Volume 5, Issue 4, October 2018 ISSN: 2348-8565 (Online)
International Journal of Modern Engineering and Research Technology
Website: http://www.ijmert.org Email: editor.ijmert@gmail.com

Comparative Analysis of Experimental and Computational Data of Evaporation Cooler By Varing Cooling Pad Material

Aniket Prakashrao Anokar
P.G. Research Scholar,
Department of Mechanical Engineering,
Dr. Rajendra Gode Institute of Technology & Research,
Amravati, (M.H.), [INDIA]
Email: aniketanokar@gmail.com

Kishor Ramdasji Gawande
Assistant Professor
Department of Mechanical Engineering,
Dr. Rajendra Gode Institute of Technology & Research,
Amravati, (M.H.), [INDIA]
Email: kishorrgawande@gmail.com

ABSTRACT

Parameterization of a system enables the enhancement of system by defining and controlling the parameters of system under study. Various techniques of parameterization whether empirical or approximate study analysis are used to study the parametric data of system. Human comfort which lies at the soul of any psychometric changes is one of the need which has given rise to evaporative cooling system. The evaporative cooling device is one of the cheapest way of providing cool air and being widely used which lends its self for enhancement of efficiency. The computational fluid dynamics is a powerful computational tool which is most widely used for the simulations of all levels of complexity. A computational analysis can be carried out with help of commercial CFD software, ANSYS CFX to study the flow pattern of the fluid in the evaporative pads which provides the evaporative cooling system a parametric dimension which can be used to optimize the best material for pad material employed in evaporative cooling. Various objective defined for further study can be found exclusively mentioned in this work of review.

Keywords:— *Evaporative cooler, Parametric, CFD Analysis*

I. INTRODUCTION

An evaporative cooling system is a device that cools air through the evaporation of water which reduces the temperature of the air. The air which is cooled by the evaporation of water consumes less energy than the refrigeration. The conventional evaporative cooler uses wood wool as the pad material and the psychometric process followed can be shown in figure1. In dry weather conditions, evaporative cooling of air has added advantage over air-conditioner, as it increases the humidity which increases the comfort of building occupants. The cooling effect of evaporative cooling system dependent on the difference between the wet-bulb and dry -bulb temperatures. In arid climates, this type of system can be an alternative to vapour compression based cooling system. Computers are most widely used in computational and simulation work as it can perform the millions of calculations required to simulate the fluid flow problems related to Mechanical engineering. The computational fluid dynamics (CFD) is a computer based tool that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows, heat transfer and other similar physical problems. The commercially available CFD packages uses sophisticated user interfaces

to input problem parameters and to examine results. All CFD software's contain three main elements such as Pre-processor, Solver and Post processor.

