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EXPERIMENTAL ANALYSIS OF METAL SHEET STRUCTURE AS EVAPORATIVE COOLING PAD

Rahul Verma
Department of Thermal Engineering (Mechanical), Student of Govt. Engineering College,
Jagdalpur, Bastar (C.G.) India
E-mail: rahulv29205@gmail.com

Himanshu Agrawal
Department of Mechanical Engineering, Associate Professor, Govt. Engineering College,
Jagdalpur, Bastar (C.G.) India
E-mail: himanshu@gecjdp.ac.in

Abstract

Evaporative cooling or vapour compression air conditioning can be used to cool a space. Each cooling system has its own set of benefits and drawbacks. The vapour compression device consumes more electrical energy while also being dangerous to the environment. The erosion of the ozone layer and global warming are two of its harmful consequences on creatures. Evaporative air cooling is inexpensive and convenient, but it does not have the ability to condition the air in the space as compared to vapour compression device. Continuous operation without proper mixing of ambient air leads in an increase in humidity. It makes the residents of the area feel uneasy. The current study focuses on these challenges and proposes the usage of Modular Cooling Pads as an alternative cooling method. The work has had the overall impact of lowering maintenance and operational costs without losing comfort. The design and performance of innovative non-cellulosic evaporative cooling pads manufactured from galvanised metal sheets are described in this article. The cooler has been subjected to a ten-day testing. The results show that the average temperature dropped by 9.5 degrees Celsius from the ambient temperature.

Key Words: Evaporative Cooling, Vapour Compression Air Conditioning, Environment, Modular Pad, Galvanized Metal Sheet.

1. INTRODUCTION

The first people to use an evaporative air cooler in the form of a wind catcher were the Egyptians and Persians(Wikipedia n.d.). The wind is routed over the water tunnel in this system, and the cooled exit air is circulated throughout the building. The concept of Khus, wood wool, and honeycomb pad evolved gradually. All of this obstructs the free passage of air while also providing a superior cooling effect. The most efficient and environmentally friendly cooling method is evaporative air cooling, which operates on the concept of heat absorption by water evaporation. Modern evaporative systems are an example of this type of evaporative system. Desert Coolers or Window Coolers are the modern names for evaporative cooling devices. Its key components include a water reservoir, a water pump, three side grills, and wood wool, khush, or honeycomb pads are the essential components of it(Stickley n.d.). The ambient air is sucked, cooled, and discharged to the room, without air conditioning, through a cooler fan. The air coming from a traditional type of evaporative cooler is hazardous to residents because the evaporation media used in this type of cooler is wood wool, and the air passing through it is not as pure. The reason for impurity is the composition of dust in wood wool, which causes allergies in residents, as well as improperly maintained wood wool pads, which are the source of bacteria in the cooler. Many studies have been conducted in the field of evaporative cooling systems to better understand the various ways to improve cooling efficiency and to determine the potential of these systems in various situations and locations. Michael Bennett, John Bell have conducted experiment on direct evaporative cooling in Australia. They try to evaluate the significance of direct evaporative cooling in different cities of Australia. Their findings demonstrate that in Australian climates, direct evaporative cooling is particularly important(Guan, Bennett, and Bell 2015). Deepak Bishoyi, K. Sudhakar Conducted experiment on direct evaporative cooler. They try to evaluate the performance of two different cooling pad first on Aspen cooling pad and second on honeycomb. Their findings show that honeycomb cooling pads outperform aspen cooling pads(Bishoyi and Sudhakar 2017). Waleed A. Abdel-Fadeel and Soubhi A. Hassanein devised an equation for estimating the wet bulb temperature from ambient temperature and humidity, as well as an equation for computing the outlet air humidity and temperature in the direct evaporative cooler. The equations produce values that are quite close to those found in existing psychrometric charts(Abdel-Fadeel and Hassanein 2012). Comparative investigation of cross-flow indirect evaporative air coolers was provided by Sergey Bolotin and colleagues(Bolotin, Vager, and Vasilijev 2015). a computational analysis of two cross-flow indirect evaporative air cooler configurations: a standard cross-flow heat exchanger and a regenerative cross-flow exchanger Performance study based on a mathematical model established allows for the establishment of optimal operating parameters that ensure relatively high efficacy while reducing pressure drops and water consumption.

