A Review on Design and Development of 360° Evaporative Air Cooler

Dhanshri Bodile[1]✉, Vaibhav Garghate[2], Rushikesh Khode[3], Aditya Yedkar[4], Ishika Wankhade[5], Anand Wankhade[6], Shubham Bhagat[7]
[1,2,3,4,5,6,7]UG Students, Department of Mechanical Engineering, Jawaharlal Darda Institute of Engineering and Technology, Yavatmal -445001, Maharashtra, India
✉ Corresponding author email: dhnshri15@gmail.com

Cite this article: Dhanshri Bodile, Vaibhav Garghate, Rushikesh Khode, Aditya Yedkar, Ishika Wankhade, Anand Wankhade, & Shubham Bhagat, "A Review on Design and Development of 360° Evaporative Air Cooler", International Research Journal of Scientific Studies, vol. 2, no. 1, pp. 13–18, Jan. 2025, doi: https://doi.org/10.5281/zenodo.14670041

Abstract: *This review presents a detailed case study on evaporative coolers, a widely-used technology for air conditioning in hot and dry climates. It is also known as swamp cooler. Evaporative cooling, an energy-efficient and environmentally friendly alternative to traditional refrigeration-based cooling systems, operates on the principle of water evaporation to reduce air temperature. The paper critically examines various aspects of 360-degree evaporative coolers, including their working principles, types, efficiency, and environmental impact. The case study explores a specific application of evaporative coolers in an industrial or residential setting, analysing performance data under different environmental conditions. Key performance metrics such as cooling efficiency, water consumption, and energy savings are discussed in comparison to conventional air conditioning systems. Additionally, factors like the local climate, water quality, and maintenance requirements are evaluated for their impact on the cooler's performance. This review also addresses common challenges faced by evaporative coolers, such as humidity limitations and scaling issues. By drawing insights from the case study, the paper provides recommendations for optimizing evaporative cooling systems for enhanced performance and sustainability. The findings suggest that, while evaporative coolers are a viable solution for specific climates, their application must be carefully tailored to maximize benefits while minimizing potential drawbacks.*

Keywords: *360^0 Evaporative coolers, Humidity, Dry bulb temperature, Cooling efficiency.*

1. Introduction

Energy demand worldwide for buildings cooling has increased sharply in the last few decades, which has raised concerns over depletion of energy resources and contributing to global warming. Current energy demand estimates stand at between 40 and 50% of total primary power consumption. In hot climate countries, the highest share of building energy use is mainly due to space air conditioning using traditional

HVAC systems. For example, in the Middle East, it accounts for 70% of building energy consumption and approximately 30% of total consumption. Nowadays, buildings air conditioning has become a necessity for people life and plays a vital role in ensuring indoor comfort levels. Hence, improving the efficiency of cooling technologies are essential, particularly ones that have the potential, i.e. high performance, low power consumption [1].

Akhilesh Yadav et. al. [2] have designed a air cooler in such a way that the people sitting in any area in the room will get equivalent cooled air. The cubical cooling chamber as shown in Figure 1 consist of four cooling pads. The exhaust fan in mounted above the chamber, below which the heating coil is mounted. Thus, this cooler can be used as a heater in winter season and as a cooler in summer season.

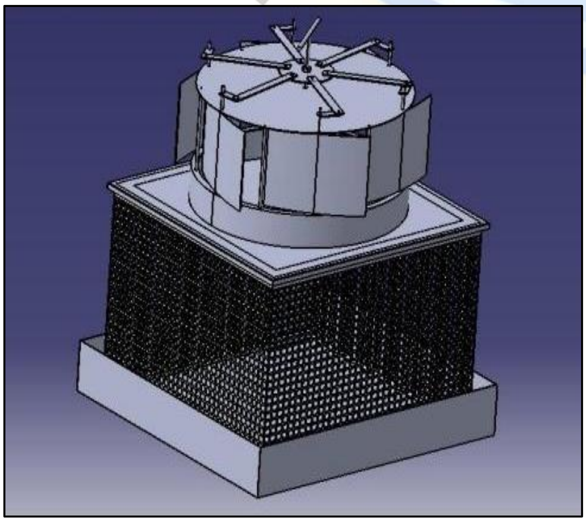

Figure 1. Air cooler with Cubical cooling chamber

Nilesh Jadhav [3] has designed 360° air cooler and heater used to cool or heat the air according to the requirement of the user. Working of 360° air cooler and heater is such that it takes latent heat of vaporization from the air that is passed through it and gives us a decrease in temperature and increases the specific humidity. 360° air cooler and heater is also beneficial as compared to conventional air conditioning system as it cools the air of all the four direction with the help of chilled water. At the time of winters, the relative humidity of the air is high which also leads to low dry bulb temperature so the cooler is in ideal condition, the efficiency will be low as high relative humidity is present. Hence, adding a heater coil will make the cooler more efficient even though the relative humidity of air is high and it will provide us with hot air in colder conditions.