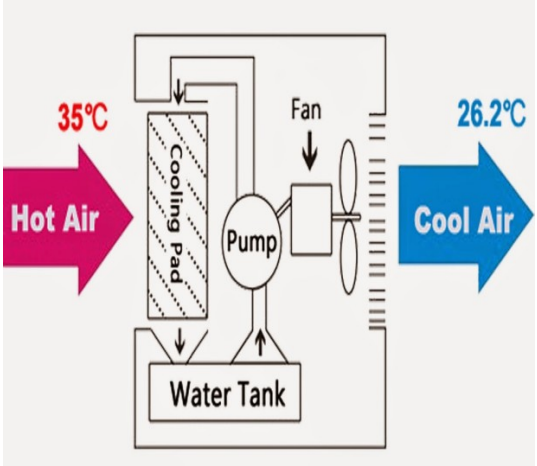

Figure 1: The Working Principle of Conventional Evaporative Cooler

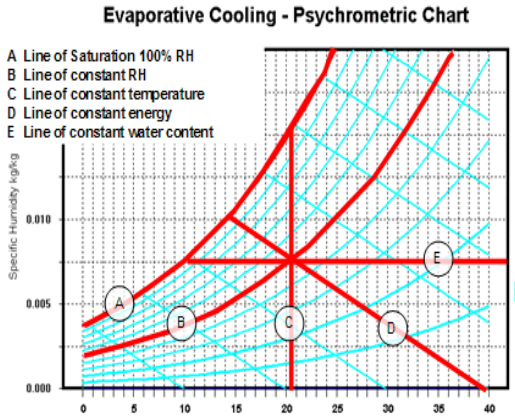

Figure 2: Evaporative Cooling—Psychrometric Chart

II. LITERATURE REVIEW

The conventional material used in conventional evaporative cooler is wood wool which is used extensively owing to the lesser cost of the same. Due to increase in demands of cooling in recent years and with an aim to find a cost effective method for domestic cooling which can find application in households or industries new materials for padding of evaporative cooler with increased capacity of water absorption and higher rate of evaporation are being researched. To study the effect of change in the pad material can be studied by experimental as well as approximate analysis method. One such approximate method and cost effective method is using CFD analysis tool of ANSYS and various work in this direction has been initiated and it is worth noticing various works of research evolving CFD analysis of evaporative cooler.

Kapilan in his work of direct evaporative cooling system has studied a system which consists of a rectangular wind tunnel, axial exhaust fan fixed at inlet of tunnel, evaporative pad and necessary instrumentation to record the observations. The evaporative pad was kept in the wind tunnel. A non-contacting tachometer was used to measure the speed of the exhaust fan and the speed of the fan were adjusted by speed control knob. A 20 liter water tank was used to supply the water to the evaporative cooling system through the nozzles which was placed above the evaporative pads. A U Tube water manometer was used to the pressure drop across the evaporative cooling pad. An energy meter was used to find out the power consumed by the fan. Thermometers were used to measure the wet bulb and dry bulb temperatures of the air at the inlet and outlet of the tunnel. The CFD analysis was carried-out successfully and results were compared with the experimental results. An evaporative cooling system was developed and tested. The experimental results were used to validate the CFD results.

Sapounas developed a methodology approach in order to simulate numerically (CFD) a greenhouse equipped with fan and pad evaporative cooling system is presented. Using the main aspects of evaporative cooling systems in terms of heat and mass transfer, the flow and boundary conditions of the simulation model are identified integrating both the external and internal climatic conditions.

The temperature and humidity of incoming air and the operational characteristics of fans were specified to set up the CFD model. The numerical analysis was based on the Reynolds-averaged Navier-Stokes equations in conjunction with the realizable k-ε turbulence model. The finite-volume method (FVM) was used to solve the governing equations. The 3D full scale model was solved in several differencing schemes of various orders in order to examine its accuracy. The simulation approach was used mainly to identify the critical parameters of microclimate of greenhouse and the regions were these have to be measured during the upcoming experiments which will take place

Franco in his work makes an aerodynamic analysis and computational fluid dynamics (CFD) simulation of the four commercial models of corrugated cellulose evaporative cooling pads that are most widely used in Mediterranean greenhouses. The geometric characteristics of the pads have been determined as well as the volume of water they retain at different flows of water, thus obtaining the mean thickness of the sheet of water which runs down them and their porosity. By means of low velocity wind tunnel experiments, the pressure drop produced by the pads has been recorded at different wind speeds and water flows. In this way it has been possible to obtain the relationship of the permeability and the inertial factor with pad porosity using a cubic type equation. Finally, a CFD simulation with a 3D model has been carried out for both dry pads.

Manoj Kumar Chopra in his work developed new evaporative cooler is designed which is semicircular in shape instead of rectangular shape (normally used now a days) and the comparison between rectangular shaped cooler and new designed semicircular shaped cooler is made with Khus as a cooling pad material in terms of temperature drop, humidity rise and cooling efficiency. By using Semicircular shaped utilization of water increases, more volume of air comes in contact due to steam line pattern, requires less cooling pad material and become compact, thus requires less space for installation. As well as performance of different cooling pad materials like Celdek, Khus, Coconut coir and Bamboo fiber (new material) is analyzed in terms of temperature drop, humidity rise and cooling efficiency by using normal water and chilled water with newly designed semi -circular shaped cooler. Also best cooling pad materials in terms of human comfort and finally best cooling pad mate rials according to climate of Bhopal is analyzed in this work. With respect to human comfort Celdek is a best material followed by Coconut, Bamboo fiber and Khus.

