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Study the Effect on Evaporative Cooling for Different Contact Profiles of Wetted Surfaces

P. L. Sarode*[1], V. R. Baviskar[2], N. P. Salunke[3]
[*1]Assistant Professor, Mechanical Department, RCPIT Shirpur, Maharashtra, India
[2]PG Student, Mechanical Department, RCPIT Shirpur, Maharashtra, India
[3]Associate Professor, Mechanical Department, RCPIT Shirpur, Maharashtra, India

ABSTRACT

The aim of this review paper is to study about evaporative cooling in hot and dry climate. In this study it been observed that the how passive cooling methodology is useful in controlling surface temperature and produces cooling effects in hot climate condition, so for in this study work different materials for wall is been used also different profile shapes has been proposed for the experimentation like cylindrical, rectangular and drop like shape along with operating conditions etc. and come up with a conclusion that the contact of evaporative surface with a dry air plays an important role in the process of evaporative cooling.
Keywords : Evaporative Cooling, Cooling Materials, Passive Cooling

I. INTRODUCTION

There are occasions where air conditioning, which stipulates control of humidity up to 50 % for human comfort or for process, can be replaced by a much cheaper and less energy intensive evaporative cooling. There are two methods of evaporative cooling i.e. direct evaporative cooling and indirect evaporative cooling. The direct evaporative cooling is very efficient and having very low cost as compare to other systems. Due to hot environment air conditioning systems are largely used, therefore electricity consumption increased[1].The two stage evaporative cooling system is more effective in hot and humid climate now a day (hot climate) demand of cooling equipment increases and in different varieties they available in market, for the human comfort evaporative cooling mostly used in terms of lower cost, lower electricity consumption, and lower ozone depletion[2]. By increasing energy crisis in the world people can used efficient equipment for cooling in building construction porous materials are more effective for cooling [3].

The evaporative cooling is a low carbon and economical method for cooling buildings in hot and dry climate. In the evaporative cooling wet media materials plays a very important role for cooling. Different materials are used such as metal foams, organic impregnated materials (Aspen), PVC padding, Celdek paper and different fibers etc.[4].Porous ceramic materials are used as a wetting media in evaporators [5]

In evaporative cooling systems are more effective when the maximum contact of dry superheated air with wetted surface takes place the water is absorbed the sensible heat of air due to this water vaporizes and this heat gives back to air in the form latent heat [6]. In urban area where climate is hot and dry there necessary to provide thermal comfort, there are natural covers i.e. trees and plants natural fibers replaced by building construction porous ceramic materials are used, by using this material cooling wall constructed having high water sucking ability[7]and this using this wall cooling comfort can provided[8].

Water evaporative cooling towers are suggested for high rise buildings with more than 100 floors [9]. The roof lawns are also more effective not only for cooling but also for energy conservation. Solar heating and cooling technologies are very important role plays in building construction for evaporative cooling [10]. The effectiveness of direct evaporative cooling is more as compare to indirect evaporative cooling [11]. Practically porous material or pads provide more water surface [12]. Honeycomb paper also used having more hygroscopic effect [13]. Evaporative cooling devices rejected the heat to the environment [14][15]. The performance of IEC is depends upon various design parameters like as wet and dry side air velocity, size of heat exchanger, mass flow rate of water on wet side, duct design factors etc. [16].some computer programs are also developed for simulating building and evaporative cooling [17]. Greenhouse is one of the important factors for evaporative cooling [18]. The direct evaporative cooling is used where environment is completely dry means there is less moisture content and indirect evaporative cooling is used where moisturized environment [19].

II. LITERATURE REVIEW

Wei Chen, Song Liu, Jun Lin presents "Analysis on the passive evaporative cooling wall constructed of porous ceramic pipes with water sucking ability." In this paper authors construct the pipes which made from porous ceramic and having water sucking ability. A mathematical model also developed for heat and mass transfer in saturated area of pipe and analyses the effect of ambient conditions and phase conditions on performance parameter of porous evaporative pipe.

