

Performance Improvement Techniques for Evaporative Air Cooler - A Review

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Abstract: Nowadays global warming is increasing day-by-day in order to maintain the human comfort the use air conditioners is increasing which indirectly leads to global warming and have to face harmful effects. In order to reduce the global warming the use of evaporative air cooling system is suggested instead of air conditioners. In an evaporative air cooling system some feature are embedded such as the air heater, humidifier, water cooler, etc. The evaporative air cooler comes out as a best alternative for air conditioners.

Keyword: *Evaporative cooler, performance, cooling pads, human comfort.*

I. INTRODUCTION

Human beings throughout the ages have tried various methods to achieve comfort in various climatic conditions. The very basic type of cooling system was initially developed thousands of years ago in Persia presently known as Iran and was named as “badger” in traditional Persian language and bad means air, “gir” means catcher together known as “Wind Catcher” commonly. Central Iran shows large diurnal temperature variations and arid climatic conditions and to overcome this the air catcher were used which had an opening on the roof top which trapped the air flowing above and send it to the subterranean water and discharged the cooling air into the building. Now this air catchers have been replaced by evaporative air cooler and they are being used very widely.

Evaporative air cooler is one of the appliance that is used to maintain the surrounding atmospheric conditions. The working differs from air-conditioning system which uses vapors compression or absorption cycles. The evaporative air cooler requires water for cooling the air and water has large enthalpy of vaporization which helps in cooling the dry air. Evaporative air cooler works on the principal of conversion of sensible heat into latent heat. The energy needed for evaporating the water is taken from air in the form of sensible heat, which reduced the temperature of air and gets converted in latent heat and during this complete transformation the enthalpy remains constant which is called as adiabatic process, dry bulb temperature of air decreases and humidity of air is increases. Water is an excellent coolant which is available in plenty, non-toxic and it evaporates easily. A simple example of natural evaporative cooling is the separation of sweat from the body, which is evaporation process.

The advantages of evaporative air cooler over the air conditioner are less expensive to install and operate, good ventilation of air, humidity can be controlled and no harmful effect on environment and there are also some

limitations like the humidity cannot be controlled easily, the amount of water required and health hazards such as asthma.

The present work aims on studying how the humidity could be controlled and improving the overall efficiency.

II. LITERATURE REVIEW

AbdollahMalli et al [1] in the present work talks about the thermal performance of cellulosic pads which were made from corrugated papers has been studied experimentally. Samples were tested in a sub sonic wind tunnel made from polyethylene. Pressure drop, humidity variation, evaporated water and effectiveness have been investigated for several inlet air velocities. Direct evaporative cooling is the most efficient technique and is used in cooling towers, humidifiers and evaporative coolers. First the warm air is drawn by the fan through the wetted pads, these pads absorbs the heat and the air leaves the system at a lower temperature. During this process the water is sprayed continuously on the pads. These pads play very important role in cooling the air, recently manufacturers have designed new pads made of cellulose paper to improve the cooling effect in different applications like residential sectors, storage warehouses, poultries, etc. These pads are energy efficient, economical, compact in size and light in weight and also pollution free.

Vivek W. Khond [2] in the present work talks about the civilizations throughout the ages who have found ingenious ways to combat the heat in their region an earlier form of air cooling, the wind catcher, was invented in Iran thousands of years ago in the form of wind shafts on the roof, which caught the wind and passed it through water and blew the cooled air into the building. Nowadays the air catchers have been changed into the evaporative coolers and evaporative cooling is a very common form of cooling building for thermal comfort since it is relatively cheap and requires less energy than any other form of cooling. The cooling pads used in the evaporative coolers play a very important role in the air cooling system and different cooling pads materials used were wood wool, khus, coconut coir and stainless steel wire mesh. The best cooling results were observed by the use of khus followed by wood wool, coconut coir and stainless steel mesh. Least consumption of water was found in the stainless steel while highest velocity of air was found in the coconut coir at same fan speed.

A.Franco et al [3] in their work made a computational fluid dynamics (CFD) simulation and aerodynamic analysis of four different types of corrugated evaporative pads made

of cellulose which are widely used across the Mediterranean region. The geometrical characteristics of pads had been determined and also the volume of water the pads can retain at various flow of water and thus critical thickness of cooling pads were obtained. By the means of a velocity wind tunnel experiment, the pressure drop produced by this pads had been observed and recorded at varying water flow and wind speeds.

Amit Kumar Jain [4] in the present work talks about the heart of the evaporative cooling system, in this system the ceramic material tubes are used instead of the cooling pads and due to the property of porosity of the tube water comes out of the tubes outer surface and cools the air passing over the tubes. The tubes are sealed at bottom end and open at the top end due to which the use of water pump is reduced and the circulation of the air is due to the creation of negative pressure produced by the fan.

It has been found that by not using the electric pump the electricity consumption have been reduced and also by the use of ceramic tubes the consumption of water has also reduced. The cooling effect have also been increased in a considerable amount and hence the overall efficiency have been improved.