Shashank Shekhar in his work investigated the comparative performance of Desert Coolers employing six different pads in terms of cooling efficiency, air velocity, and water consumption for a sustainable and economic application. In real practice, we use wood wool, khus, coconut coir fiber, ceramic materials tubes, stainless steel, galvanized metal sheets as pads in desert coolers and the paper focusses on the best of the pads used, quite suitable to the rural masses in operational and economic senses, on a wide range of comparisons. This investigation is sorted out to bring the performance indicator of the best suited pad out of different pads used globally. From the comparative account, it has been observed that the vertically aligned galvanized metal sheets could withstand to any temperature range in the country's scenario and the cooling efficiency is nearly 85% above all the performance indicators. In the new design, it is wiser to remove salt deposition and dust built up on the pads surfaces which

would render a longer useful life compared to the commercially available cellulosic pads.

V. S Shammy in his work has performed ethnographic study and questionnaire survey has been done for understanding the user product interface. The issues related to current air cooler have been found out. QFD and PDS are prepared based on the data collected. Concepts are generated according to the PDS prepared. Concepts of a air cooler with additional of a separate fan to spread the water in to the air for cooling. Air cooler with a separate fan is selected as the final concept through weighted ranking method. Colours are chosen according to its applications to make it aesthetically good. A working model of the final concept is made using wood.

Nishant Dhanore in his project work involves the manufacturing and design of split cooling unit which will cool air but not increase its humidity. It will maintain the room at comfort conditions by recirculating the air in the room through split unit. For our comfort conditions generally we use an air conditioner, it uses a vapour compression refrigeration system. This refrigeration system consumes very large amount of power (about 1.5 KW), also the cost of this system is high. So the other option for maintaining comfort is evaporative cooler. The cost of evaporative cooler is less than that of AC; also it consumes less power than AC. The main drawback of evaporative cooler is that the air supplied by the cooler contains the large amount of humidity. Due to which when an individual sits in the air of the cooler, he/ she feels stickiness on the body which is not comfortable for him/her.

Nikhil Vanraj Thakare in his work shows study of multi-purpose evaporative cooler. It has basically two stage of cooling – first is sensible cooling (Q precool) and second one is evaporative cooling (Q evaporative). An Evaporative Cooler produces effective cooling by combining the natural process - water evaporation with simple, reliable air-moving system. During study it is proved that Evaporative Cooling has versatile applications. A small size Dessert Cooler can cool the water up to Wet Bulb Temperature (WBT) of outside air as well as could store vegetables for considerable period of time. The damper is used to control the humidity level inside the room as per the requirement. The Multi-Purpose Evaporative Cooler is generally has major functions like it will control the humidity and temperature for wide range, as a cold storage to store the food stuff like a vegetables, bakery products, chocolates, medicines etc. The main medicines which can be stored in the temperature range of 22 - 27 0C and the food stuff can be stored for a period of time without any decay in their properties shows in figure 7 and to cool drinking water. This system performs better than the normal desert cooler in term of utilization of cooling effect for cooling of air, cooling of water and cold storage. Humidity of cooled air coming out from the MPEC is low as compared to conventional desert cooler. By performing experiment, the most predominant factor is it requires less amount of water than conventional desert cooler. The overall percentage of saving as compared to desert cooler is 53.33%.

