Experimental Investigation on Influence of Working Air Velocity in Wet Channel on Outlet Water Temperature in DPEC System Based on Cross Flow Heat Exchanger

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This paper aims to investigate the influence of working air velocity in the wet channel on temperature of outlet water which measures the overall performance of the DPEC system. The DPEC system based on cross flow heat exchanger is designed and developed and trial on the same is carried out. The experimental trial is carried out by keeping velocity of product air 2.7 m/s constant in dry channel, varying working air velocity from 2.2 m/s to 8.5 m/s in wet channel. Trial is also carried out at different Dry bulb temperature and relative humidity. The experimental results show that, the temperature of the water at the outlet decrease with increase in velocity of working air in wet channel. The result also indicates that at the higher DBT and lower RH, there is more drop in water temperature that shows high rate of evaporation in the wet channel and higher performance of DPEC System.

Keywords: Dew point evaporative cooling, wet channel velocity, dry channel velocity, Relative humidity, DPECS, M-cycle.

1. Introduction

Dew points evaporative cooling system is an advanced version of indirect evaporative cooling system in which both mass and heat exchange takes place between dry and wet plate. This system is popularly known as Maisotsenko cycle (M-Cycle). This system has an ability to drop the temperature of product air below wet bulb temperature of inlet condition which is the barrier in simple direct and indirect evaporative cooling system. This system not only cross the barrier of direct evaporative cooling system, can also drop the temperature of product air up to dew point temperature without addition of any water vapour.

The performance of this system is measured by mainly wet bulb effectiveness and dew point effectiveness and these performance parameters depends on dry bulb temperature, relative humidity, wet channel velocity (working air velocity) and dry channel velocity (Product air velocity). DPEC System has more effectiveness at lower humidity and higher DBT, hence it is more useful in the hot and dry region. This system can also be used at higher DBT and higher relative humidity by adopting dehumidifier at the inlet of wet channel.

2. Working principle

- The Dew point evaporative (DPEC) cooling system based on cross flow heat exchanger consist of dry channel, working dry channel and working wet channel

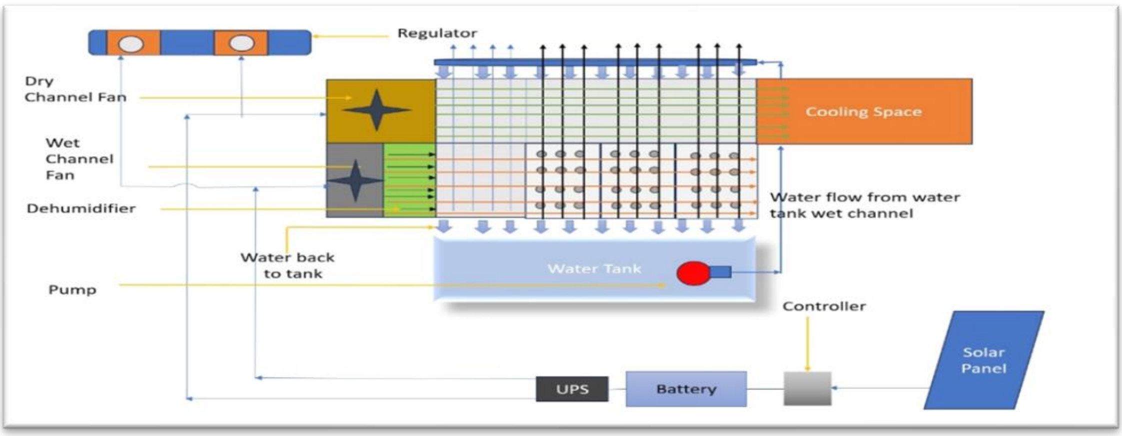


Fig1. line diagram explains working principle of dew point evaporative cooling system

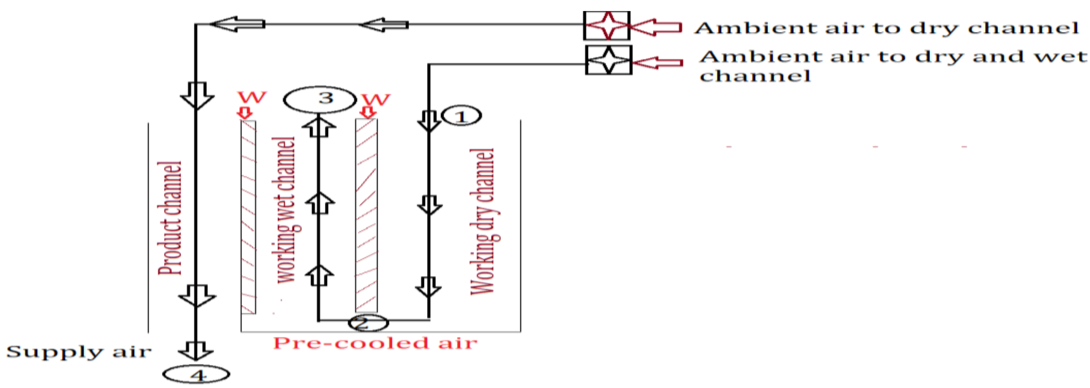


Fig.2 flow of product air (Primary air) and working air (secondary air)