V. S. Shammy [5] in the paper talks about air Cooler as one of the appliance that keeps the atmosphere cold. The basic concept of water cooling is to find a medium that can handle and transport heat more efficiently than air. Water has a very good ability to retain heat, in the meantime stay in a liquid form. The paper works on designing and developing a low cost air cooler which can be used in houses and offices. The designing was done based on the Quality Function Deployment (QFD) and Product Design Specification (PDS).

Farhan A. Khmamas [6] in the present work studied that the air-coolers are very widely used due to their convenient method of cooling and cheap cost but however humidity, smoking, noise and problem in maintaining the surrounding temperature are some of the disadvantages. In the research, they suggested the use of indirect evaporative cooling method as an alternative to direct cooling method. The method used for air cooling is modified method used in the cooling towers to get cool water by means of evaporation process and this evaporation process represents the external unit of the cooling system. This cooled water is then pumped back to the main or internal unit which contains the cooling fan unit.

A S Alosiamy [7] in the current work, discussed about the novel configuration in cooling system by means of the solar powered dehumidification system which acts as drying agent. The work comprises of two evaporative air cooling systems. Out of these two systems, one worked as the absorber while the other system was coupled to the solar water heater and functioned as a regenerator. In this experimental part, Calcium Chloride was regenerated by the use of solar energy and hot water from the solar heater was recirculated through the air heater in order to regenerate liquid Calcium Chloride. System efficiency comprised of the work and heat added in the system which was well defined. The mass high concentrated solution per kg of vapor produced and regeneration temperature were

found to be depending on operating concentration of Calcium Chloride. Experimental results showed that the solution with approximately 30% concentration could be regenerated by the use of solar energy up to 50%. Good agreement was found in the data collected by the ANN (artificial neural network) model and experimental measurements over the wide range of inlet air temperature.

B.L.Thakor [8] in their present work talks about the global warming and its prime concern to the human being. Global warming has got different types of harmful effects. The weather of the Globe is changing in an unpredictable and drastically way. Countries on equatorial line and on tropics are experiencing high temperatures due to global warming and greenhouse effect. Due to industrialization the concentration of the greenhouse gases have increased. To obtain the human comfort conditions and to reduce the effect of high temperature a machine has been developed called as evaporative air conditioner. This evaporative air conditioner works on the combined principles of both evaporative air cooler with air conditioning system together to give the better results.

Jose' Rui Camargo et al [9] in this paper discussed the principle of evaporative cooling for human comfort and the operating principle of evaporative cooling system and the development of mathematical equations for determination of saturation effectiveness. The experiment was carried in the Air Conditioning Lab in the University of Taubate, Department of Mechanical Engineering and the results were used for calculating the co-efficient of convective heat transfer and the results were also compare with mathematical model.

J.M. Wu et al [10] in their work presented that heat and mass transfer across the water and air film in direct evaporative cooler were analyzed theoretically. The frontal air velocity and thickness of pads influence the cooling of direct evaporative cooler which are discussed. Approximately 2.5m/s frontal velocity was recommended for the determination of pads frontal area module for the recommended air flow. After the test was conducted it was concluded that the relation between cooling efficiency and energy balance analysis of air was valid.

A.Fouda et al [11] in their paper discussed heat and mass transfer method used in direct evaporative cooler. To explain the relation of heat and mass transfer in between water and air in the evaporative cooler mathematical model was described. Latent heat of water was taken as source of heat energy in the equation, and mass of water evaporated was treated as source of mass in the equation. In the study a comparison was done between the experimental results and computed results for direct evaporative cooler. The pad thickness, frontal inlet air velocity and dry-bulb temperature influenced cooling efficiency which were calculated and analyzed. The results obtained showed that the mathematical model was valid for the designing of evaporative cooler.

E. Velasco Gómez el al [12] said that evaporative cooling process is a very common phenomenon in nature, which are used since ancient times. Evaporative cooling method is a low energy consumption method and is also a cheaper alternative to other cooling methods like air-

conditioning. In modern buildings evaporative cooling method is used very rarely for cooling purpose. To reduce the risk, evaporative cooling was produced from humid environment, in such a way that water evaporates due to the difference of vapor pressure between the surface and the air, and thus minimizing the generation of aerosols, responsible for the spread of legionnaire disease. Aerosols are nevertheless produced in conventional systems where water is sprayed or directly in contact with the stream of air.

Mohamed M. El-Awad [13] in the paper presents a winter air-conditioning system which is suitable for regions with mildly cold but dry winters. The system modifies the evaporative air-cooler that is commonly used for summer air-conditioning in such regions by adding a heating process after the humidification process. The paper describes a theoretical model that is used to estimate the system's water and energy consumption. The proposed modification of the conventional summer air-cooler to be used for winter air-conditioning encourages the continued use of this energy-efficient system in the future. An important advantage of the proposed system is that part of the heating can be obtained by utilizing solar energy. By using this clean and renewable energy source, the system also maintains the main advantage of evaporative air-coolers over refrigerated systems with regard to the environmental impact.

