A REVIEW ON PERFORMANCE OF EVAPORATIVE COOLONG SYSTEM

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ABSTRACT

The standard of living is continuously improving in all climatic areas of the world causing higher energy demands especially in building sector. An alternate type of cooling, which does not use hydro-chlorofluorocarbons (HCFs), chlorofluorocarbons (CFCs) and consumes much less energy is highly desirable. The evaporative cooling may be considered as one of such eco-friendly methods of achieving confortable conditions in building sector. An evaporative cooling system is a system that cools air through the evaporation of water. It is different from typical air conditioning systems, which use vapor-compression or absorption refrigeration cycles. Evaporative cooling uses the fact that water will absorb a relatively large amount of heat in order to evaporate. The temperature of dry air can be dropped significantly through the phase transition of liquid water to water vapor. In extremely dry climates, evaporative cooling of air has the added benefit of conditioning the air with more moisture for the comfort of building occupants.

Keyword : - *Evaporative cooling, Low energy cooling, Mathematical model, Air cooler.*

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1. INTRODUCTION

Evaporative cooling is a physical phenomenon in which evaporation of a liquid, typically into surrounding air, cools an object or a liquid in contact with it. Evaporative cooling occurs when air, that is not too humid, passes over a wet surface; the faster the rate of evaporation the greater the cooling. Evaporative cooling effect is provided by the evaporation of water. Water used as a coolant and also as the working substance that can meet many air conditioning needs in both residential and commercial applications. It can work more effectively in hot and dry climates and provides 100% fresh and cooled air to the space. In this technology, heat is removed due to forced convective process. It brings the comfort by increasing the humidity in dry climates, improves the air quality. In hot climates with high atmospheric moisture, the cooling effect is less because the high moisture contents present in the surrounding air. Evaporative air cooling can be categorized as direct, indirect and two- stage system.

1.1. Direct Evaporative Cooling

In direct evaporative cooling sensible heat energy evaporates some water, and reduced the air’s dry bulb temperature. Greater the differences in dry bulb and wet bulb temperatures; better is the cooling effect to the space and the temperature of saturated moist air is achieved almost near the wet bulb temperatures. It commonly used for residential, commercial, and industrial systems, cools the air by evaporation of water to increase the moisture content of the air. In industrial system mainly uses cellulose pads as evaporative medium. When hot and dry air blows through wet medium, the water gets saturated and evaporates. This evaporation of water provides cooling effects.

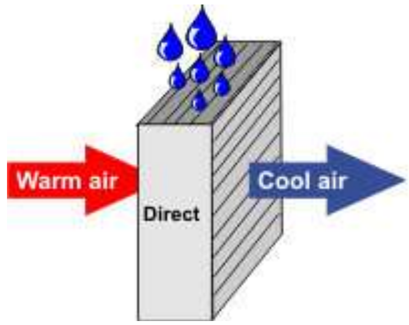

Figure 1: Direct Evaporative Cooling

1.2 Indirect Evaporative Cooling

In indirect evaporative cooling systems heat and mass transfer takes place and uses an air to air heat exchanger to remove heat from the primary air stream without addition of moisture by means of cooled secondary stream evaporatively. During the heating season, an indirect system's heat exchanger can preheat outside air if exhaust air is used as the secondary air stream. During the summer season, an indirect system's heat exchanger can preheat outside air if exhaust air is used as the secondary air stream. In indirect evaporative process air moisture content stays constant during temperature decreasing. Due to less energy losses in indirect evaporative cooling process; it results in less effective than direct evaporative. Indirect evaporative cooling systems takes advantage of evaporative cooling effects, but cools without raising indoor humidity.

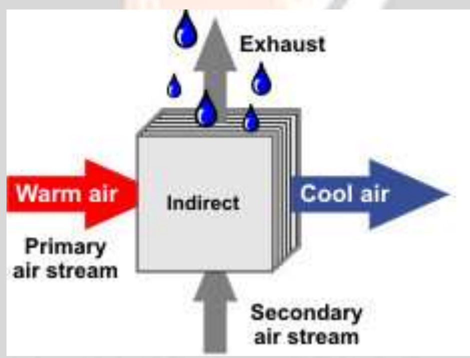

Figure 2. Indirect Evaporative Cooling

1.3 Two-Stage Evaporative Cooling

Indirect cooling is paired with a second direct evaporative cooling stage, to cool the supply air further while adding some moisture to the supply air. Two stage systems provide cooler supply air at a lower relative humidity than direct evaporative coolers. The first indirect stage cools the supply air without increasing humidity. Since the air is cooled it has a reduced capacity to hold moisture. The air is then passed through a direct stage, which cools the air further while adding moisture. Indirect – Direct systems used in arid climates can have power consumption as low as 0.22 kW/ton, much lower than compressor-based cooling.

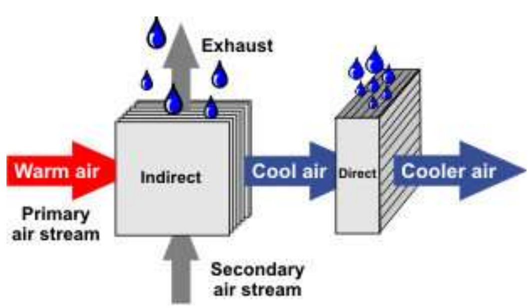

Figure 3. Two Stage Evaporative cooling

2. SUMMARY OF THE PREVIOUS PAPER

Fouda and Melikyan [1] developed a simplified mathematical model to describe the heat and mass transfer between air and water in a direct evaporative cooler. Model consists of the governing equations with their boundary conditions and some associated algebraic equations. The related latent heat of water evaporation is taken as a heat source in the energy equation, and the mass of evaporated water is treated as a mass source in the mass equation. The study presents a comparison of the computed results with that of experimental results for the same evaporative cooler.

