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DESIGN AND DEVELOPMENT OF ENHANCED DEW POINT EVAPORATIVE COOLER BY MODIFIED DRY MEDIUM

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ABSTRACT
The increasing energy demand for air conditioning system prompted a need to find energy efficient alternative to vapor compression cooling systems. Dew-point Evaporative Cooling is an advanced configuration of indirect evaporative cooling technology, which has been regarded as a game changer. However, to improve its cooling performance by incorporating certain geometrical design modifications for the flow of atmospheric air and water. This design concept focuses on combining the conventional dew point cooling model with Maisotsenko dew point cooling model that improves the cooling capacity by circulating low temperature air into the system. The dry medium is divided into three sections and the flow configuration is one primary supply air and the two secondary supply air. Secondary supply air makes counter flow arrangements with inlet primary air that makes efficient heat transfer possible. Evaporative cooling in the wet medium is done by additional air supply which is parallel and opposite to the wet stream that improves evaporation rate. The design is made by using solid works. The geometrical design modification shows how the different flow configuration made in the dry medium can affect the cooling performance.

Keywords:
Evaporative cooler, Dew point Indirect Evaporative Cooling (DPIEC), Maisotsenko cycle, turbulence flow.

I Introduction

Air conditioning is important due to its capability to regulate the local thermal environment. It enables humans and other living beings to thrive in some of the most challenging weather conditions. In contemporary life, mechanical vapor compression systems are found in nearly every building and infrastructure. Statistics indicate that nearly 90 percent of air conditioning units rely on mechanical vapor compression systems, which come with several drawbacks and consume a significant amount of electricity.[1] This paper discusses the opportunities and challenges of a dew point evaporative cooling. The challenges of developing dew point evaporative cooling includes optimization of water consumption rate, cooling capacity, etc. [2] The goal of this project is to create a robust machine model for Maisotsenko dew point evaporative cooler performance prediction and comprehensive analysis.[3] The best design and operation of a mixed-flow dew point evaporative cooler are covered in this study. Because of their low production and operating costs, evaporative cooling technologies offer a promising solution to address the growing cooling energy poverty. More intricate designs, including dew point indirect evaporative cooling (DIEC) systems, can reach high performance.[4] In this study, the dew point evaporative cooler is manufactured using additive manufacturing, and the model is experimentally analyzed. An intriguing substitute for lowering energy use and CO_2 emissions related to building cooling is evaporative cooling (EC).[5] This study demonstrates how turbulence produced by a roughened dry medium affects cooling performance. Dew-point evaporative cooling (DPEC) is well known for its high efficiency and low energy use.

II Exploration Methodology

The exploration methodology focusses on understanding the current state of cooling techniques and challenges to focus on efficiency of the system modification. It also explores existing studies about material properties, flow configuration and evaporation rate. The vapour compression cycles have a better cooling rate compare to evaporation cooling cycles but it impacts the environment. The major drawback of the vapour compression cycle is it impacts the climate change and the refrigerants used in vapour compression cycles impacts the ozone layer and it's the major factor of ozone layer depletion. Another drawback of the vapour compression cycle is the energy consumption. According to a study half percent of the building electricity is consumed due to vapour compression cycles. On the other side evaporative cooling cycle is environmentally friendly and it's the major concern of today. The reason the evaporative cooling is noted today due to the environmentally friendly nature. According to data, today ten percent of the air conditioning units is works on evaporative cooling and 2035 estimated 20 percent of the air conditioners worked by a principle of evaporative cooling. The drawback of the evaporative coolers is the cooling capacity. The project focusses on increasing the cooling capacity of dew point evaporative coolers that benefit the future.

IIIModel Design and Development

In this analysis work, a novel Dew point Indirect Evaporative Cooling (DPIEC) design is developed. The device is composed of overlapping modular elements made of polycarbonate and the fluid film thickness of 0.8mm made up of fibre clothing with 8 number of channels assembled and with other design parameters as shown in Table 1**.** The base element consisted of dry channels and a wet plate, with the latter covered with a wicking material on one side.