Experimental examination of water spraying in an indirect evaporative cooler from the perspectives of nozzle type and spray strategy were provided by Tiezhu Sun et al(Sun, Huang, Chen, et al. 2020). According to their findings, water distribution has a significant impact on indirect evaporative cooler performance (IEC). Experimental research on a spray evaporative cooling system for air-cooled chiller condensers was presented by Hua Yang et al(Yang et al. 2020). Their findings suggest that judicious application of a spray cooling system can reduce the power consumption of air-cooled systems and so save energy. Demis Pandelidis et al.(Pandelidis et al. 2021) conducted an experimental study on eight different plate materials for evaporative air coolers. The findings indicate that synthetic materials are better suited for plate materials in evaporative air coolers. Theoretical and experimental investigation of heat and mass transport of a porous ceramic tube type indirect evaporative cooler is presented by Tiezhu Sun and colleagues(Sun, Huang, Qu, et al. 2020). The best performance of the porous ceramic IEC prototype has been attained, according to the results of an experimental research. A. Fouda and Z. Melikyan attempted to create a simplified model for heat and mass transfer analysis in a direct evaporative cooler. Their research indicates that the calculated and experimental results are in good accord(Fouda and Melikyan 2011). Nandy Putra, Bintang Fikri, and Evi Sofia tested the performance of a direct–indirect evaporative cooler with heat pipe for effective heat and mass transmission. The saturation efficiency of a multistage direct evaporative cooler with a pre-cooler was improved by organising the heat pipe and evaporative cooler as a multistage direct evaporative cooler with a pre-cooler(Fikri, Sofia, and Putra 2020). Performance investigation of two new evaporative cooling pad materials was presented by J.K. Jain and D.A. Hindoliya. Coconut and palash fibres were evaluated in a laboratory with a specially constructed test set up. Palash and coconut fibres have a lot of potential for usage as a wetted media in home and commercial direct evaporative coolers, according to their findings(Jain and Hindoliya 2011). Computational Fluid Dynamic Analysis of an Evaporative Cooling System was carried out by Kapilan N., Manjunath Gowda M., and Manjunath H. N. Their findings reveal that the system's experimental and CFD results are identical(Kapilan, Gowda, and Manjunath 2016). Non-cellulosic evaporative cooling pads made of galvanised metal sheets are designed and tested by Mohammed A. Alodan and Abdulelah A. Al-Faraj. When compared to stated results of commercial cellulose pads, the studies in this study produced very good cooling efficiency results(Al-Faraj, Alodan, and Al-Faraj 2005).
The cooling media, which is responsible for cooling, is the subject of this research. In an evaporative cooling system, wood wool, khush, or honeycomb mesh are utilized. In this study, the cooling medium is a cooling pad (Sheet material framework).

2. METHODOLOGY

This study looked at the performance of two distinct types of evaporative coolers. The evaporative medium in cooler 1 is khus, while the evaporative medium in cooler 2 is honeycomb mesh. Both coolers are of medium size. The table 1 shows the various parameters on which coolers were compared.

Table 1: Comparison between two different types of evaporative cooler

Parameter	Cooler 1	Cooler 2
Fan diameter	381 mm	381 mm
Evaporative Medium	Khus	Honeycomb Mesh
Ambient Temperature	34 °C	35 °C
Ambient Humidity	32%	27%
Water temperature at start	27 °C	26°C
Conditioned Temperature	25 °C	24°C
Conditioned Humidity	67%	62%
Water temperature at end	23°C	22°C

2.1. Physical Design: A physical model of a cooler was built using a modular cooling pad as the evaporative medium. A cooler with dimensions of 779.78 x 584.2 x 543.56 mm3 is being prepared, as illustrated in the diagram below.