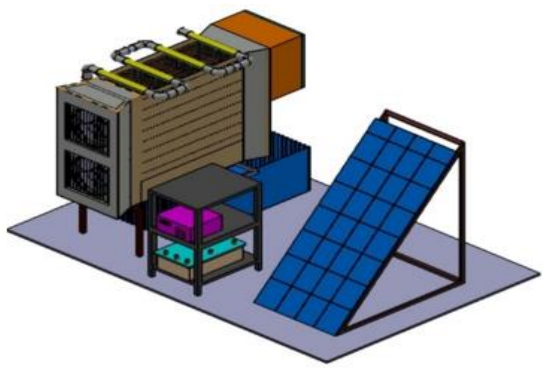
- The dry channel (upper half) and working dry channel (lower half) divide the single sheet in to two parts and on the other side there is a wet channel. The air that passes through dry channel is called primary air or product air on the other hand the air that passes through wet channel is called secondary air or working air

- But here the twist is, some quantity of air directly goes to wet channel and some quantity of air first enters in the lower portion of dry channel (working dry channel) and goes to wet channel through holes made on heat exchanger sheet.
- There are two blowers, they blow and regulates the flow of air through wet and dry channel
- The upper blower, blow the primary air that passes through dry channel (upper half of dry channel) form one end to complete another end. As per dew point evaporative cooling system principle, this air can be cooled up to its dew point temperature without addition of any water vapour.
- The lower blower, blows the secondary air that passes through both working wet channel and working dry channel (below half portion of the dry channel)
- The air that enters in to the working dry channel sensibly cooled and goes to the working wet channel through the holes.
- The objective of this mechanism is to lower the wet bulb temperature of working air before it enters in to working wet channel so that evaporation rate in the wet channel will be enhanced that results in improvement of overall performance of DPEC system in terms of dry bulb effectiveness and dew point effectiveness

3. Experimental set up:

Experimental set up consists of a heat exchanger that has 21 dry channel and 19 wet channels built together with the help of acrylic sheet and other supporting structure. At the lower end of heat exchanger, water reservoir is there, from where a submerged pump supplies water to the heat exchanger through PVC pipe. From this source water is sprayed on wet pad with the help of nozzle connected to small filter pipes which are joined to PVC pipe as shown in fig 3. There are two blowers, which controls the flow of air though dry and wet channel. this system is also facilitated with solar panel in order take advantage of renewable energy source.

a) Actual experimental setup



b) CAD set up

Fig 3. Experimental setup used for trial

4. Methodology

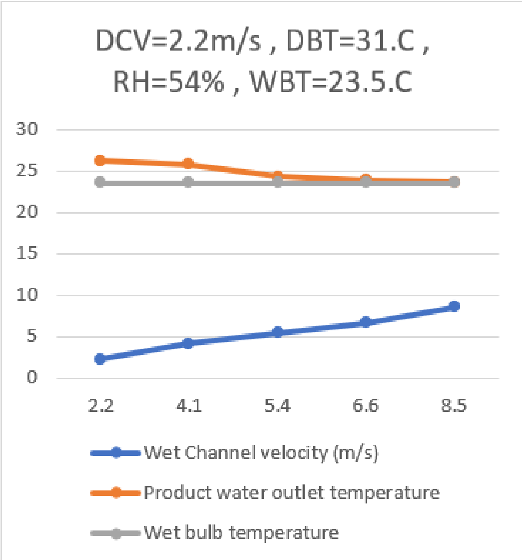
- The experiment involved keeping a consistent velocity in the dry channel while altering the velocity in the wet channel at different dry bulb temperatures. This method facilitated the accurate measurement of temperature decreases in the air around the product, the air used for work, and the water, so offering valuable information on the system's efficiency in varying temperature scenarios.
- The experiment entailed manipulating the velocity in the wet channel at varied relative humidity levels, while maintaining a constant velocity in the dry channel. This technique facilitated the examination of temperature decreases in the water, ambient air, and processed air, elucidating the influence of humidity variations on the cooling mechanism.
- The experimental configuration was tested under two conditions: with and without the inclusion of a solar panel. This was done to observe any variations in the system's performance. This comparative method allowed for the evaluation of how the use of solar energy affects the performance and efficiency of the cooling system.
- In order to assess how variations in relative humidity affect the system's performance, an experiment included the use of a dehumidifier. This component enabled researchers to examine the effects of changes in relative humidity levels on the cooling process and overall system performance.