VijaykumarKalwa et al [14] in their present work talks about increased use of refrigeration and air conditioning system due to the high temperature and humid weather conditions, so that humans should feel comfortable and relaxed. But due to their high costs and power cuts problem in small towns and villages, this systems are not suitable to use. So solar powered systems are considered as an alternative to the electrical systems. Using this technology results in improved air quality and also maintains the humidity in proper range. Solar cooling system is suited for schools, offices and residential application especially for villages. The present work reviews solar powered cooling system with special cooing compartment to store food items for household applications.

Deling Xiao et al [15] in the current work designed an air conditioner with water evaporator and cooling humidifier which is based on requirements of domestic air conditioner. Details of design procedure and operating mechanism is presented in the current paper, and series of trials were done and concluded that an air conditioner with water evaporator and cooling humidifier improves humidification and also maintains original efficiency of air conditioner.

NileshVarkute et al [16] in the paper discusses about controlling the human comfort parameters like temperature, air quality and relative humidity. Evaporative coolers, dehumidifiers and air conditioners serve the purpose but there are some drawbacks or some problems such as this systems are costly, low efficiency in humid conditions. This present work focuses on the developing of peltier operated air cooler which will be coupled with the dehumidifier. The work is done in order to give a good and cheaper alternative to the air conditioners for indoor use.

Monika Frontczak et al [17] in the current work explores the human comfort conditions inside the building. A survey was performed to gather the data about the new concepts used to control indoor environmental conditions for human comfort and during the survey the factors influencing were visual, thermal, acoustic and air quality. From the survey it was concluded that while developing the cooling system the type of building, seasons and the climatic changes considered and taken into account and after that the temperature, thermal comfort and air quality are to be considered. Hence all the parameters are very important for the human comfort mentally as well as physically.

III. SUMMARY OF LITERATURES

Sr. No	Name of Authors.	Paper Title.	Year	Findings.
1.	Jose´ Rui Camargo, et al	Experimental performance of a direct evaporative cooler operating during summer in a Brazilian city.	2005	Principles of evaporative cooling for human comfort.
2.	J.M. Wua, et al	Theoretical analysis of heat and mass transfer in a direct evaporative cooling.	2008	Heat and mass transfer of air and water over the evaporative cooler was analyzed.
3.	E. Velasco Gomez, et al	The phenomenon of evaporative cooling from a humid surface as an alternative for air-conditioning.	2010	Evaporative cooling as a natural process in cooling by the nature.
4.	Deling Xiao, et al	The research of Water Evaporating-cooling Humidifiers application in air conditioners.	2010	Based on domestic requirements designed a cooler.
5.	AbdollahMalli, et al	Investigating the performance of cellulosic evaporative cooling pads	2011	Performance analysis of corrugated paper cooling pads.
6.	Vivek W. Khond	Experimental investigation of dessert cooler performance using four different cooling pads.	2011	Performance comparison of steel wire mesh, khus, coconut coir and wood wool.
7.	A. Franco, et al	Aerodynamic analysis and CFD simulation of several cellulose evaporative cooling pads used in Mediterranean greenhouses	2011	CFD simulation and aerodynamic analysis of four different cellulose cooling pads.
8.	Farhan A. Khamamas	Improving the environmental cooling for air by using the indirect cooling method.	2011	Cheap way of cooling and improving its performance.
9.	A. Fouda, et al	A simplified model for analysis of heat and mass transfer in a direct evaporative cooler.	2011	Heat and mass transfer method used in direct evaporative cooler.

10.	Mohamed M. El-Awad	Feasibility of a solar assisted air-conditioning system using evaporative air-cooler.	2011	Suggested a winter air-conditioning system suitable for mildly cold region.
11.	Monika Frontczak, et al	Literature survey on how different factors influence human comfort in indoor environments.	2011	Human comfort conditions inside a building and maintaining them for comfort.
12.	Amit Kumar Jain	Thermal Performance Analysis of Pump Less Earthen Pipe Evaporative Air Cooler.	2012	Increased cooling effect and performance by using the earthen pipe.
13.	V.S. Shammy	Design and development of a low cost air cooler	2013	Designing of cooler by using QFD and PDS.
14.	A S Alosiamy	Application of evaporative air coolers coupled with solar water heater for dehumidification of indoor air	2013	Dehumidification of air by use of solar energy.
15.	Vijaykumar Kalwa, et al	Modelling and fabrication of solar power air cooler with cooling cabin for household food items.	2014	Solar powered cooler with food storage cabin for preservation of food.
16.	B.L.Thakor	Economical Evaporative air conditioner for equatorial and tropical regions.	2015	Using evaporative air cooler to reduce global warming.
17.	Nilesh Varkute, et al	Design and fabrication of peltier operated portable air cooling system.	2016	Works on human comfort parameters and eliminating drawbacks.

IV. CONCLUSION

Evaporative air coolers are found to be better option against the air conditioners as they help in the humidification of the air being conditioned. The use of air coolers has long operational history with timely studies by the researchers worldwide for the performance improvement through design improvement, by using new methods and by adding new features or by using solar energy. Thus from the literature studied it can be said that the air coolers have scope for improvement for better comfort conditions.

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