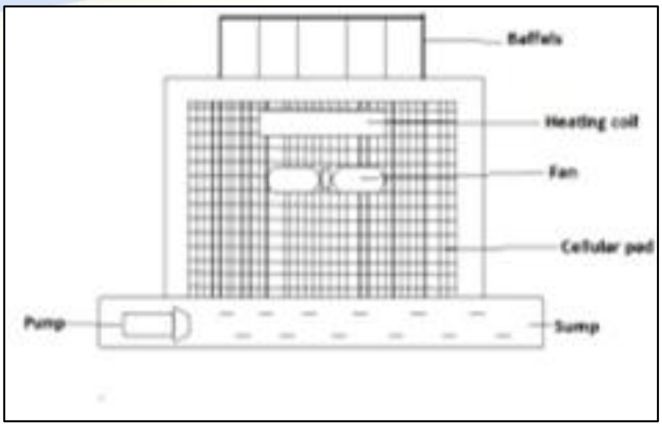

Figure 2. 360° air cooler and heater

R. Boukhanouf et.al. [4] have presented a computer model and experimental results of a sub-wet bulb temperature evaporative cooling system for space cooling in buildings in hot and dry climates. The cooler uses porous ceramic materials as the wet media for water evaporation. Under selected test conditions of airflow dry bulb temperature of up to 45°C and relative humidity of up to 50%, it was found that the supply air could be cooled to below the wet bulb temperature with a maximum cooling capacity of 280 W/m^2 of the wet ceramic surface area. It was also shown that the overall wet bulb effectiveness is greater than unity. This performance would make the system a potential alternative to conventional mechanical air conditioning systems in hot and dry regions.

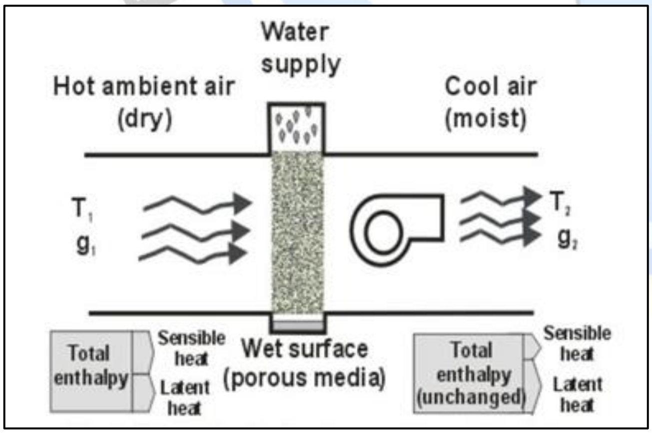

Figure 3. Schematic of direct contact air cooler

Rajesh Maurya et. al. [5] have represented working principles, and performance of evaporative cooling technology under broad range of operating conditions. The effectiveness of evaporative cooling in different application can be discussed in this paper and benefits in terms of power consumption, cost savings and environmental impacts, specifically for the facility required to support conventional air-conditioning and the facility required to support space cooled via evaporative cooling. This paper also discussed desiccant assisted evaporative cooling and heat and mass transfer analysis. The superior cooling of air and ventilation can be provided by evaporative cooling system while consuming less energy and also provides environmentally friendly cooling technologies.

Pratik bhake et.al. [6] have researched evaporative cooling literatures in the way that would help research academicians to take a closer look at the growth and development of this technique. This paper aims to review the recent development concerning evaporative cooling technologies that could potentially provide sufficient cooling effort, reduce environmental impact and lower energy consumption. The authors have reviewed various journal papers and suggested different schemes of classification. The review covers working principle, performance of evaporative cooling technology and also studied direct, indirect and direct-indirect cooling system. The study focusing on investigating the method of cooling, benefits in terms of power consumption, cost saving and various environmental aspects, in addition, certain gap areas are identified that would help researchers in future research.

Hemanth Suvarna et.al. [7] have developed the energy efficient, environment friendly direct evaporative air conditioning and forced heating system having low operating cost suitable for hot and dry regions and climates. To manufacture advanced 360-degree rotating air cooler& heater which rotates and provide air cooling and heating in all directions.360-degree design air cooler& heater will allow person to sit in any direction during winter for heater and cooler for summer. Simple 360-degree evaporative cooling is achieved by direct contact of water particles & a moving air stream. When a hot and dry air is allowed to pass through a wet cooling pad, the temperature of incoming air is reduced with an increase in specific humidity as some water from the pad is evaporated taking the latent heat of vaporization from the incoming air. 360-degree heater, is forced convective heater that has an electric fan to speed up the air flow. In a convection heater, the heating element heats the air in contact with it by thermal conduction. Hot air is less dense than cool air, so it rises due to buoyancy, allowing more cool air to flow in to take its place, to achieve comfortable temperature either as heater or cooler.