In this paper author arranges the porous ceramic pipe in three rows with staggered and parallel arrangement and check the performance. The results are temperature differences and air decreases as compared to staggered arrangement, when considered a single pipe then

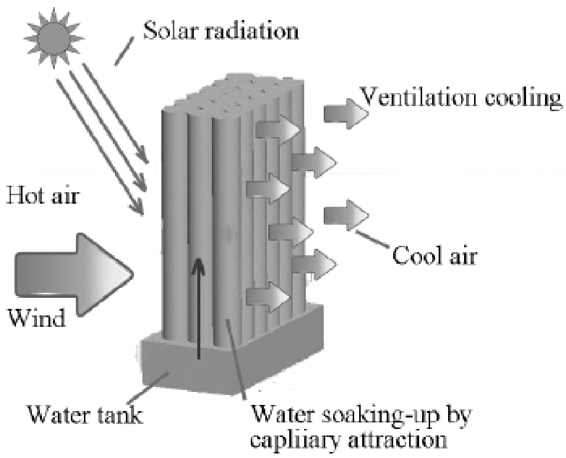

Figure 1: Porous Ceramic Wall [1]

Evaporation of wet porous pipe takes place at lower ambient relative humidity, changes in porosity will affect changing in surface temperature of pipe, more evaporation and condensation takes place with higher temperature gradient and higher vapour moving speed. He concludes that porous pipe surface temperature 4-50C below the ambient temp. This system is not suitable where the shortage of water and humid climate.

Mario el hourani, kamel ghali, nesreen ghadar works on "Effective desiccant dehumidification system with two stage evaporative cooling for hot and humid climates." In this paper authors do the design and operation of hybrid air conditioning system using 100% fresh air and integrates solid desiccant dehumidification with two stage evaporative cooling system to optimize system operation with respect to energy and water consumption while maintaining occupant thermal comfort. He concludes that the 16.15% reduction energy consumption and 26.93% reduction in water consumption achieved by using two stage evaporative cooling system as comparing to single stage evaporative cooling system.

Gerson H. dos Santos nanthan memdes presents a paper "Numerical analysis of passive cooling using a porous sandy roof." In this paper author consider a mathematical model for simulating an unsaturated sandy roof considered in order to predict its effects buildings passive cooling. For predicting room air temperature and relative humidity a lumped transient approach considered for building room. He concludes the variation in room air temperature with sand and humid sand layer is very small but it causes better comfort index in all long days.

Rabah Boukhanouf, Abdulrahman Alharbi, Hatem G Ibrahim and Meryem Kanzariworks on "investigation of a sub-wet bulb temperature evaporative cooler for buildings." In this author presents a computer model and experimental results of an indirect evaporative cooling system in hot and dry environment. In this system porous media used as a wet media for water evaporation, Experiment carried out in 300c to 450c dry air temperature and relative humidity lower than 65%. He concludes that evaporative cooler achieve higher thermal performance in terms of low air supply temperature and effectiveness.

Wei Chen study on "Thermal analysis on the cooling performance of a wet porous evaporative plate for building" in this paper he studied on wet porous ceramic evaporative plate which is used as a building wall. He also developed the mathematical model to analyse persuade of ambient conditions and the porous plate thickness on the cooling performance of the porous evaporative plate. Cooling of the porous evaporative plate inside the room supplied with decreasing ambient relative humidity and increasing in ambient temperature. The ambient wind speed and the thickness of porous plate also have significance persuade on the average temperature of the porous plate. He concludes that at lower ambient relative humidity and higher ambient temperature, the rate of evaporation and vapour velocity of porous evaporative cooling plate is high.