Figure 1.a: Isometric View of Cooler

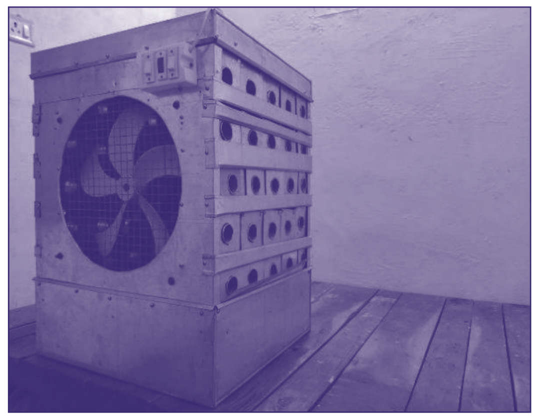


Figure 1.b: Back View of Cooler

For air suction and water distribution in the model 70 cooling pads, 25 pads were utilised on the left, 25 pads on the right, and 20 pads in the back. For the cooled air outlet, a 779.78 mm x 584.2 mm hollow cut with a diameter of 381 mm was employed on the front surface. This model uses a cooling pad with dimensions of 101.6 x 101.6 x 66 mm3, a hollow tube at the centre with a diameter of 40.64 mm and a length of 66 mm, as illustrated in Figure 2.

Figure 2.a: Isometric View of Single Cooling Pad

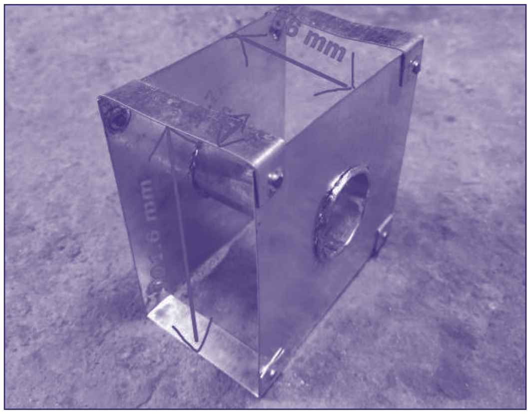
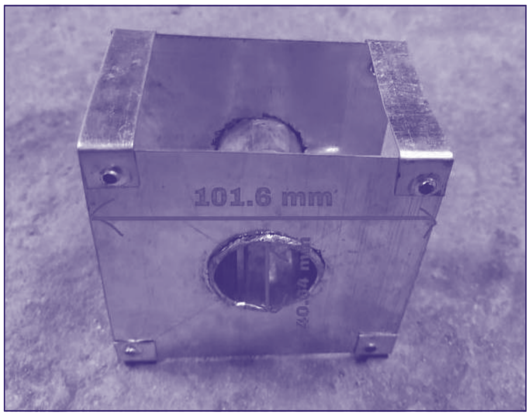


Figure2.b: Front View of Single Cooling Pad



The IS 277 sheet material that is utilised to make the cooling pad and cooler body has a thickness of 0.6 mm. The cooled air exit in this type is a 1275 rpm fan with a diameter of 381 mm. Three pipe mesh and a 900 Ltr/hr water pump are used for water supply. Continuously ten days from 01/03/22 to 10/03/22 experiment was done at Raipur, Chhattisgarh, India (21.224503,81.607892). The experiment was set to take place between the hours of 1:00 and 5:00 p.m. The measurement was conducted every half hour during this time frame. The temperature and humidity of the ambient and room conditions were measured using a little LCD digital thermometer hygrometer temperature metre gauge equipment. The water temperature was measured using an infrared forehead thermometer.