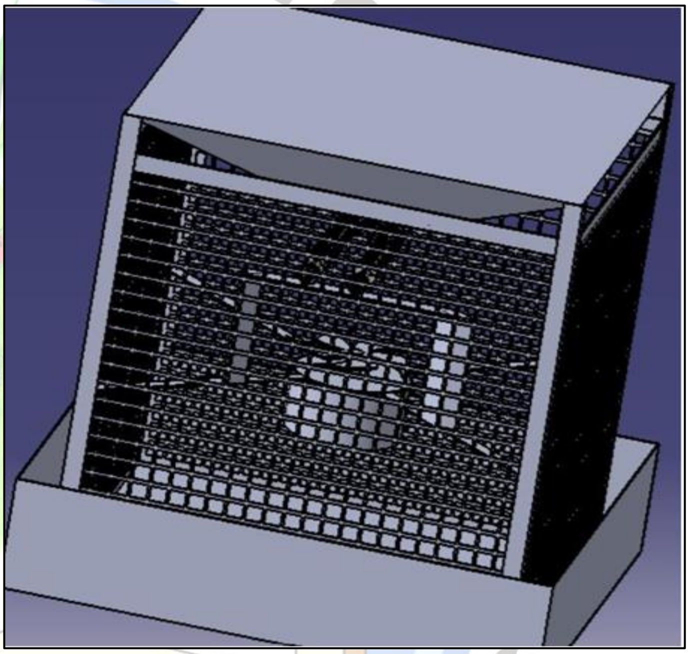

Figure 4: 360^0 air coolers

Conclusion

After extensive review about evaporative cooling, the following key conclusions have been derived:

- The shape and size of the evaporative coolers matters a lot. The whole cooling effect can be changed with concentration to the shape and size of the evaporative coolers. 360 - degree evaporative coolers provide widest surface area gives the most cooling effect whereas conventional coolers with the least surface area gives the least cooling effect as it will take the maximum time because of the larger size and water inside it will get maximum time to cool down.

- Evaporative cooling is a physical process, meaning that the relative humidity does affect the effectivity with which an evaporative cooling system cools. The more humid a climate is, the harder it is for an evaporative cooling system to cool effectively.
- Evaporative cooling depends on the evaporation of water into the air stream only. There is no need for any additive to improve this. Some problems exist, like impurity of water but the additives like polymer helps in to improve evaporation.
- Interspacing is a matter of great concern in evaporative cooling and while doing the investigation it was found that the arrangement in parallel gives better cooling effect.
- Environmental and climatic change effects a lot in evaporative cooling. We get maximum cooling effect in hot sunny days when the temperature is very high.

Reference:

[1] V. Vakiloroaya, B. Samali, A. Fakhar, and K. Pishghadam, "A reviewof different strategies for HVAC energy saving," Energy Conversion and Management, vol. 77, pp. 738-754, 2014.

[2] Akhilesh yadav, rajatkumar bachchan, sankesh toraskar, dattaprasad tendolkar, prof. Ramankumar. "Design And Fabrication Of 360° Cooler Cum Heater." Dept of mechanical engineering, S. S. P. M college of engineering kankavli, international research journal of engineering and technology (IRJET). Volume: 05 Issue: 05-may-2018.

[3] Nilesh ambaji Jadhav, "Design Of 360° Air Cooler and Heater.", Assistant professor, department of mechanical engineering Anantrao pawar college of engineering and research, pune india. JETIR. Volume:6, issue 1, January 2019.

[4] R. Boukhanouf, H. G. Ibrahim, A. Alharbi, and M. Kanzari "Investigation of an Evaporative Cooler for Buildings in Hot and Dry Climates.". Journal of clean energy technologies, Vol. 2, No.3 july 2014.

[5] Rajesh maurya, Dr. Nitin shrivastav, Vipin Shrivastava "Performance and Analysis of An Evaporative Cooling System: A Review.". Dept. of mechanical engineering, University Institute of technology-RGPV,

Bhopal, (M.P.) India. International journal of scientific and engineering research (IJSER), Volume:5, Issue 10, October-2014.

[6] Pratik bhake, shrirang joshi, ataul haque, kunal mishtra, prof. Mrs. P. K. Tawele ,"Evaporative Cooling Method: A Literature Review.", UG student assistant professor, department of mechanical engineering, priyadarshini college of engineering, nagpur. International journal for scientific research and development (IJSRD) Vol. 5, issue 01,2017.

[7] Hemanth Suvarna, Dhanush R, Ibrahim Khaleel Farooqui, Mohammed Ifraz and Muhammed Alfaz, "Design and Fabrication of 360 Degree Cooler Cum Heater",Assistant professor, Dept. of Mechanical Engineering, Alva's Institute of Engineering and Technology, Karnataka, India., International Journal of Emerging Trends in Engineering and Development, Issue 8, Vol.3 (April-May 2018).

Article History:

Submitted: 2025-01-03
Accepted: 2025-01-11
Published: 2025-01-16