Vivek W. Khond investigate a performance of Desert Cooler using four different pad materials in terms of cooling efficiency, water consumption andair velocity. Pads of Stainless steel wire mesh, coconut coir, Khus and Wood wool were fabricated and tested using a laboratory-scale experimental arrangement. Maximum water consumption was observed in wood wool pad (0.24 Lit/ min). Coconut coir (0.134 Lit/min) and Khus pad (0.21 Lit/min) also shown less

water consumption rate as compared to conventional wood wool pad. Minimum water consumption was observed in Stainless steel wire mesh pad (0.066 Lit/ min) at same fan speed. Stainless steel wire mesh pad (4.5 m/s) and coconut coir pad (5.2 m/s) shown higher air velocity which provides proper air distribution in room while Wood wool pad (4m/s) and Khus pad (3.4 m/s) were shown lower velocity. Maximum and minimum cooling efficiency were found in wood wool pad and Stainless steel wire mesh pad. Experimentation was conducted under varying speed of fan, and parameters like water consumptions, cooling efficiency, and air velocity were measured. Maximum water consumption was observed in wood wool pad. Coconut coir and Khus pad also shown less water consumption rate as compared to conventional wood wool pad. At fan speed, water consumption was lower for all pad materials.

S.S Kachhawa presents a simple and efficient methodology to design a household desert cooler, predict performance of evaporative medium and determine pad thickness and height for achieving maximum cooling. Inputs for formulation include inlet air DBT and humidity ratio, air velocity, water temperature and flow rate, and geometrical properties of evaporative medium. A test rig was designed and fabricated to collect experimental data. Predictions of air condition at cooler outlet for given input conditions agree satisfactorily for air exit temperature (+15%) and humidity ratio (+10%). Results are useful for size selection of medium geometry required for an evaporative cooler design.

Chandrakant b. Kothare has developed an Air Conditioner cum refrigerator for people who cannot afford costly equipments like air conditioner, refrigerator and other such appliances. It cools the air more than the conventional Desert cooler. The modified desert cooler is developed for providing better cooling effect than conventional desert cooler. It also provides cold-pure water for drinking purpose comparatively at low cost than Refrigerator with the help of modifies Matka attached with it. It also decreased moisture content of the air coming through desert cooler upto some extent.

M. S. Sodha in his work presents a model for the evaluation of the variation of the water temperature along the direction of flow in an evaporating pad. The model has been used to evaluate the mean air exit temperature and the transient temperature of the water in the tank. The analytical results are in agreement with the observations in our experiments. The time variation of the temperature of water in the tank has been investigated and the new concept of using the tank water for cooling have been investigated theoretically and experimentally; the theory is in good agreement with experiment. It is seen that the penalty on the mean exit air temperature is negligible for thermal loads $\dot{Q}$ (for cooling) of the order of 1 kW; it is seen that it is 0.6 °C for $\dot{Q}$ = 2 kW. Further it is concluded that for typical coolers the steady state temperature of water in the tank is reached in a time of the order of one hour or less.

Various Pad materials for Analysis of Evaporative cooler

Conventionally, evaporative cooler pads comprising of wood wool termed as excelsior, Coconut Coir fiber are used. Coconut coir fiber is used to fabricate coconut coir pads . The coconut coir pad was analyzed and compared with those of commercial wood known as wood wool pad. Commercial development appears feasible for the co availability. The span of life of coconut coir pad as compared to wood pad is more. Similarly, ceramic

material tubes, stainless steel, galvanized metal sheets are compared and tested.

Ceramic materials have a crystalline structure, fully or partially, or amorphous. The ceramics objects are pottery made from either self or mixing with other materials and fire hardened after proper mixing. These materials withstand chemical erosion taking place in other materials subjected to acidic or caustic environment and withstand to very high temperatures even up to 1,600 °C. This cooler is a device having very low initial and running cost compared to the unitary air conditioners. Evaporative cooling systems using relatively expensive cellulosic paper pads are widely used in residential, commercial purposes. However, the minerals and dust built up in due course of operation shorten the life of these pads. Water drips from the top distribution bath over the pads through small openings. The commonly used pad materials for evaporative cooler are as follows.