Figure 3.a: Back View of Experimental Setup of Cooler

Figure 3.b: Front View of Experimental Setup of Cooler

3. RESULT AND DISCUSSION

The examination of two different types of evaporative coolers is shown in Table 1. Cooler 1 has a 9°C temperature drop, while cooler 2 has an 11°C temperature drop. Figure 4 show the change of ambient temperature, conditioned room temperature and water reservoir temperature during the experiment. Figure 5 show the change in humidity during the experiment. The minimum, maximum, and average of the recorded measurements are summarised in Table 2. The numbers and table clearly indicate the ambient temperature throughout a ten-day period. The average ambient temperature was around 35 °C and the minimum and maximum temperature were around 30 and 37 °C, respectively. Ambient humidity during the experiment ranged from 21 to 41% with an average of around 33.3%. Average conditioned room temperature was around 25 °C. Average Humidity of the room was around 67%. At the start of the experiment average water temperature was around 25 °C and at the end average water temperature was around 21.5 °C. Figure 4 shows that on 10th march the temperature drop is around 11 °C which is significant temperature drop. In this experiment on an average 9.5 °C temperature drop was observed.

Figure 4:Line Chart of Ambient, Conditioned, water at start and water at end Temperatures

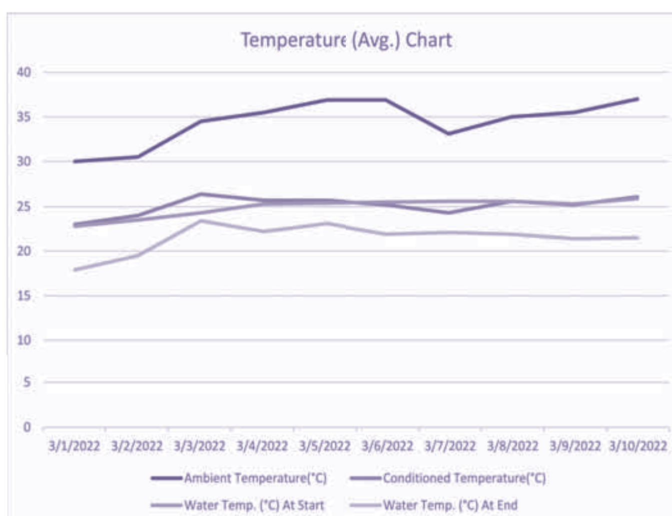


Figure 5: Line Chart of Ambient humidity and Conditioned Humidity

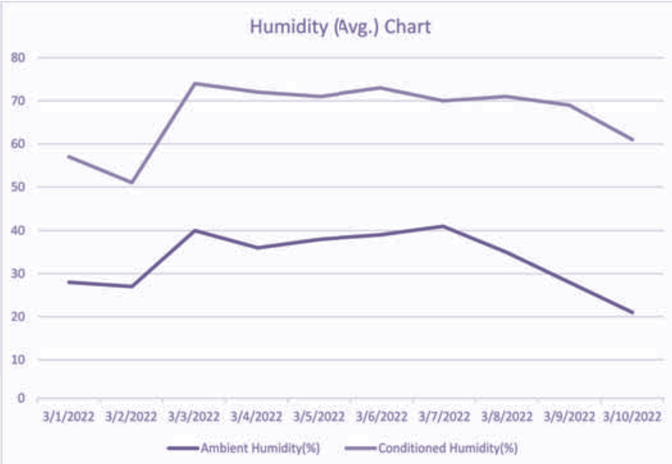


Table 2: Minimum, Maximum & Average of the parameters during the experiment

Parameters	Minimum	Maximum	Average
Ambient Temperature	30	37	34.49
Ambient Humidity	21	41	33.3
Water Temperature (At start)	22.8	25.9	24.92
Conditioned Temperature	23	26.4	25.15
Conditioned Humidity	51	74	66.9
Water Temperature (At end)	17.9	23.4	21.49

4. CONCLUSION

This research work presents a novel type of cooling pad which can be replace Khus and other cellulose pads. The temperature drop is significant in this study which is similar kind of result given by the traditional type of evaporative cooler. Salt deposition and dust build-up on the pad's surfaces are easier to remove with the revised pad layout. In comparison to commercially supplied cellulosic pads, this will undoubtedly have a longer usable life. Because metal sheets are heavy and corrode with time, they may not be the best solution for non-cellulosic media. However, the positive findings of this study will serve as a foundation for our efforts to develop non-cellulosic pad materials that are less expensive, lighter in weight, have a longer usable life, and are more effective at cooling than cellulosic pads.

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