5. Results and discussion

Trials on experimental set up i.e. on DPEC system are performed at various DBT and relative humidity by keeping velocity in dry channel constant (primary air) 2.7m/s and varying working air velocity from 2.2 m/s to 8.5 m/s in wet channel. During each reading, it has been given sufficient time to the heat exchanger to come to steady state. Highly accurate instruments are adopted like thermometer, anemometer and hygrometer to measure temperature, velocity and relative humidity. sufficient number of observations are recorded before coming to experimental conclusion.

Table (1): Experimental observations at different DBT and RH

		Product water outlet temperature							
Dry channel velocity(m/s)	Wet channel velocity(m/s)	DBT-31d.C RH-54%	DBT-32 d.c RH-46%	DBT-31 d.c RH-47%	DBT-31d.c RH-42.60%	DBT-32 d.c RH-42%	DBT-33 d.c RH-40%	DBT-33.5 d.c RH-39%	DBT-34 d.c RH-32.5%
2.7	2.2	26.2	25.4	27.6	24.7	25	23.3	26.6	24.1
	4.1	25.8	25.1	26.5	24	24	22.6	25	23.2
	5.4	24.3	24.8	25.2	23.4	23.4	22.1	23.6	22.8
	6.6	23.9	24.6	24.5	23	23.1	21.6	23.1	22.6
	8.5	23.6	24.8	23.6	22.8	22.3	21.3	22.8	22.3



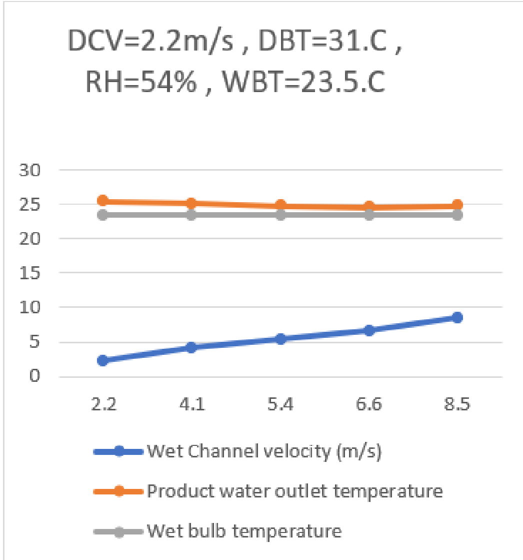
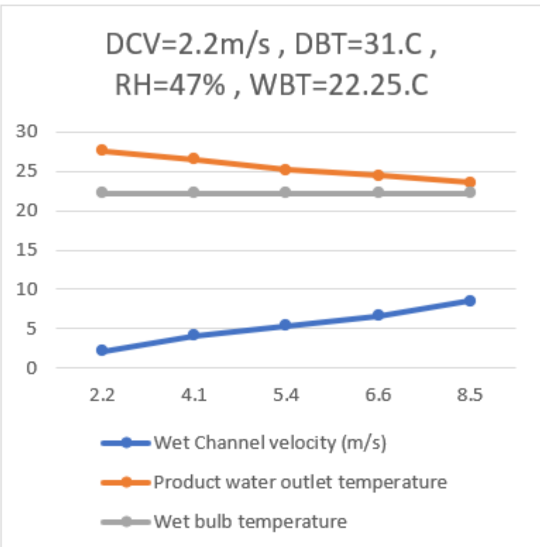


Fig (4) wet channel velocity vs water Temp Fig (5) wet channel velocity vs water Temp