- ***Khus***: It is pad material mostly found in market and recovered from agricultural waste.
- ***Palash:*** Palash fibers were obtained from the roots of palash tree.
- ***Coconut coir:*** Coconut fibers were obtained from the roots of coconut tree.
- ***Wood wool:*** Wood wool is a product prepared by wood slivers cut from logs. Steel wire mesh: It is made by 0.2 -1.5 mm diameter of steel wire.
- ***Aspen:*** Aspen pad evaporative media is prepared by aspen fibers, held jointly in a pad form with plastic netting.
- ***GLASdek:*** GLASdek evaporative media is prepared by a flame retardant material equipped with special rigidifying agents.
- ***CELdek:*** CELdek evaporative media is prepared by a specially engineered cellulose paper that is chemically treated to resist deterioration

III. OBJECTIVES

The extensive literature survey has revealed that a substantial amount of work has been carried out on the evaporative cooling device in context of increasing the efficiency by changing the design and material of the pad used for evaporation . To optimize the best material for the evaporative cooling the tool of approximation that is CFD analysis will be employed along with the experimental validation of the same.

The various objectives of the proposed work can be enumerated as follows.

- The evaporative cooling Pad geometry along with the assembly of evaporative cooler is to be modeled using CAD software.
- The model assembled will be subjected to CFD analysis using Fluent package of ANSYS using the boundary conditions of evaporative cooler for different pad materials
- The experimental setup is to be fabricated to calculate the evaporative cooling effect for three different pad materials.
- This is followed by optimization of best pad material in context of efficiency and costing of the pad material.

III. CONCLUSION

Review work has been carried out to study the effect of different pad material on the cooling efficiency of evaporative cooler. The defined objectives are drawn on the basis of study done which clears the way for design and analysis of the evaporative

cooler in context of defining the boundary conditions for CFD analysis of the system.

REFERENCES:

[1] Kapilan N "Computational Fluid Dynamics Analysis of An Evaporative Cooling System" Journal of Mechanical Engineering Volume 66, No 2, 2016 pp. 117 – 124

[2] Sapounas, A.A., Bartzanas T., Nikita-Martzopoulou, C., and Kittas, C.: Aspects of CFD Modelling of a Fan and Pad Evaporative Cooling System in Greenhouses, *International Journal of Ventilation*, 2008, 6(4), 379-388.

[3] Franco, A., Valera, D.L., Peña, A., Pérez, A.M.: Aerodynamic analysis and CFD simulation of several cellulose evaporative cooling pads used in Mediterranean greenhouses, *Computers and Electronics in Agriculture*, 2011, 76(2), 218–230

[4] Manoj Kumar," Design of New Evaporative Cooler and Usage of Different Cooling Pad Materials for Improved Cooling Efficiency" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 04 Issue: 09

[5] Shashank Shekhar "Performance of Different Pad Materials In Advanced Desert Coolers- A Comparative Study"

[6] V. S. Shammy Srinivasa, H. S. Lohit, "Design And Development of a Low Cost Air Cooler", Sastech Journal, Vol. 12, Issue 2, September 2013

[7] Nishant Dhanore "Modified Air Cooler with Split Cooling Unit" International Journal of Science and Research (IJSR)ISSN (Online): 2319-7064

[8] Vivek W. Khond, "Experimental Investigation of Desert Cooler Performance Using Four Different Cooling Pad Materials", American Journal of Scientific & Industrial Research, 2011

[9] S. S. Kachhwaha and Suhas Prabhakar, Heat and mass transfer study in a direct evaporative cooler, Journal of Scientific 7 Industrial Research, Vol. 69, September 2010

[10] M. S. Sodha and A. Somwanshi, "Variation of Water Temperature along the Direction of Flow: Effect on Performance of an Evaporative Cooler", Journal of Fundamental of Renewable Energy and Applications, Vol. 2(2012)

* * * * *