Kachhwaha, S. S., and Suhas Prabhakar [2] gives 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. The prediction of air conditions at cooler outlet for given input conditions satisfied for air exit temperature and humidity ratio.

Wu, J. M., X. Huang, and H. Zhang [3] developed a simplified mathematical model to describe the heat and moisture between water and air in a direct evaporative cooler, they treated mass of evaporated water as a mass of source of air flow and the related latent heat of water evaporation is taken as a heat source in the energy equation and decide the effective air viscosity and diffusion coefficient experimentally. They validate the models and methods by comparing the numerical results with those of experiment for the same evaporative cooler.

Camargo, Jose Rui, Carlos Daniel Ebinuma, and Jose Luz Silveira [4] presents the paper of basic principles of the evaporative cooling process for human thermal comfort, the principles of operation for the direct evaporative cooling system and the mathematical development of the equations of thermal exchanges, allows the determination of the effectiveness of saturation. They also presents the results of experimental tests in a direct evaporative cooler to determinate the convective heat transfer co-efficient and compare with the mathematical model.

Singh, S. P., T. R. Tulsidasani, R. L. Sawhney, and M. S. Sodha [5] developed a mathematical model to evaluate the relative thermal performance of a building coupled with an indirect or direct evaporative cooler and compare their performance under different climatic conditions, they found that the indirect evaporative cooler is a more effective and energy efficient system than the air-conditioner; it can hence be commercially used for computer and electronic exchange applications as well as for human comfort in a variety of climatic conditions, whereas direct evaporative cooler has limited use (only in hot-dry and composite climates).

Shariaty-Niassar, M., and N. Gilani. [6] investigated the effects of air stream direction in the channels of indirect evaporative cooler (IEC) on system performance, the dependence of system performance on outdoor air temperature and relative humidity has been studied to determine the allowable conditions for proper operation of the system, with respect to thermal comfort criteria. For this; the different types of IECs were investigated using the CFD technique. Several codes were defined in MATLAB for modeling the parallel flow, counter flow and cross flow layout. They validate the CFD program against theoretical data from the literature and good agreement between the prediction and measurement was achieved.

Jiang, Yi, and Xiaoyun Xie [7] introduced an indirect evaporative chiller in the world, driven by outdoor dry air to produced cold water as the cooling source for air conditioning system and the principle and the structure of the chiller is presented. The key components of the chiller are an air cooler and a padding tower. To improve the heat transfer performance inside the chiller, a quasi-countercurrent air cooler was designed; a subsection linear method was used for the mathematical model of the padding tower. The first indirective evaporative chiller, designed and developed in 2005 and used in Kairui building, a big hotel in Shihezi, Xinjiang Autonomus Region. No CFCs are used in this chiller, it would not cause any pollution to the environment.

3. REVIEW WORK ON EVAPORATIVE COOLING SYSTEM

Fouda and Melikyan [1] established a basic mathematical model which describes the mass and heat transfer between water and air in a direct evaporative cooler. They concluded that the optimum frontal air velocity which provides higher efficiency should be assumed as 2.5 m/s and the cooling efficiency is augmented with the increase in the pad thickness, because of increased contact surface between water and air.

Similarly Kachhwaha and Prabhakar [2] work was related to the design of a household desert cooler. Parameters as input involved dry bulb temperature of inlet air, velocity of the air and geometrical properties for evaporative medium to predict the performance. During dry months upto10oC of reduction in dry bulb temperature was seen in results by employing evaporative cooling. Present methodology could be used for size selection of an evaporative cooler design.

The impacts of the face velocity of inlet air, pad thickness and inlet air wet-bulb and dry bulb temperatures on the cooling efficiency of the evaporative cooler were also analyzed by Wu *et al*., [3]. The results that were predicted showed that the direct evaporative cooler with higher performance pad material may be well applicable for the purpose of air conditioning with suitable pad thickness and inlet air face velocity.

Evaporative cooling systems can be used as a substitute to conventional systems in many tropical areas providing thermal comfort. Jose´ Rui Camargo *et al*., [4] has developed mathematical equations. From performance analyses temperature difference of up to 7.4oC-8oC between the external DBT and at the DEC outlet temperature was possible to obtain thus concluded that the evaporative cooler is more efficient when the temperatures are higher.

Tulsidasani *et al*., [5] researched on the thermal performance of a building that is non-airconditioned and equipped with an IEC system. In India for three different climatic conditions (dry/hot, humid/hot, humid/warm), effects of various IEC parameters to thermal comfort of the building space was investigated. The results indicated that the IEC system is effective in improving the thermal comfort of the buildings in dry/ hot climatic condition.

Shariaty-Niassar and NGilani [6] also found that with respect to thermal comfort criteria, IECs can be effectively used in hot and humid climates. In another study, Jiang *et al*., [7] offered the viability to use a newly established indirect evaporative chiller for different parts of the world by analysing the design climatic data that was derived from the ASHRAE handbook 2001. The paper specified that the technology is appropriate for use in dry climatic areas of the world.

4. CONCLUSIONS

On the basis of above review we can concluded that significant research has been done for implementation of different types of evaporative cooling systems in different climatic conditions of world. However, the performance of such systems is strongly dependent on local climate conditions. Therefore, there is dire need to analyse these systems in local climate of India and select the best system's type for each climate zone. Thus, the key objective of the current study is to initially design and develop 03 different types of evaporative cooling systems model including direct, indirect, and two-stage systems. Afterwards, simulations will be performed in 05 different climate zones of India.

5. REFERENCES

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