Table 1: Design parameters

Design Elements	**Parameters in mm**
Length	63
Width	30
Inside loop thickness	1
Inner wall thickness	0.25
Channel width	3
Outer wall thickness	1
Fluid film thickness	0.8
Number of channels assembled	8

3.1 Model Creation

The base element consisted of dry channels and a wet plate, with the latter covered with a wicking material on both sides. In this study we create an additional dry air medium which is equal and opposite of the primary dry air medium. In that additional dry medium, remaining air passes through in cross flow arrangements, which makes better heat transfer possible and it also rotates and joins the primary air medium that creates turbulence in the region. A water distributor was installed at the top of the device to supply water to the wet channels. Figure 2 illustrates the photograph of the assembled device, along with the inlet and outlet of the air flow. The cross sectional view shows how the flow is reverses and how the reversing medium is affecting heat transfer rate.

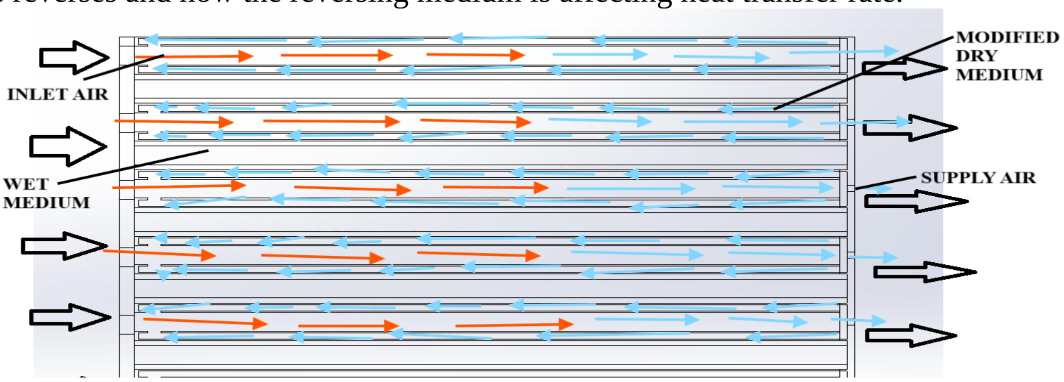

Figure 2: Schematic section of the prototype and 3D flow paths

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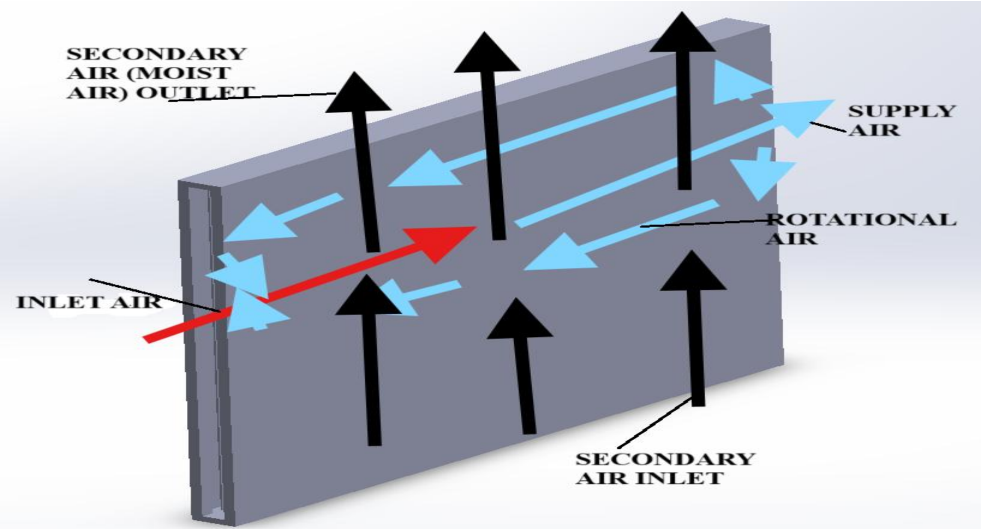


Figure 3: Modified dry medium 3D fluid flow path

In the 3D flow path figure 3 shows how the modified dry medium will affect the heat transfer rate.