A. Fouda, Z. Melikyan presents “A simplified model for analysis of heat and mass transfer in direct evaporative cooler” in this paper author developed a mathematical model for describing the heat and mass transfer between air and water a direct evaporative cooler. After experiment results are taken out he had seen that in steady state conditions effect of pad thickness on the cooling efficiency gives different values of frontal air velocity, cooling efficiency decreases with increasing frontal air velocity. He concludes that the direct evaporative cooler rapidly achieves steady state conditions therefore there is no need of applying mathematical model for unsteady conations and the mathematical model is serves as a sub model of global mathematical model for direct evaporative cooling air conditioning system.

Jiang He, Akira Hoyano works on “experimental study of practical applications of passive evaporative cooling wall with high water sucking ability.”And “Experimental study of cooling effects of a passive evaporative cooling wall constructed of porous ceramics with high water sucking ability.” The aim of these authors is to provide or to create cooling comfort in urban environment by controlling the increasing urban surface temperature.

Here a passive evaporative wall constructed by porous ceramic material, the ceramic having capability their vertical surfaces to wet up to 100 cm. The surface temperature of pipe maintained near or equal to the wet bulb temperature outdoor air. In experiment new ceramic pipe developed, this pipe reached a height over130 cm at outdoor location in summer days and air passing over it is cooled having temperature reduced by 20c in summer days.

Figure 2: Photo of Experimental Mock up [8]

Figure 3: Developed Passive cooling Wall [7]

Average cooling efficiency is 0.17 in summer days. The limitation of this system is not applicable in very high humid climate.

B. Naticchia, M.D’orazio, A.Carbonari, I.Persico presents, “Energy performance evaluation of a noval evaporative cooling technique” In this study authors evaluates energy performance by using some evaporative cooling techniques. For better cooling or reducing indoor temperature insulation and porous material which store the water is used in building construction. Currently Europeans and Italians work on these directions. Hoy –yen Chan, Saffa B. Riffat, Jie zhu, revise the solar heating and cooling techniques, heating, ventilating, HVAC, Air conditioning systems are consumes more energy and releases large amount of carbon dioxide in environment which very harmful for human comfort. In this review authors discussed on working mechanisms i.e. buoyancy and evaporative effects. X. Zhao, shuli lieu, S.B. Riffat, doing comparative study of heat and mass exchanging materials for indirect evaporative cooling systems and concludes that in terms of costing fibres are cheaper, carbons and metals cost more than fibres but less than ceramics.

J. R. Camargo, C.D. Ebinuma developed a mathematical model for direct evaporative cooling air conditioning systems. This presents basic principles of the evaporative cooling system and development of mathematical thermal equations for determining effectiveness. Y.J. Dai, K. Sumath, does theoretical study on a cross-flow direct evaporative cooler using honeycomb paper as packing material and investigated. A mathematical model also developed having governing equations of liquid film and gas phases.S. Onmura, M. matsumoto, S. hokoi studied on evaporative cooling effect of roof lawn gardens and concluded cooling effectiveness increases by controlling effects of solar radiations. Boris Halasz develops a general mathematical model of evaporative cooling devices T. R. Tulsidasani, r. L. Sawhney, s. P. Singh and m. S. Sodha researched on an indirect evaporative cooler (IEC) part 1 and optimized the COP and concluded for optimum value of air velocity COP is maximum means if air velocity decreases then COP will increases which affects on cooling. E. H. Mathews, m. Kleingeld, J. Grobler studies on integral simulation of building and evaporative cooling systems and observed that if well-known computer program used to develop building then it is easy to us suitable evaporative cooling systems provided to building for comfort cooling. T Boulard, A Ballle, developed simple green house climate control model incorporates effects of ventilation and evaporative cooling. William m. Worek, shyr tzer hsu and zalman lavan, optimized the wet- surface heat exchangers.

III. CONCLUSION

From the above literature review we conclude that there is a scope for further study in evaporative cooling considering the different profile shape for evaporative wall of Ceramic rod for better and effective cooling. Also there is a scope to make different arrangements for positioning of Ceramic rod in order to increase the contact of air with wetted surface.

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