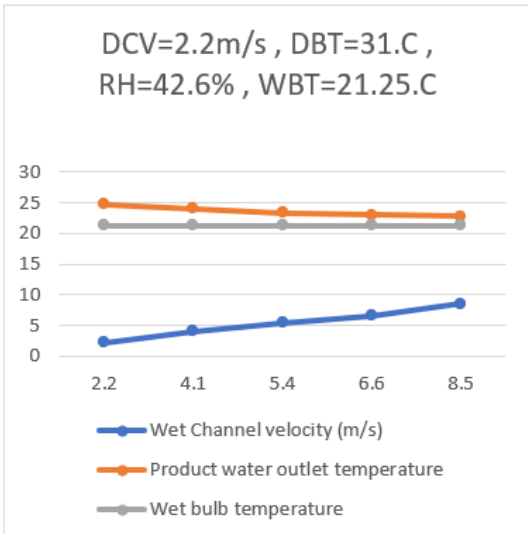
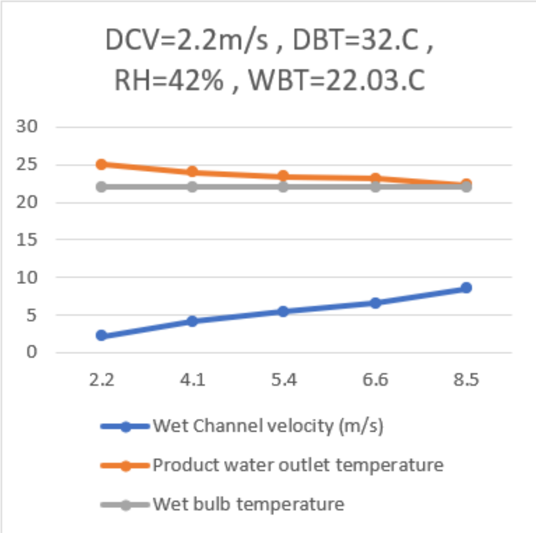


Fig (6) wet channel velocity vs water Temp Fig (7) wet channel velocity vs water Temp



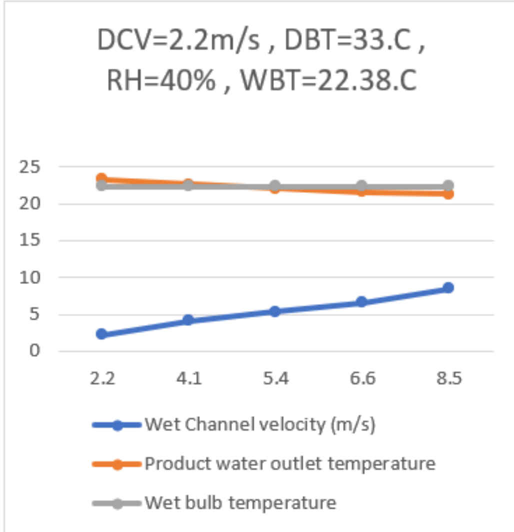
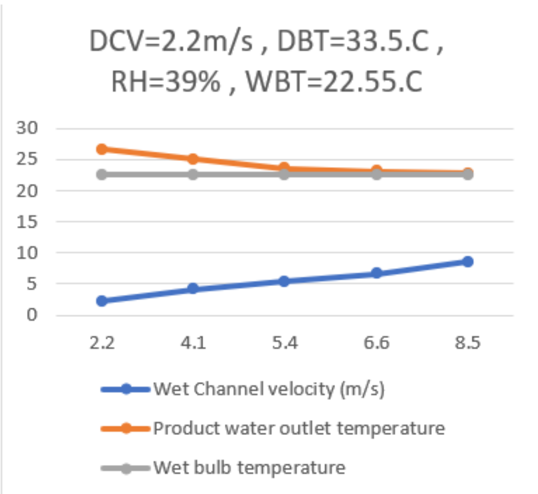


Fig (8) wet channel velocity vs water Temp Fig (9) wet channel velocity vs water Temp



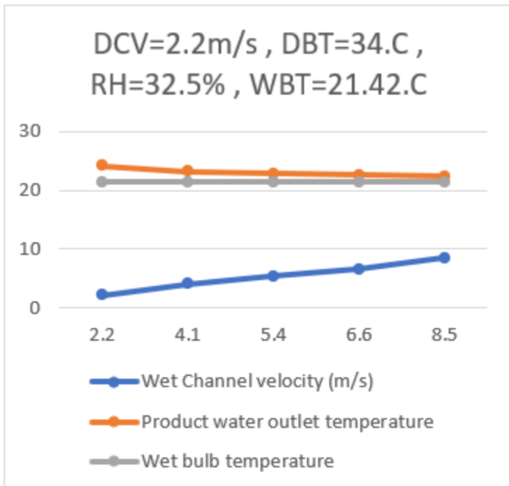


Fig (10) wet channel velocity vs water Temp Fig (11) wet channel velocity vs water Temp

6. conclusion:

It is concluded form the experimental trials and observations made

- Increase in velocity of wet channel (working air) there is considerable decrease in water temperature. As per observation made, at DBT 33 degree C and relative humidity 40% and when velocity of wet channel is maintained 8.5m/s, water temperature is dropped up to 21.3 degree C from ambient which is lowest in the observation table
- It is also found that at lower relative humidity, there is drastic decrease in water temperature from the ambient.

• Finaly it is concluded that at higher velocity in wet channel (working air), high DBT and low relative humidity makes the water temperature drop more, this influence on high evaporation rate in the wet channel and overall improvement in performance of DPEC system

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