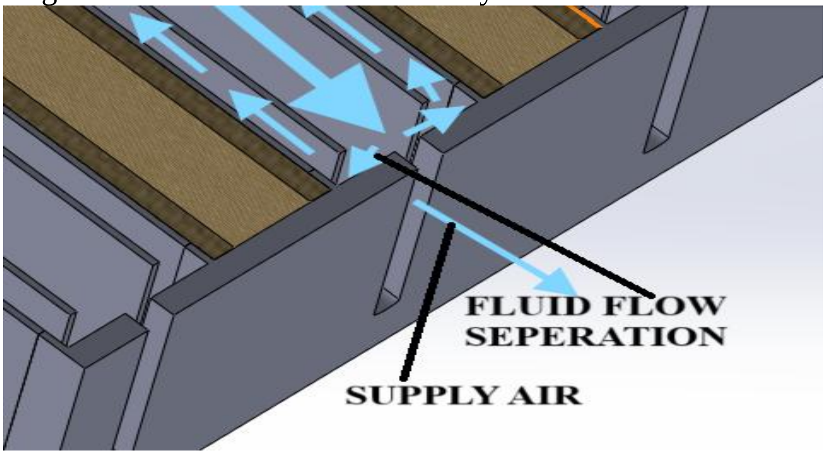


Figure 4: Pressure generation and fluid flow reversal

The figure 4 shows how the fluid reverses because of the pressure created because of the blockade, this pressure makes the flow reverses and rotated in the medium.

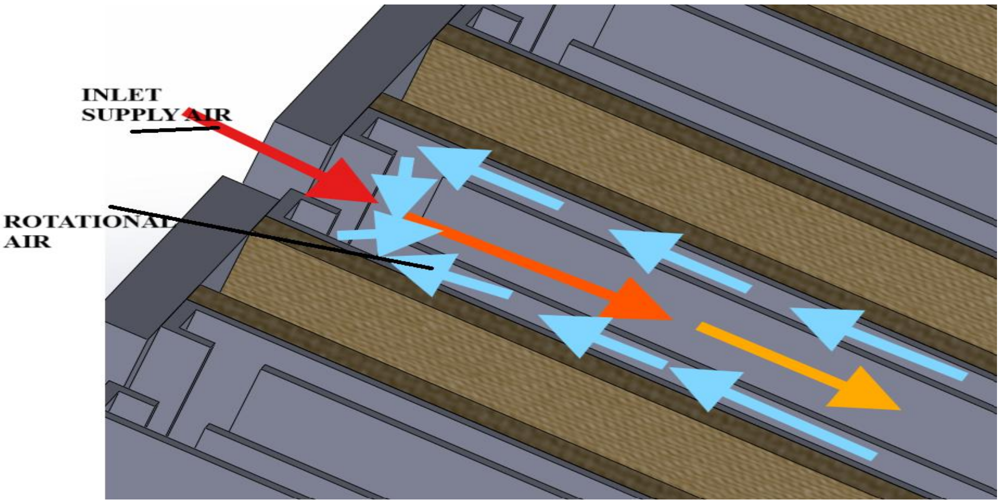


Figure 5: Heat exchange and turbulence creation

In the figure 5, the rotational air comes near to the inlet supply air and creates turbulence in the dry medium. This rotational air also makes inlet supply air temperature decreases suddenly. Figure 6 shows the total assembly setup of the enhanced dew point evaporative cooling with the modified dry medium. 8 dry mediums are arranged and in between the wet medium is placed. Additional air flows in between that is equal and opposite to the wet stream that makes efficient evaporation possible. The primary air entrance cross section is shown in the figure 7

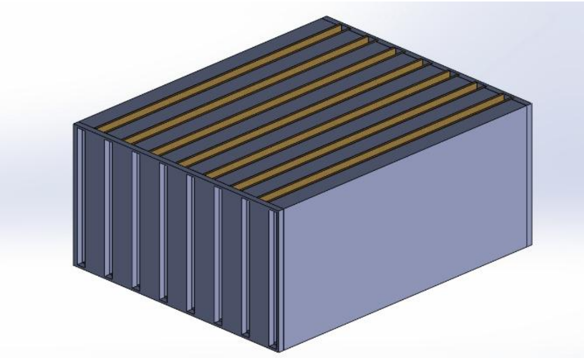


Figure 6: Assembly Isometric view

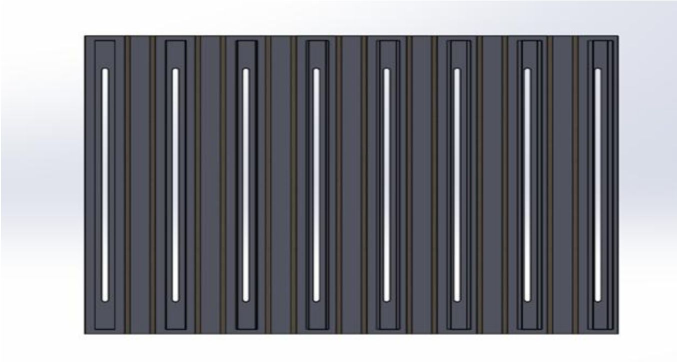


Figure 7: Side view primary air entrance

The side view primary air exit is shown in the figure 8. The outlet air passes through this side. Upper air secondary air exit cross sectional view is shown in the figure 9. Moist air which is highly wet content that transfer heat mass into the atmosphere. Overall design modifications tries to show how the different flow configurations affect the cooling capacity of the dew point evaporative cooler**.**

