6.6 m/s, the wet bulb effectiveness diminished by 7.5% and the dew point effectiveness reduced by 2.57% as the relative humidity increased from 43% to 54%. This suggests that the effect of relative humidity on system performance is comparatively little when wet channel velocities are elevated.

4.4 Power Consumption

The incorporation of solar energy to power the air circulation blower and water circulation pump in the system appears to have a minimal effect on critical parameters such as wet bulb efficacy, dew point effectiveness and air relative humidity. In the arrangement

independent of solar energy, the blower utilises 30W of electrical power, whilst the water pump consumes 20W. Both devices function with efficiency of 70% and 60%, respectively. These elements collectively utilise a total of 77 watts. The daily electrical energy usage is 0.616 kilowatt-hours (kWh) over 8 hours of operation, incurring corresponding costs.

Conversely, the solar-powered system employs sustainable and eco-friendly energy, hence obviating the need for conventional means of generating electrical energy. Over one year, comprising 365 days, the solar system produces substantial savings of 224.84 kilowatt-hours (kWh) of electrical energy, with daily operation lasting 8 hours. The utilisation of solar energy not only reduces operational expenses but also emphasises its eco-friendly and sustainable attributes.

5.0 Conclusion

The research investigated the efficacy of evaporative cooling across various DBTs, emphasising the significant influence of wet channel velocity. The experimental trials demonstrated that increasing the velocity of the wet channel resulted in a decrease in the temperature of the air exiting the outlet, an enhancement in the efficiency of the wet bulb and an improvement in the efficacy of the dew point, irrespective of the DBT of the air. For example, when the DBT attained 32°C, increasing the velocity of the moist channel led to a decrease of 3.2°C in the temperature of the air egressing the system. This was accompanied by an enhancement in wet bulb efficacy from 0.55 to 0.9 and dew point effectiveness from 0.36 to 0.6.

Nonetheless, the integration of a solar system did not have a significant impact on the system's performance. The enhanced heat transfer characteristics noted at elevated velocities in the wet channel were the primary cause of the augmented wet bulb and dew point effectiveness. Furthermore, it was shown that for a constant DBT, both the dew points and wet bulb efficacy diminished as relative humidity rose. The employment of solar energy to power the pump and blower led to significant energy savings of 224.84 kWh over 365 days, based on 8 hours of daily operation, compared to an electrically driven system.

6.0 References

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