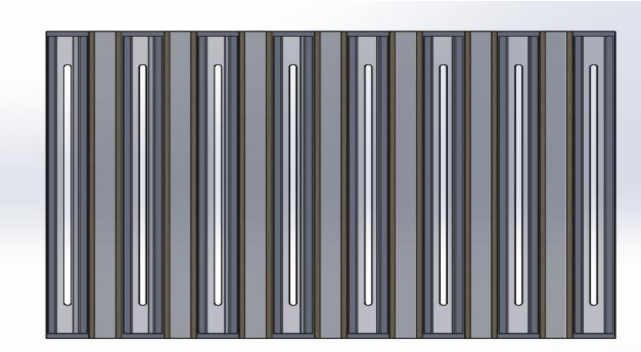
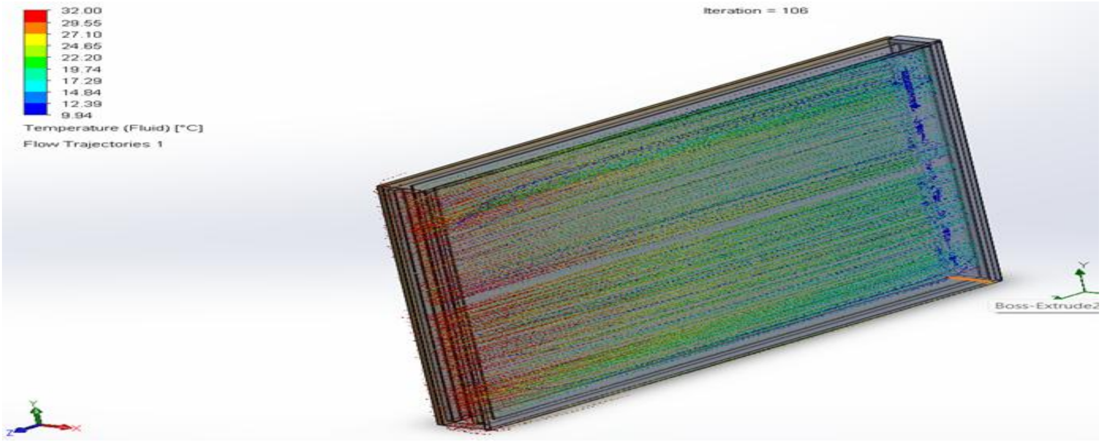


Figure 8: Side view primary air exit


Figure 9: Upper view secondary air exit

IV Result and Conclusion

The analysis shows the reduction of temperature in the region and also stabilize the distribution of heat from the region. The flow analysis is made by using solid works flow simulation. In the figure 10 the flow is distributed and it's rotated by an additional of 2 ducts which is parallel and opposite to the primary medium. The analysis not showing the perfect heat distribution of the medium. The perfect optimization makes the research capable of getting better heat transfer. This study developed and experimentally tested a novel mixed-flow DPIEC. The goals of the design were low production costs, low complexity of equipment, and compactness. Therefore, the device was a small prototype made of polycarbonate sheets**.** The additional medium was proposed to balance the high effectiveness of the counter-flow configuration with the ease of construction of the cross-flow configuration. Plates covered with a wicking material was selected to be consistent with the most recent developments.



Fugure10: Flow analysis single dry medium

Rotational fluid arrangement in the system is novel and it has several benefits compared to the conventional and Maisotsenko evaporative coolers. Cross flow arrangement with the fluid to fluid medium makes a better heat transfer possible, the evaporation is decreased by increasing temperature so the additional fluid medium helps to increase the evaporation rate and the turbulence created by the additional medium helps to increases the cooling rate. Despite the effect of water distribution being generally disregarded in the literature, a few published works on the topic agreed on the importance of uniform water distribution. This compactness of the device could make it more attractive for commercialization.

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